

Generic Environmental Impact Statement for License Renewal of Nuclear Plants

Supplement 38

Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3

Final

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Supplement 38

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ABSTRACT

This second supplement to the final supplemental environmental impact statement (FSEIS) for the proposed renewal of the operating licenses for Indian Point Nuclear Generating Unit Nos. 2 and 3 (IP2 and IP3) incorporates new information that the U.S. Nuclear Regulatory Commission (NRC) staff has obtained since the publication of the first supplement to the FSEIS in June 2013.

This supplement includes the NRC staff's evaluation of revised engineering project cost information for severe accident mitigation alternatives (SAMAs), a summary of the results of additional sensitivity analyses to address uncertainties in the SAMA cost-benefit conclusions as directed by the Commission, newly available aquatic impact information, and the additional environmental issues associated with license renewal resulting from the June 2013 revision to Table B–1 in Appendix B to Subpart A of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 51 and NUREG–1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. This supplement also incorporates the impact determinations of NUREG–2157, *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel*, in accordance with the requirements in 10 CFR 51.23(b). Additionally, this supplement describes the reinitiation of consultation under Section 7 of the Endangered Species Act of 1973, as amended (ESA), regarding the northern long-eared bat (*Myotis septentrionalis*), the initiation of a conference under Section 7 of the ESA for proposed critical habitat of the Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), the staff's November 2017 request for the National Marine Fisheries Service to amend the 2013 biological opinion's Incidental Take Statement, and to provide its concurrence with the NRC staff's effect determination with respect to the final designated Atlantic sturgeon critical habitat, and it provides an update on the status of the operating licenses for IP 2 and IP 3.

This supplement also reflects the closure agreement signed in January 2017 by the parties to legal proceedings related to the renewal of the operating licenses for IP2 and IP3. Based on the agreement, a motion was filed with the NRC's Atomic Safety and Licensing Board

Abstract

(ASLB or the Board) on February 8, 2017, seeking to dismiss the remaining contentions in the proceedings. The Board subsequently issued an Order on March 13, 2017, dismissing the remaining contentions and terminating the proceeding. That decision became final on July 11, 2017.

The closure agreement, among other things, resolves all litigation concerning license renewal and calls for an early shut down of IP2 and IP3. Although the closure agreement calls for early shut down of the units, the shortened periods of extended operation do not affect any of the conclusions presented in this supplement with the exception of the impact rating for the issue titled "Radionuclides Released to Groundwater," due to recent releases of radionuclides into the groundwater in 2016. A shorter license renewal period leaves less time for the processes of natural attenuation to remove onsite radionuclide contamination from the groundwater while the plant is operating. Therefore, this issue will likely have an impact rating of MODERATE throughout the period of plant operations. Any remaining groundwater restoration will be addressed after plant operations have ceased.

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EXECUTIVE SUMMARY

BACKGROUND

By letter dated April 23, 2007, Entergy Nuclear Operations, Inc. (Entergy), submitted an application to the U.S. Nuclear Regulatory Commission (NRC) to issue renewed operating licenses for Indian Point Nuclear Generating Unit Nos. 2 and 3 (IP2 and IP3) for additional 20-year periods.

Under Title 10 of the *Code of Federal Regulations* (10 CFR) 51.20(b)(2) and the National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. 4321 et seq.), the renewal of a power reactor operating license requires preparation of an environmental impact statement (EIS) or a supplement to an existing EIS. In addition, 10 CFR 51.95(c) states that the NRC shall prepare an EIS, which is a supplement to the Commission's NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), Revision 1, which was issued in June 2013.

The NRC staff published its final supplemental environmental impact statement (FSEIS) for IP2 and IP3 in December 2010. In June 2013, the NRC staff issued a supplement to the FSEIS, updating its final analysis to include corrections to impingement and entrainment data presented in the FSEIS; revising conclusions on thermal impacts based on newly available thermal plume studies; and providing an update of the status of the NRC's consultation, under Section 7 of the Endangered Species Act of 1973, as amended, with the National Marine Fisheries Service regarding the shortnose sturgeon and Atlantic sturgeon.

Subsequent to publishing the 2013 FSEIS supplement, the NRC staff identified new information that necessitated changes to its assessments in the FSEIS and Supplement 1 to the FSEIS. This new information is derived from the following:

- Entergy provided refined engineering project cost estimates for the 22 potentially cost-beneficial severe accident mitigation alternatives (SAMAs) previously identified in the FSEIS.
- Entergy provided newly available information relevant to the NRC staff's evaluation of impacts from the operation of IP2 and IP3 on certain aquatic species in the Hudson River.
- In June 2013, the NRC amended its regulations at Appendix B to Subpart A of 10 CFR Part 51 to redefine the number and scope of the environmental issues that must be addressed during license renewal environmental reviews. This revision was supported by analyses conducted for, and reported in, Revision 1 to the GEIS.
- In September 2014, the NRC amended its regulations at 10 CFR 51.23 to adopt the generic impact determinations made in NUREG-2157, *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel*, regarding the continued storage of spent nuclear fuel.
- On February 8, 2017, Entergy submitted to the NRC an amendment to the license renewal application (LRA) reflecting shortened license renewal terms for IP2 and IP3. The shortened license renewal terms do not affect any of the conclusions presented in this supplement with the exception of the impact rating for the issue titled "Radionuclides Released to Groundwater," due to recent releases of radionuclides into the groundwater in 2016. A shorter license renewal period leaves less time for the processes of natural attenuation to remove onsite radionuclide

contamination from the groundwater while the plant is operating. Therefore, this issue will likely have an impact rating of MODERATE throughout the period of plant operations. Any remaining groundwater restoration will be addressed after plant operations have ceased.

To address this new information, the NRC staff has prepared this supplement to the FSEIS in accordance with 10 CFR 51.92(a)(2) and 10 CFR 51.92(c), which address preparation of a supplement to a final EIS for proposed actions that have not been taken under one of the following conditions:

- There are new and significant circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts.
- The NRC staff determines, in its opinion, that preparation of a supplement will further the purposes of NEPA.

In addition to supplementing the FSEIS for the reasons stated above, the NRC is also taking the opportunity to provide an update on the status of the IP2 and IP3 operating licenses and the reinitiation of consultation under Section 7 of the Endangered Species Act of 1973 (ESA), as amended, regarding the northern long-eared bat (*Myotis septentrionalis*) and initiation of a conference under Section 7 of the ESA for proposed critical habitat for the New York Bight distinct population segment of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). This supplement also discusses the NRC staff's November 2017 request for the National Marine Fisheries Service to amend the 2013 biological opinion's Incidental Take Statement and to provide its concurrence with staff's effect determination with respect to the final designated Atlantic sturgeon critical habitat.

PROPOSED ACTION

The proposed action as stated in the FSEIS (on pages 1–6 and 1–7) has been revised, as follows, to reflect the change in status for the IP2 and IP3 licenses:

The proposed Federal action is renewal of the operating licenses for IP2 and IP3 (IP1 was shut down in 1974). IP2 and IP3 are located on approximately 239 acres of land on the east bank of the Hudson River at Indian Point, Village of Buchanan, in upper Westchester County, New York, approximately 24 miles north of the New York City boundary line. The facility has two Westinghouse pressurized–water reactors. IP2 is currently licensed to generate 3,216 megawatts thermal (MW(t)) (core power) with a design net electrical capacity of 1,078 megawatts electric (MW(e)). IP3 is currently licensed to generate 3,216 MW(t) (core power) with a design net electrical capacity of about 1,080 MW(e). IP2 and IP3 cooling is provided by water from the Hudson River to various heat loads in both the primary and secondary portions of the plants. ~~The current operating license for IP2 expires on September 28, 2013, and the current operating license for IP3 expires on December 12, 2015.~~ By letter dated April 23, 2007, Entergy submitted an application to the NRC (Entergy 2007a) to renew the IP2 and IP3 operating licenses for an additional 20 years. **The operating licenses for IP2 and IP3 were set to expire on September 28, 2013, and December 12, 2015, respectively. However, having met the requirements in 10 CFR 2.109, Entergy is allowed to continue to operate IP2 and IP3 under the existing licenses until the NRC reaches a decision on the**

license renewal request. As amended, the application seeks renewal of the operating licenses for IP2 and IP3 until no later than April 30, 2024, and April 30, 2025, respectively.

PURPOSE AND NEED FOR ACTION

The purpose and need for action remains the same as stated in the FSEIS (on page 1–7):

Although a licensee must have a renewed license to operate a reactor beyond the term of the existing operating license, the possession of that license is just one of a number of conditions that must be met for the licensee to continue plant operation during the term of the renewed license. Once an operating license is renewed, State regulatory agencies and the owners of the plant will ultimately decide whether the plant will continue to operate based on factors such as the need for power or matters within the State’s jurisdiction—including acceptability of water withdrawal, consistency with State water quality standards, and consistency with State coastal zone management plans—or the purview of the owners, such as whether continued operation makes economic sense.

Thus, for license renewal reviews, the NRC has adopted the following definition of purpose and need (GEIS Section 1.3):

The purpose and need for the proposed action (renewal of an operating license) is to provide an option that allows for power generation capability beyond the term of a current nuclear power plant operating license to meet future system generating needs, as such needs may be determined by State, utility, and where authorized, Federal (other than NRC) decision makers.

This definition of purpose and need reflects the Commission’s recognition that, unless there are findings in the safety review required by the Atomic Energy Act of 1954, as amended, or findings in the NEPA environmental analysis that would lead the NRC to reject an LRA, the NRC does not have a role in the energy–planning decisions of State regulators and utility officials as to whether a particular nuclear power plant should continue to operate. From the perspective of the licensee and the State regulatory authority, the purpose of renewing the operating licenses is to maintain the availability of the nuclear plant to meet system energy requirements beyond the current term of the plant’s licenses.

ABBREVIATIONS, ACRONYMS, AND SYMBOLS

°C	degree(s) Celsius
°F	degree(s) Fahrenheit
AACE	Association for the Advancement of Cost Engineering International
ac	acre(s)
ac-ft	acre-foot (feet)
ADAMS	Agencywide Documents Access and Management System
AEC	Atomic Energy Commission
ARERR	Annual Radioactive Effluent Release Report
AFW	auxiliary feedwater
AREOR	Annual Radiological Environmental Operating Report
ASMFC	Atlantic States Marine Fisheries Commission
ASLB	Atomic Safety and Licensing Board (or the Board)
ASSS	alternate safe shutdown system
BCG	Biota Concentration Guide
BLS	Bureau of Labor Statistics
BMPs	best management practices
BSS	Beach Seine Survey
BTA	best technology available
CAA	Clean Air Act of 1970
CDFRM	cost per person of decontaminating non-farmland to a specific level
CFR	<i>Code of Federal Regulations</i>
cfs	cubic foot (feet) per second
CHGEC	Central Hudson Gas and Electric Corporation
CIMR	conditional impingement mortality rate
CMR	conditional mortality rate
cm	centimeter
CO _{2eq}	carbon dioxide equivalent
CPUE	catch per unit effort
CV	coefficient of variation
CWA	Clean Water Act
dBA	A-weighted decibels

Abbreviations, Acronyms, and Symbols

DF	decontamination factor
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
DOT	U.S. Department of Transportation
DPS	distinct population segment
DTS	dry transfer system
EIA	Energy Information Administration
EIS	environmental impact statement
EMR	entrainment mortality rate
Entergy	Entergy Nuclear Operations, Inc.
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ER	Environmental Report
ESA	Endangered Species Act of 1973, as amended
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FCTR	factor
FERC	U.S. Federal Energy Regulatory Commission
FES	<i>Final Environmental Statement Related to Operation of Indian Point Nuclear Generating Plant Unit No. 2</i>
FLIGHT	Facility Level Information on GreenHouse gases Tool
FR	<i>Federal Register</i>
FSEIS	final supplemental environmental impact statement
FSS	Fall Shoals Survey
ft	foot (feet)
ft ²	square foot (feet)
Fukushima Dai-ichi	Fukushima Dai-ichi Nuclear Power Plant
FWS	U.S. Fish and Wildlife Service
GEIS	NUREG–1437, <i>Generic Environmental Impact Statement for License Renewal of Nuclear Plants</i>
GHG	greenhouse gas
gpm	gallon(s) per minute
Gy/d	gray per day
ha	hectare(s)
HCFC	hydrochlorofluorocarbons

Abbreviations, Acronyms, and Symbols

HRBMP	Hudson River Biological Monitoring Program
HRSA	Hudson River Settlement Agreement
I&E	impingement and entrainment
IMR	impingement mortality rate
in.	inch(es)
IP1, IP2, and IP3	Indian Point Nuclear Generating Unit Nos. 1, 2, and 3
IPEC	Indian Point Energy Center
ISFSI	independent spent fuel storage installation
ISLOCA	intersystem loss-of-coolant accident
ITS	Incidental Take Statement
kV	kilovolt
L/min	liter(s) per minute
LOE	line of evidence
LRS	Long River Survey
m	meter(s)
mm	millimeter(s)
m ²	square meter(s)
m ³ /min	cubic meter(s) per minute
m ³ /s	cubic meter(s) per second
mrem	millirem
MCL	maximum contaminant level(s)
mgd	million gallons per day
MMT	million metric tons
MT	metric ton(s)
MW	megawatt(s)
MWe	megawatt electric
MWh	megawatt hour
NAAQS	National Ambient Air Quality Standards
NEI	Nuclear Energy Institute
NEPA	National Environmental Policy Act of 1969
NES LME	Northeast U.S. Continental Shelf Large Marine Ecosystem
NGCC	natural gas combined-cycle
NHPA	National Historic Preservation Act of 1966
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration

Abbreviations, Acronyms, and Symbols

NRC	U.S. Nuclear Regulatory Commission
NRR	Office of Nuclear Reactor Regulation
NYB	New York Bight
NYCRR	New York Codes, Rules, and Regulations
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOS	New York State Department of State
OECR	offsite economic cost risk
OTR	ozone transport region
PCB	polychlorinated biphenyl
pCi/L	picocurie(s) per liter
PDR	population dose risk
PM	particulate matter
PM _{2.5}	particulate matter, 2.5 microns or less in diameter
PM ₅	particulate matter, 5 microns or less in diameter
PM ₁₀	particulate matter, 10 microns or less in diameter
PORV	power-operated relief valve
PSDAR	post-shutdown decommissioning activities report
QA	quality assurance
QC	quality control
rad/d	radiation-absorbed dose per day
RAI	request for additional information
REMP	Radiological Environmental Monitoring Program
RHR	residual heat removal
RIS	representative important species
RKm	river kilometer
RM	river mile
ROW	right of way
RP	Recommended Practice
SAMA	severe accident mitigation alternative
SDWA	Safe Drinking Water Act
SEIS	supplemental environmental impact statement
SOARCA	State-of-the-Art Reactor Consequences Analyses
SOC	strength of connection
SPDES	State Pollutant Discharge Elimination System

Abbreviations, Acronyms, and Symbols

SRM	Staff Requirements Memorandum
SCFWH	Significant Coastal Fish and Wildlife Habitat
TIMDEC	time required to complete decontamination to a specific level
USACE	U.S. Army Corps of Engineers
USCB	U.S. Census Bureau
USGCRP	U.S. Global Change Research Program
USGS	U.S. Geological Survey
VDEPOS	deposition velocity
VOC	volatile organic compound
WOE	weight of evidence
yd	yard(s)
YOY	young-of-year

1.0 INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) staff prepared this supplement to the final supplemental environmental impact statement (FSEIS) for Indian Point Nuclear Generating Unit Nos. 2 and 3 (IP2 and IP3), in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) 51.92(a)(2) and 10 CFR 51.92(c), which address the preparation of a supplement to an FSEIS for proposed actions that have not been taken if the following conditions apply:

- There are new and significant circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts.
- The NRC staff determines, in its opinion, that preparation of a supplement will further the purposes of the National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. 4321 et seq.).

The NRC staff prepared this supplement to the FSEIS because it received new data and analyses from Entergy Nuclear Operations, Inc. (Entergy), which had the potential to change, and in some cases did change, the NRC staff's conclusions in the FSEIS, as supplemented by the 2013 supplement to the FSEIS. Additionally, the NRC revised its regulations at 10 CFR Part 51, which resulted in changes to the number and scope of environmental issues that must be addressed during license renewal environmental reviews. This supplement contains the text, tables, and figures that changed as the result of this new information.

Five sources provided information that was evaluated in this supplement.

First, by letter dated May 6, 2013, Entergy (2013b) provided refined engineering project cost estimates for the 22 potentially cost-beneficial severe accident mitigation alternatives (SAMAs) previously identified in the FSEIS. As a result of the revised cost estimates, Entergy stated that six of the SAMAs that had previously been identified as potentially cost beneficial were no longer cost beneficial. Chapter 3 of this supplement presents the NRC staff's evaluation of this new information.

Second, Entergy (2014b) submitted new information and analyses relevant to the NRC's species-specific impact determinations in the FSEIS for the blueback herring, hogchoker, rainbow smelt, and white perch. Chapter 4 of this supplement presents the NRC staff's evaluation of this new information, which is supported by technical information summarized in Appendix A.

Third, the NRC amended its regulations at Table B-1 in Appendix B to Subpart A of 10 CFR Part 51 in June 2013 to redefine the number and scope of the generic and site-specific environmental impact issues that must be addressed during license renewal environmental reviews (*Federal Register* (FR) (78 FR 37282)). This amendment was supported by analyses conducted for, and reported in, Revision 1 to NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), dated June 19, 2013 (NRC 2013a). Based on its review of the 2013 GEIS and Table B-1 in Appendix B to Subpart A of 10 CFR Part 51, the NRC staff determined that several environmental issues have been added to the scope of license renewal environmental reviews since issuing the FSEIS in December 2010 and the first supplement to the FSEIS in June 2013. Chapter 5 of this supplement presents the NRC staff's evaluation of these issues.

Fourth, in September 2014, the NRC revised its regulations at 10 CFR 51.23 addressing the environmental impacts of continued storage of spent nuclear fuel beyond the licensed life for operation of a reactor (79 FR 56238). The revised rule adopts the generic impact determinations made in NUREG-2157, *Generic Environmental Impact Statement for Continued*

Introduction

Storage of Spent Nuclear Fuel (NRC 2014f) and codifies the NRC's generic determinations regarding the environmental impacts of continued storage of spent nuclear fuel beyond a reactor's operating license. Chapter 6 incorporates the impact determinations of NUREG-2157.

Fifth, on February 8, 2017, Entergy submitted to the NRC an amendment to the license renewal application (LRA) reflecting shortened license renewal terms for IP2 and IP3, in accordance with the closure agreement submitted to the NRC's Atomic Safety and Licensing Board (Entergy 2017c; NYS et al. 2017). Although the closure agreement calls for early shut down of the units, the shortened periods of extended operation do not affect any of the conclusions presented in this supplement with the exception of the impact rating for the issue titled "Radionuclides Released to Groundwater," due to the recent release of radionuclides into the groundwater in 2016. A shorter license renewal period leaves less time for the processes of natural attenuation to remove onsite radionuclide contamination from the groundwater while the plant is operating. Therefore, this issue will likely have an impact rating of MODERATE throughout the period of plant operations. Any remaining groundwater restoration will be addressed after plant operations have ceased. See Section 5.4.3 of this supplement.

In addition to supplementing the FSEIS for the reasons stated above, the NRC also is taking the opportunity to provide an update on the status of the IP2 and IP3 operating licenses, the reinitiation of consultation under Section 7 of the Endangered Species Act of 1973, as amended, regarding the northern long-eared bat (*Myotis septentrionalis*), and the initiation of a conference under Section 7 of the ESA for proposed critical habitat for the New York Bight distinct population segment of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). Chapter 2 updates the information in the FSEIS pertaining to the expiration date of the IP2 and IP3 licenses; the January 8, 2017, Indian Point Closure Agreement; and Entergy's associated LRA amendment to revise the license renewal term. Chapter 7 discusses the status of ESA Section 7 consultation regarding the northern long-eared bat, ESA Section 7 conference regarding proposed critical habitat of the Atlantic sturgeon, and the staff's revised NEPA findings for threatened and endangered species. Chapter 7 also discusses the staff's November 2017 request for the National Marine Fisheries Service to amend the 2013 biological opinion's Incidental Take Statement and to provide its concurrence with the NRC staff's effect determination with respect to the final designated Atlantic sturgeon critical habitat. Finally, Chapter 7 describes the status of IP2's and IP3's Coastal Zone Management Act consistency certification, water quality certification under Section 401 of the Federal Water Pollution Control Act (i.e., the Clean Water Act), and renewed State Pollutant Discharge Elimination System (SPDES) Permit.

The NRC staff issued a draft of this FSEIS supplement for public comment on December 22, 2015. The public comment period closed on March 4, 2016 (NRC 2015g). Based on comments received, the NRC staff amended the draft FSEIS supplement, as necessary, and it is publishing this final supplement to the FSEIS. The NRC staff's responses to public comments are presented in Appendix B of this supplement.

Where appropriate, **bold** text indicates specific text corrections or additions to the FSEIS, and **bold strikeout** indicates deletions from the text. Change bars (vertical lines in the page margin) indicate changes that have been made to the text of the draft supplement to the FSEIS, in issuing this final supplement.

2.0 TIMELY RENEWAL, INDIAN POINT CLOSURE AGREEMENT, AND REVISED LICENSE RENEWAL TERM

2.1 Timely Renewal

By letter dated April 23, 2007, Entergy Nuclear Operations, Inc. (Entergy), submitted an application to the U.S. Nuclear Regulatory Commission (NRC) to renew the Indian Point Nuclear Generating Unit Nos. 2 and 3 (IP2 and IP3) operating licenses for an additional 20 years (Entergy 2007a). The operating licenses for IP2 and IP2 were set to expire on September 28, 2013, and December 12, 2015, respectively. However, Entergy is allowed to continue to operate IP2 and IP3 under the existing licenses in accordance with the requirements in Title 10 of the *Code of Federal Regulations* (10 CFR) 2.109. The NRC's regulations at 10 CFR 2.109 implement Section 558 of the Administrative Procedure Act of 1946 (5 U.S.C. 500 et seq.), which states that "[w]hen the licensee has made timely and sufficient application for a renewal or a new license in accordance with agency rules, a license with reference to an activity of a continuing nature does not expire until the application has been finally determined by the agency." Under 10 CFR 2.109(b), an application for renewal is considered timely if a licensee files a sufficient request for a renewed operating license at least 5 years before the expiration of its current license. Because Entergy submitted its application for renewed licenses—which the NRC found sufficient for docketing—more than 5 years before the expiration of the IP2 and IP3 licenses, it is allowed to continue the operation of IP2 and IP3 under its existing licenses until the NRC reaches a decision on the license renewal request.

Based on the change in status for the IP2 and IP3 licenses, the NRC staff has updated the FSEIS as described below.

Lines 13-15 of page xv in the Executive Summary of the FSEIS are revised as follows:

If the operating licenses are not renewed, then IP2 and IP3—the licenses for which were set to expire on September 28, 2013, and December 12, 2015, respectively, but are allowed to continue to operate under the existing licenses pending completion of the NRC's review—would be required to shut down.

Lines 24-29 of page 1-1 in Section 1.0 of the FSEIS are revised as follows:

IP2 has operated under operating license DPR-26 since August 1974. The IP2 operating license ~~will expire was set to expire~~ on September 28, 2013. IP3 has operated under operating license DPR-64 26 since August 1976. The IP3 operating license ~~will expire was set to expire~~ on December 12, 2015. ~~However, having met the requirements in 10 CFR 2.109, Entergy is allowed to continue to operate IP2 and IP3 under the existing licenses until the NRC reaches a final decision on the license renewal request.~~ Indian Point Unit No. 1 (IP1), which is not the subject of this license renewal application, was shut down in 1974 and is currently in SAFSTOR (a decommissioning strategy that includes maintenance, monitoring, and delayed dismantlement to allow radioactivity to decay prior to decommissioning).

Lines 7-10 of page 1-7 in Section 1.3 of the FSEIS are revised as follows:

~~The current operating license for IP2 expires on September 28, 2013, and the current operating license for IP3 expires on~~

~~December 12, 2015.~~ By letter dated April 23, 2007, Entergy submitted an application to the NRC (Entergy 2007a) to renew the IP2 and IP3 operating licenses for an additional 20 years. **The operating licenses for IP2 and IP3 were set to expire on September 28, 2013, and December 12, 2015, respectively. However, having met the requirements in 10 CFR 2.109, the facility is allowed to continue to operate under the existing licenses until the NRC reaches a decision on the license renewal request.**

Lines 8-13 of page 1-8 in Section 1.5 of the FSEIS are revised as follows:

~~Two-Three~~ state-level issues, **issuance of a final State Pollutant Discharge Elimination System (SPDES) permit**, consistency with State water quality standards, and consistency with State coastal zone management plans, ~~have been~~**yet to be** resolved. On April 24, 2017~~0~~, the New York State Department of Environmental Conservation (NYSDEC) issued a **final SPDES permit and associated Final Environmental Impact Statement and State Environmental Quality Review Act findings, and a Notice of Denial regarding the Clean Water Act Section 401 Water Quality Certification to Entergy. In addition, by letter dated March 2, 2017, the New York State Department of State informed Entergy that it concurred with Entergy's revised Federal coastal zone consistency certification. Entergy has since requested a hearing on the issue, and the matter will be decided through NYSDEC's hearing process.**

2.2 Indian Point Closure Agreement

On January 8, 2017, as a result of extensive negotiations between Entergy and the State of New York and Riverkeeper, which had filed various contentions related to Entergy's application to renew the operating licenses for IP2 and IP3 for an additional 20 years (to 2033 and 2035, respectively), the parties reached an agreement, among other things, to terminate all pending litigation and to close IP2 and IP3 no later than 2024 and 2025, respectively. In accordance with the terms of the closure agreement, on February 8, 2017, a motion was filed with the NRC's Atomic Safety and Licensing Board (ASLB) to dismiss the remaining contentions (NYS et al. 2017). The Board subsequently issued an Order on March 13, 2017, granting the motion to dismiss the remaining contentions and to terminate the proceeding (ASLB 2017). Although the closure agreement calls for early shut down of the units, the shortened periods of extended operation do not affect any of the conclusions presented in this supplement with the exception of the impact rating for the issue titled "Radionuclides Released to Groundwater," due to the recent release of radionuclides into the groundwater in 2016. A shorter license renewal period leaves less time for the processes of natural attenuation to remove onsite radionuclide contamination from the groundwater while the plant is operating. Therefore, this issue will likely have an impact rating of MODERATE throughout the period of plant operations. Any remaining groundwater restoration will be addressed after plant operations have ceased.

2.3 Revised License Renewal Term and Associated Revisions to the Proposed Action

In the original license renewal application (LRA) submitted to the NRC by letter dated April 23, 2007 (Entergy 2007a), Entergy requested a 20-year extension of the current operating licenses to midnight September 28, 2033, for IP2, and to midnight December 12, 2035, for IP3. As a result of the agreement between Entergy and the State of New York and Riverkeeper, Entergy agreed to the early closure of IP2 and IP3.

On February 8, 2017, Entergy submitted to the NRC an amendment to the LRA reflecting the shortened license renewal terms for IP2 and IP3 in accordance with the closure agreement (Entergy 2017c). The amendment revised several sections of the LRA, including Section 1, "Administrative Information," and Section 1.2, "Plant Description." These sections were revised to state that the units currently are operating in "timely renewal" as discussed above. Section 1 also revised the shutdown dates to April 30, 2024, for IP2, and to April 30, 2025, for IP3.

The remaining revisions to the application were related to safety issues and not the staff's environmental review.

Although the closure agreement calls for early shut down of the units, the shortened periods of extended operation do not affect any of the conclusions presented in this supplement with the exception of the impact rating for the issue titled "Radionuclides Released to Groundwater." A shorter license renewal period leaves less time for the processes of natural attenuation to remove onsite radionuclide contamination from the groundwater while the plant is operating. During the longer period of active operations evaluated in the draft, impacts to onsite groundwater were described as MODERATE with the potential to move to SMALL during active operations. However, the shorter period of active operations will result in less time for attenuation of impacts to onsite groundwater during operations, so this impact is more likely to remain as MODERATE. Any remaining groundwater restoration will be addressed after plant operations have ceased. See Section 5.4.3 of this supplement.

3.0 REVISED AND SUPPLEMENTAL SAMA ANALYSES

The severe accident mitigation alternatives (SAMAs) analysis constitutes a systematic and comprehensive process for identifying potential plant improvements, evaluating the implementation costs and risk reduction for each SAMA, and determining which SAMAs may be cost beneficial to implement. The analysis is technically rigorous and consistent with the expectation by the National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. 4321 et seq.), that Federal agencies take a “hard look” at the environmental impacts of their proposed actions, including consideration of viable alternatives. If a SAMA is determined to be potentially cost beneficial but is not related to adequately managing the effects of aging during the relicensing period, it is not required to be implemented as part of the license renewal process pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 54. Further refinement beyond determining whether a SAMA is potentially cost beneficial is not necessary for an objective evaluation. Nevertheless, potentially cost-beneficial alternatives are identified and considered as part of the license renewal process, and licensees often commit to further evaluate the most promising cost-beneficial SAMAs among those that have been identified for possible future implementation in order to further reduce plant risk. Such a commitment to perform a further evaluation is not a condition of granting a renewed license. Accordingly, a license renewal applicant’s decision to defer this further evaluation of the potentially cost-beneficial SAMAs that it has identified to some point in the future (i.e., outside the license renewal SAMA review) is acceptable.

3.1 Review of Entergy’s Completed Engineering Project Cost Estimates for SAMAs Previously Identified as Potentially Cost Beneficial

3.1.1 Background

As required by 10 CFR 51.53(c)(3)(ii)(L), Entergy (2007a) performed and submitted the results of its SAMA analysis as part of its Environmental Report. Through the course of review by the NRC staff, and as a result of NRC staff questions, Entergy revised the SAMA analysis and ultimately found that 22 SAMAs were potentially cost beneficial (Entergy 2009b). For these SAMAs, Entergy stated that it submitted the potentially cost-beneficial SAMAs for engineering project cost-benefit analysis (Entergy 2007a, 2009b).

In the 2010 FSEIS (NRC 2010), the NRC staff found that the methods used by Entergy for the evaluation of the SAMAs were sound and that “the treatment of SAMA benefits and costs support the general conclusion that the SAMA evaluations performed by Entergy are reasonable and sufficient for the license renewal submittal.” In addition, the NRC staff agreed that further evaluation of the cost-beneficial SAMAs by Entergy was appropriate. However, the NRC staff stated that the cost-beneficial SAMAs do not relate to adequately managing the effects of aging during the period of extended operation and, therefore, do not need to be implemented as part of license renewal.

The State of New York filed several contentions regarding the license renewal application, including NYS–35, which contended that Entergy’s SAMA cost-benefit analysis was incomplete, and NYS–36, which contended that the NRC staff either requires implementation of cost-beneficial SAMAs before issuing a renewed license or provides its rationale for not requiring their implementation.

In June 2010, the Atomic Safety and Licensing Board (ASLB) issued Order LBP-10-13 granting admission of NYS-35 and consolidating it with NYS-36 (ASLB 2010). In its decision, the ASLB noted the following:

The NRC Staff's obligation regarding SAMAs under NEPA and Part 51 is met by taking a hard look at those SAMAs identified as potentially cost-beneficial. While the only SAMAs that an applicant must implement as part of a license renewal safety review are those dealing with aging management, an order by the NRC Staff to implement SAMAs not dealing with aging management can be issued concurrently as part of a Part 50 CLB review. Consistent with the mandate of the Administrative Procedure Act (APA) and NEPA, if properly carried out, the NRC Staff's hard look analysis of all potentially cost-beneficial SAMAs under NEPA and Part 51 (not just those that are aging-related) ensures that it has given proper consideration to all relevant factors in granting a license renewal.

In January 2011, the State of New York filed a motion for summary disposition, requesting that the ASLB deny Entergy's application for a renewed license because both Entergy's and the NRC staff's analyses of cost-beneficial SAMAs were not adequate.

In July 2011, the ASLB granted New York State's motion for summary disposition (and denied Entergy's and the NRC's motions) regarding contention NYS-35/36 (ASLB 2011) ordering the following:

Entergy's licenses cannot be renewed unless and until the NRC Staff reviews Entergy's completed SAMA analyses and either incorporates the result of these reviews into the FSEIS or, in the alternative, modifies the FSEIS to provide a valid reason for recommending the renewal of the licenses before the analysis of potentially cost-effective SAMAs is complete and for not requiring the implementation of cost-beneficial SAMAs.

Entergy appealed the ASLB's decision to the Commission; however, in December 2011, the Commission found that the appeal was interlocutory and that the required standards for interlocutory appeals had not been satisfied (NRC 2011). The Commission noted the following:

NEPA is a procedural statute—although it requires a “hard look” at mitigation measures, it does not, in and of itself, provide the statutory basis for their implementation. In granting New York's motion for summary disposition of Contention NYS-35/36, the Board was careful not to *require* that the Staff impose the cost-beneficial SAMAs as a condition on the renewal of Entergy's licenses. Rather, it provided the Staff with an option to *explain* further its reasoning for not requiring implementation of cost-beneficial SAMAs in the context of this license renewal review. To the extent the Board would have the Staff elaborate on its analysis, the Board's decision, in our view, does not appear patently unreasonable.

In a letter dated May 6, 2013, Entergy Nuclear Operations, Inc. (Entergy) submitted revised cost estimates for SAMAs previously identified as potentially cost beneficial (Entergy 2013b). Based on the refined cost estimates, Entergy determined that 6 of the 22 SAMAs previously determined to be potentially cost beneficial would no longer be cost beneficial. These SAMAs for Indian Point Nuclear Generating Unit Nos. 2 and 3 (IP2 and IP3) are identified as IP2-021, IP2-022, IP2-053, IP2-056, IP3-018, and IP3-019. In addition to providing refined cost

estimates, Entergy stated that it has elected to voluntarily implement 4 of the cost-beneficial SAMAs but to defer implementation of the remaining 12 cost-beneficial SAMAs until resolution of certain issues, such as actions required in response to NRC Order EA-12-049, “Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events.”

Entergy did not adjust the benefit for the remaining potentially cost-beneficial SAMAs to account for implementation or planned implementation of the four cost-beneficial SAMAs. As noted in its letter, Entergy stated that “certain SAMA candidates are acting on the same accident sequences. Therefore, as certain SAMAs (or post-Fukushima Dai-ichi actions) mitigating the dominant accident sequences are implemented, the baseline risk, as calculated, is reduced. This reduces the likelihood that other SAMA candidates acting on the same accident sequences will remain potentially cost-beneficial” (Entergy 2013b).

By letter dated November 22, 2013, the NRC staff requested that Entergy provide additional detailed information describing the revised engineering project cost estimates (NRC 2013c). By letter dated January 2, 2014, Entergy provided detailed engineering project cost estimates for each of the 22 previously identified, potentially cost-beneficial SAMAs (Entergy 2014a).

In June 2016, the Commission issued a decision overturning the ASLB’s decision regarding Contention NYS–35/36 (NRC 2016c). In overturning the summary disposition decision, the Commission stated (83 NRC at 517):

In sum, the Staff’s SAMA analysis conclusions for Indian Point were not deficient as a matter of law. The Staff provided sufficient grounds for why in this license renewal proceeding it will not impose SAMA implementation requirements.

In its decision, the Commission directed the NRC license renewal staff to refer the pending potentially cost-beneficial SAMAs to the appropriate staff within the Office of Nuclear Reactor Regulation (NRR) for review and disposition, as appropriate, in the context of current plant operations. The NRC staff has referred those SAMAs to the appropriate staff in NRR, as directed by the Commission.

3.1.2 Entergy’s Completed Engineering Project Cost Estimates

As a result of its SAMA analysis, which the NRC staff found acceptable in the 2010 FSEIS, Entergy found that 22 SAMAs would be potentially cost beneficial (Entergy 2009b). For each of these SAMAs, Entergy provided a detailed project cost estimate (Entergy 2014a). The estimates include a description of the proposed modification, along with a preliminary materials list, an impact screening summary, conceptual design sketches (if applicable), and a cost estimate. The cost estimate includes a summary of the assumptions, a cost estimate summary, and a detailed implementation estimate worksheet. Entergy compared the refined engineering project cost estimates to the benefits previously calculated for the SAMAs identified in 2009 as being potentially cost beneficial (Entergy 2009b, 2013b).

Entergy’s refined cost estimates include, as applicable, costs associated with the following:

- Entergy engineering support, including study, design, and project management;
- contract engineering support, including field engineers and planners;
- materials and equipment;
- plant craft labor;

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- other Entergy support, including quality control (QC), training, and operations department; and
- other contract support, including security, health physics, and radwaste processing and storage.

Entergy stated that the cost estimates are based on 2012 craft labor billing rates at IP2 and IP3 and are projected to 2014 by increasing the rates 3 percent per year (Entergy 2013b). However, in a letter dated November 20, 2014, Entergy clarified that the craft labor billing rates are from 2010 (Entergy 2014j). In addition, the estimates incorporate a site encumbrance premium (i.e., 20 percent) to reflect NRC-imposed site access restrictions, some of which were not in effect when the initial conceptual cost estimates were prepared (Entergy 2013b). In addition, each cost estimate incorporates project contingencies (i.e., 20, 30, 40, or 50 percent) to reflect the location and complexity of the work and consistency with guidance from the Association for Advancement for Cost Engineering International (AACE) (Entergy 2013b). Lastly, the cost estimates include “loaders” of 30 percent, as explained below (Entergy 2014a).

3.1.3 Review of Entergy’s Refined Cost Estimates

The NRC staff reviewed the description of each proposed modification and compared it against the conceptual design sketches provided. The NRC staff confirmed that the cost estimates included costs for design, implementation, and materials appropriate for the design modification. The NRC staff then verified the reasonableness of the costs for materials by contacting several manufacturers or vendors noted in the literature provided by Entergy.

The NRC staff reviewed the assumptions listed in the Implementation Estimate and compared those assumptions with costs stated in the Implementation Estimate Work Sheet to see if there were any discrepancies. For example, an assumption might be that training will be provided for 12 operations personnel. The NRC staff then reviewed the cost in the Implementation Estimate Work Sheet to confirm that a cost for training of 12 operations personnel was included.

The NRC staff reviewed all line items in the Implementation Estimate Work Sheet that Entergy provided to determine whether the description, level of effort, and cost for each activity of the proposed modification were reasonable. The staff compared similar activities from one proposed modification to those in a similar modification. For example, if the modification included installation of a concrete slab, the NRC staff confirmed that the labor, hours, and materials needed to install a concrete slab in one modification were similar to the labor, hours, and materials needed to install a concrete slab in another modification. In addition, the NRC staff compared assumptions, labor hours, labor rates, and material costs across the proposed modifications and noted any discrepancies.

During its review of the refined cost estimates, the NRC staff noted some discrepancies or found that some practices were not explained or described in detail in the supporting documentation. In most instances, correction, inclusion, or exclusion of a particular cost did not alter Entergy’s conclusion about whether a SAMA is or is not potentially cost beneficial. However, when the missing or unexplained information was generic in nature or affected multiple SAMAs, the NRC staff requested additional information. The staff’s requests, and Entergy’s responses, are discussed below.

In its letter dated May 6, 2013, Entergy explained that the refined cost estimates “incorporate a site encumbrance premium to reflect NRC-imposed site access restrictions, including security and personnel access training and controls, some of which were not in effect when the initial conceptual cost estimates were prepared.” Entergy added a site encumbrance of 20 percent to the subtotal for each SAMA (Entergy 2013b). However, it did not provide the basis for the value

used as the site encumbrance premium. The NRC staff also noticed that Entergy added the premium to the materials. Therefore, by letter dated October 6, 2014, the NRC staff issued a request for additional information (RAI) requesting that Entergy provide the basis for the value used for the site encumbrance premium and that it explain why it was levied against all aspects of the modification (NRC 2014h).

In its response dated November 20, 2014, Entergy explained that site encumbrance premium represents the percentage increase over the normal time required to perform the work associated with a plant modification if the work was performed in a non-nuclear facility (Entergy 2014j). The value is based on site-specific and industry experience and is similar to the term “productivity/difficulty factor” that is used in Entergy fleet administrative procedures to improve the accuracy of the cost estimate based on the location of the work being performed. Entergy also explained that the encumbrance premium is applied to all aspects of the SAMA modification because site constraints affect all aspects of work performed within the Owner-Controlled Area, such as transporting the materials through security checkpoints, receiving them in the warehouse, moving the materials through security fencing into the protected area and then possibly into a vital area within the protected area.

The NRC staff reviewed Entergy’s response and has determined that the application of encumbrance premium for the purpose of accounting for site access restrictions is reasonable. Entergy is required to have a physical security plan in place, including Owner-Controlled Area searches and personnel access authorization requirements. Because all the proposed modifications affect systems or structures within the Owner-Controlled Area, all persons performing work on, or delivering materials to, the site must go through various personnel access controls or vehicle searches. The inclusion of a cost factor to account for the additional burden associated with granting access to a licensed nuclear power plant versus a non-nuclear facility is reasonable.

In each of the refined cost estimates, provided by letter dated January 2, 2014, Entergy applied “loaders” of 30 percent (Entergy 2014a). The “loaders” were applied to the total after the contingency and site encumbrance premium were applied. However, Entergy did not provide an explanation for what is included in the “loaders,” nor did it provide a basis for the value. Therefore, by letter dated October 6, 2014, the NRC staff issued an RAI requesting that Entergy explain what the term “loaders” includes and that it provide the basis for the value used (NRC 2014h).

In its response dated November 20, 2014, Entergy explained that the 30-percent loader applied to the refined SAMA cost estimates accounts for the total sum of the estimated overhead costs for material loaders, capital suspense, and applied interest allowance for funds used during construction (Entergy 2014j). It also stated that the site finance department determined the specific value and that its fleet administrative procedures for project cost estimating specify that estimates for capital projects should include applicable loaders. The NRC staff reviewed Entergy’s response and finds that inclusion of a loader is reasonable because this is a standard practice for Entergy plants that involve capital expenditures.

As noted in the individual Implementation Estimate Work Sheet for each SAMA (Entergy 2014a), Entergy applied a factor of 1.7 to the labor rates for work conducted during outages, but an explanation was not provided. Therefore, by letter dated October 6, 2014, the NRC staff issued an RAI requesting that Entergy provide a brief explanation of the use of this factor and the basis for the value used (NRC 2014h). In its response, dated November 20, 2014, Entergy explained that the factor of 1.7 is a factor applied to craft labor hours associated with the installation phase of the modification for the SAMAs requiring outage work in the reactor containment building to account for time and productivity losses associated

with the difficulty of working in the highly restricted containment area (Entergy 2014j). Entergy further explained that its cost-estimating template provides a table for the unit rate adjustments/difficulty factors for use during the estimating phase of the modification and that this table specifies a factor of 1.7 as a multiplier to use when performing work in the reactor containment building. The NRC staff reviewed Entergy’s response and finds that inclusion of a factor applied to craft labor hours for installation inside containment is reasonable. The NRC staff acknowledges that work performed inside containment, particularly modifications, can be difficult due to space limitations, environmental conditions, and radiation hazards. Therefore, the NRC staff concludes that it is reasonable to account for productivity losses associated with such constraints.

During its review of the cost estimates in the Implementation Estimate Work Sheet for the 22 SAMAs, the NRC staff noted that Entergy used various labor rates for the same labor category, but it did not provide an explanation for the labor categories. Because the NRC staff could not readily determine why different labor rates were used for the same labor category, it issued an RAI requesting an explanation of the differences in the labor rates used for the same labor category (NRC 2014h). In its response, Entergy made corrections to the labor categories and provided revised, corrected SAMA cost estimates (Entergy 2014j). Entergy stated that the percent changes in the cost estimates were small and ranged from a decrease of 1.44 percent to an increase of 3.90 percent; however, the revised cost estimates did not change its conclusions in its May 6, 2013 (Entergy 2013b) letter regarding the economic feasibility of the 22 SAMAs. The NRC staff reviewed Entergy’s response and finds that it is acceptable because Entergy provided corrected labor rates inflated to 2014 and revised corrected SAMA cost estimates (see Table 3–1).

The table below contains a summary of the 22 previously identified, potentially cost-beneficial SAMAs; the estimated benefit with uncertainty; the previous estimated cost; and the refined cost estimate.

Table 3–1. Summary of Refined and Corrected Cost Estimates for 22 SAMAs

SAMAs Previously Determined To Be Cost Beneficial	Benefit with Uncertainty	Estimated Cost (2009)	Refined Estimated Cost (2013)	Corrected Estimated Cost (2014)
IP2-009 – Create a reactor cavity flooding system – Deferred	\$13,363,217	\$4,100,000	\$1,738,982	\$1,741,724
IP2-021 – Install additional pressure or leak monitoring instrumentation for interfacing-systems loss of coolant accidents (ISLOCAs)	\$4,408,109	\$3,200,000	\$4,607,051	\$4,632,227
IP2-022 – Add redundant and diverse limit switches to each containment isolation valve	\$2,255,716	\$2,200,000	\$7,685,460	\$7,692,784
IP2-028 – Provide a portable diesel-driven battery charger	\$2,856,939	\$938,000	\$2,137,804	\$2,154,767
IP2-044 – Use fire water system as backup for steam generator inventory	\$4,948,485	\$1,656,000	\$3,046,418	\$3,073,130
IP2-053 – Keep both pressurizer power-operated relief valve (PORV) block valves open	\$1,388,873	\$800,000	\$1,467,848	\$1,471,234
IP2-054 – Install flood alarm in the 480 VAC switchgear room	\$11,772,170	\$200,000	\$456,985	\$458,843

SAMAs Previously Determined To Be Cost Beneficial	Benefit with Uncertainty	Estimated Cost (2009)	Refined Estimated Cost (2013)	Corrected Estimated Cost (2014)
IP2-056 – Keep residual heat removal (RHR) heat exchanger discharge motor operated valves (MOVs) normally open	\$102,574	\$82,000	\$1,705,367	\$1,704,938
IP2-060 – Provide added protection against flood propagation from stairwell 4 into the 480 VAC switchgear room	\$2,684,920	\$216,000	\$715,145	\$721,303
IP2-061 – Provide added protection against flood propagation from the deluge room into the 480 VAC switchgear room	\$5,799,982	\$192,000	\$933,981	\$943,792
IP2-062 – Provide a hard-wired connection to a safety injection (SI) pump from alternate safe shutdown system (ASSS) power supply	\$1,789,822	\$1,500,000	\$1,624,840	\$1,662,692
IP2-065 – Upgrade the ASSS to allow timely restoration of seal injection and cooling	\$11,772,170	\$560,000	\$1,789,771	\$1,859,587
IP2-GAG – Steam Generator safety gagging device (To be Implemented)	\$13,000,000	\$50,000	\$458,617	\$453,745
IP3-007 – Create a reactor cavity flooding system	\$7,301,552	\$4,100,000	\$1,869,811	\$1,874,933
IP3-018 – Route the discharge from the main steam safety valves through a structure where a water spray would condense the steam and remove most of the fission products	\$14,637,545	\$12,000,000	\$35,676,701	\$35,691,159
IP3-019 – Install additional pressure or leak monitoring instrumentation for ISLOCAs	\$3,082,120	\$2,800,000	\$6,462,470	\$6,369,223
IP3-052 – Open city water supply valve for alternative AFW pump suction (Implemented)	\$361,446	\$50,000	\$138,378	\$138,378
IP3-053 – Install an excess flow valve to reduce the risk associated with hydrogen explosions (To be Implemented)	\$722,892	\$228,000	\$340,790	\$344,599
IP3-055 – Provide hard-wired connection to an SI or RHR pump from the Appendix R bus (MCC 312A)	\$5,903,118	\$1,288,000	\$1,589,189	\$1,601,888
IP3-061 – Upgrade the ASSS to allow timely restoration of seal injection and cooling	\$6,317,929	\$560,000	\$2,258,137	\$2,282,668
IP3-062 – Install flood alarm in the 480 VAC switchgear room	\$6,317,929	\$196,800	\$494,175	\$496,071

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SAMAs Previously Determined To Be Cost Beneficial	Benefit with Uncertainty	Estimated Cost (2009)	Refined Estimated Cost (2013)	Corrected Estimated Cost (2014)
IP3-GAG – Steam Generator safety gagging device (To be Implemented)	\$19,000,000	\$50,000	\$458,617	\$453,745

Sources: Entergy 2013b, 2014j; NRC 2010

As indicated in its cost estimates and in its response to an NRC staff RAI, Entergy used all-inclusive man-hour contractor billing rates, which include factors such as overhead, general and administrative costs, and profit. The NRC staff finds that the use of actual billed labor rates as inflated, for cost-estimating purposes, is a reasonable approach because the rates are known labor rates and they represent what will likely be charged for a future modification.

Entergy stated that it inflated the 2012 billed craft labor rates by 3 percent per year to 2014 (Entergy 2014a). According to the Bureau of Labor and Statistics (BLS), compensation costs for private industry workers increased 2.3 percent over the year, and wages and salaries increased 2.3 percent for the current 12-month period ending September 2014 (BLS 2014). Although a 3-percent increase in labor rates is slightly higher than the current rate at which compensation costs and wages rose, the NRC staff does not believe that its use is unreasonable for the purposes of estimating costs for SAMAs. The use of a lower inflation factor would result in insignificant changes to the cost estimates and would not alter Entergy's conclusions about the economic feasibility of the SAMAs.

In the Implementation Estimate Work Sheets for the 22 refined cost estimates, Entergy provided hourly rates for various activities conducted by Entergy plant personnel; however, the basis for these rates was not provided, nor did Entergy indicate for which year the labor rates were given. Therefore, by letter dated October 6, 2014, the NRC staff issued an RAI requesting that Entergy explain the basis for these hourly rates, what costs are included in the rates, and in terms of year, on which year the rates are based (NRC 2014h).

In its response, dated November 20, 2014, Entergy explained that to allow flexibility to either subcontract the tasks to an engineering firm or perform the tasks using in-house engineering resources, it used contract engineering rates, which bound in-house engineering personnel rates (Entergy 2014j). Entergy also stated that the rates, which are all-inclusive man-hour billing rates, are based on 2012 and were not inflated to 2014 dollars. Entergy further stated that the rates do not include contingencies and Entergy loaders, which are applied above these values. Lastly, Entergy clarified that the quality assurance (QA) and health physics personnel rates should be \$100 per hour, not \$80 per hour, to reflect the assumption that it would subcontract the necessary QA and health physics tasks to a qualified outside firm. The revised cost estimates, as shown in Table 3–1, include this correction (Entergy 2014j). The staff reviewed Entergy's response and finds that the rates used for activities presumably performed by Entergy plant personnel are reasonable. The rates were based on contractor engineering rates and bound Entergy's engineering rates.

As noted in the Impact Screening Summary for several of the SAMAs (e.g., IP2-021, IP2-022, IP2-028, IP2-044), Entergy checked the Nuclear Analysis item as "YES," indicating that the proposed modification involves changes to plant evaluations, technical specifications, the Technical Requirements Manual, or a full 10 CFR 50.59 evaluation. However, for these noted SAMAs, Entergy did not include a cost for this activity. By comparison, for SAMA IP2-009, Entergy checked the Nuclear Analysis item as "YES" and included a cost of \$81,000 (675 hours) for "Tech Specs/FSAR, Analysis Calcs [calculations]." The NRC staff further

noticed that for other SAMAs (e.g., IP-054 and IP2-061), an assumption on the Implementation Estimate states that the estimate does not include funding for unreviewed safety questions or NRC submittals, but if required, the additional cost will be added. Because the same apparent activity was treated differently among the SAMAs, the NRC staff issued an RAI requesting Entergy to explain why this activity/task was treated differently for the SAMAs and to indicate whether a cost for such an evaluation should have been included (NRC 2014h).

Entergy explained that although the “Nuclear Analysis” box was checked “YES” for the SAMAs noted in the RAI, the evaluations are not expected to require significant Entergy resources or regulatory agency review; therefore, they do not have an associated cost for this activity (Entergy 2014j). Entergy further explained that, in contrast, significant evaluations would be required for SAMA IP2-009; therefore, a cost of \$81,000 was included. Lastly, Entergy explained that it did not need to change any cost estimates to address the NRC staff’s issue. The NRC staff reviewed Entergy’s response and finds that its explanation for exclusion of costs for nuclear analyses is sufficient and agrees that inclusion of costs deemed to be insignificant at this stage of the cost estimating is unnecessary.

Similar to the issue described above, for several of the SAMAs (e.g., IP2-028, IP2-053, IP2-062), on the Impact Screening Summary, Entergy checked the Simulator Impact item as “YES,” indicating that the proposed modification impacts or involves changes to the simulator. However, for these SAMAs, Entergy did not include a cost for this activity. In comparison, for SAMAs IP2-054, IP2-056, IP2-060, IP2-061, and IP3-062, the Simulator Impact item is checked “YES,” and a cost was included for “Simulator Changes.” Because the same apparent activity was treated differently among the SAMAs, the NRC staff issued an RAI requesting Entergy to explain why this activity/task was treated differently for the SAMAs and to indicate whether a cost for such an evaluation should have been included (NRC 2014h).

Entergy explained that for SAMAs, such as IP2-028, IP2-053, and IP2-062, for which only an operating procedure is affected, no additional costs for simulator changes were included. However, costs were included for simulator procedure changes under the “OPS/OPS Support” line item (Entergy 2014j). Although not indicated by Entergy in its response, the NRC staff notes that Entergy did not alter any cost estimates as a result of its review and response. The NRC staff reviewed Entergy’s response and finds that it is acceptable because costs for changes to the simulator were appropriately included when necessary, and changes to procedures for the simulator were included when appropriate.

3.1.3.1 NRC Staff’s Review of Six SAMAs Identified as Not Cost Beneficial as a Result of Refined Cost Estimations

In its letter dated May 6, 2013, Entergy stated that as a result of the refined cost estimation, it determined that six of the 22 SAMAs previously identified as potentially cost beneficial are no longer cost beneficial. These SAMAs are IP2-021, IP2-022, IP2-053, IP2-056, IP3-018, and IP3-019 (Entergy 2013b). These determinations did not change as a result of Entergy’s corrections to costs in response to the NRC staff’s RAIs, as discussed earlier.

Because Entergy’s conclusion on the economic feasibility of these SAMAs changed from its conclusion in 2009, the NRC staff’s review of these six SAMAs is described below. A brief description of the proposed modification is given followed by the NRC staff’s observations about various aspects of the cost estimate that appeared to be errors, overestimations, or that could not be readily understood. The NRC staff focused on these aspects because it believed they could potentially alter the estimated cost of the modification.

SAMA IP2-021

This modification involves the installation of pressure transmitters at nine interfacing-systems loss-of-coolant accident (ISLOCA) paths to measure pressure changes within an isolation boundary and to transmit the information to a location outside containment for remote display and monitoring (Entergy 2013b). The original cost estimate was \$3.2 million (Entergy 2009b). The refined cost estimate is \$4.63 million, which exceeds the estimated benefit with uncertainty of \$4.4 million by \$224,000 (Entergy 2014j).

NRC Staff Observations:

- On the Implementation Estimate Work Sheet for the QA/QC verification item, a cost of \$15,000 is listed, but there is also a cost of \$15,000 for a subcontractor. It is not clear what this additional \$15,000 subcontractor cost is for. The similar SAMA for IP3 (IP3-019) does not include an additional subcontractor cost.
- On page 1 of the Implementation Estimate Work Sheet, Item 1 of the non-outage work appears to be a labor-only item, with the cost being \$2,466. However, a cost of \$2,466 is also included as a material cost. In comparison, for SAMA IP2-009, the same item (“Gather material and stage tools and materials”) is only a labor cost; there is no materials cost for that line item.
- For the fire watch (during the outage), the FCTR (factor) is only 1.0, not 1.7. Because the work is being performed inside containment, a factor of 1.7 should have been used.

For these items, the NRC staff determined that, even if the cost estimate was decreased to remove the costs in the first two items or increased to reflect the factor of 1.7 for the fire watch in containment, the total cost would still be higher than the estimated benefit. However, as discussed in Section 3.1.3.4, there is uncertainty in the cost estimates; therefore, the NRC staff recommends that Entergy retain this SAMA for further consideration.

SAMA IP2-022

This modification involves the installation of limit switches to monitor the position of 22 check valves and 2 motor-operated valves within containment associated with an ISLOCA and to transmit information on valve position to a remote location outside containment. Entergy determined that a retrofit of the valves to accommodate the switches would be very difficult; therefore, the modification includes new valves (Entergy 2013b). The original cost estimate was \$2.2 million (Entergy 2009b). The refined cost estimate is \$7.69 million, which exceeds the estimated benefit with uncertainty of \$2.26 million by \$5.44 million (Entergy 2014j).

NRC Staff Observations:

- For qualification testing of the valve, the largest and more costly valve is used.
- A cost range for the valves was given; however, in the cost estimate, the highest cost for each valve is used.
- On the Implementation Estimate, Item 2 assumes that non-outage work will occur in 2011, yet the labor rates for the non-outage work are presumably for 2014 because the labor rates are not different from those used for outage work, which is assumed to occur in 2014.
- There are hourly charges for nondestructive evaluation profile of the welds for the valves; however, there is also a subcontractor charge for nondestructive evaluation of \$70,000.

For these items, the NRC staff determined that, even if the cost estimate was decreased to reflect testing of a smaller and less costly valve, the lower price in the cost range for the valves was used, the labor rates were reduced by 3 percent per year to 2011, and the subcontractor charge of \$70,000 was eliminated, the total cost would still be higher than the estimated benefit and would not alter Entergy's conclusion about the economic feasibility of the proposed modification.

SAMA IP2-053

As described in Entergy's May 6, 2013, letter, this SAMA undoes a previous modification to two pressurizer power-operated relief valve (PORV) block valves. The control circuit of the two PORV block valves will be modified to keep the valves open during normal plant operations. Previously, a modification was made that installed an interlock in each PORV block valve's control circuit to keep it closed during normal operations. The modification will require a new 10 CFR Part 50, Appendix R (fire protection), compliance analysis (Entergy 2013b). The original cost estimate was \$800,000 (Entergy 2009b). The refined cost estimate is \$1.47 million, which exceeds the estimated benefit with uncertainty of \$1.39 million by \$82,000 (Entergy 2013b).

NRC Staff Observations:

- Item 7 of the Implementation Estimate assumes that a 10 CFR Part 50, Appendix R, evaluation will cost \$250,000 and will be performed by a contract person; however, in response to RAI 5I (Entergy 2008a), although Entergy acknowledged that a change to the fire protection program would be needed, it did not initially include \$250,000 for the evaluation.
- 1,700 hours of contractor design support are estimated. This seems high for what appears to be a relatively straightforward design (i.e., undo the previous modification).

The NRC staff acknowledges that any changes to a 10 CFR Part 50, Appendix R, fire protection program require evaluation; therefore, the staff does not disagree that a cost for an evaluation should be included. The NRC staff notes that for a SAMA for IP3 (SAMA IP3-053), which also involves a 10 CFR Part 50, Appendix R, evaluation, Entergy proposed the same cost of \$250,000 for the evaluation. As an aside, the NRC staff notes that, even though Entergy stated in the assumptions for IP3-053 that a cost of \$250,000 is included for the 10 CFR Part 50, Appendix R, evaluation, the actual cost estimate did not include the \$250,000 cost (Entergy 2014a).

With regard to the seemingly large contractor design support effort to "un-install the modification" and "restore the original design" (Entergy 2014a), the NRC staff notes that contractor design support efforts for other proposed modifications that are "new" are on the order of 1,000 to 1,700 hours and that several are even less. A reduction in the contractor design support effort of 325 hours would reduce the total cost estimate to a value that would make the modification potentially cost beneficial.

As discussed in Section 3.1.3.4, there is uncertainty in the cost estimates; therefore, the staff recommends that Entergy retain this SAMA for further consideration.

SAMA IP2-056

This modification previously considered changes to plant procedures and required analytical confirmation to maintain two residual heat removal (RHR) heat exchanger discharge valves, which are normally open during normal plant operations (Entergy 2013b). Entergy subsequently determined that this change could not be implemented with the current system configuration

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without increasing the potential over-pressurization risk to the RHR heat exchangers and piping. Therefore, additional RHR system pressure relief valves are required (Entergy 2013b). The original cost estimate for SAMA IP2-056 was \$82,000 (Entergy 2009b). The refined cost estimate is \$1.7 million, which exceeds the estimated benefit with uncertainty of \$103,000 by \$1.6 million (Entergy 2013b).

NRC Staff Observations:

- On the Implementation Estimate, Items 2 and 3 assume that the non-outage and outage work will be completed in 2012. However, the labor rates are presumably for 2014 because the labor rates used are not different from those used for other SAMAs for which work was assumed to be conducted during 2014.
- A cost for a decontamination contractor (\$10,000) has been included; however, a cost for radwaste has not been included. Although it is not clear whether radioactive waste will be generated as part of this modification, it is also not clear why a decontamination contractor is needed for this modification. The NRC staff notes that a decontamination contractor is proposed only for this SAMA and SAMA IP2-022, which does involve the replacement of existing valves.

For these items, the NRC staff determined that even if the cost estimate was decreased to reflect labor rates in 2012 and to remove the decontamination contractor cost of \$10,000, the total cost would still be higher than the estimated benefit and would not alter Entergy's conclusion about the economic feasibility of the proposed modification.

SAMA IP3-018

This modification involves the installation of a system or facility that captures the steam released from the main steam safety valves and that processes the steam to remove fission products (Entergy 2013b). There are a total of 20 main steam safety valves. The proposed modification consists of four large vessels (one for each main steam line), each enclosed in its own structure. Each vessel requires a piped water supply and pumps to spray the steam with water to condense the steam. Additional controls for maintaining the water level and its recirculation also would be needed, as well as electrical power for pumps, controls, heaters, and exhaust fans (Entergy 2013b). The original cost estimate was \$12 million (Entergy 2009b). The refined cost estimate is \$35.7 million, which exceeds the estimated benefit with uncertainty of \$14.6 million by \$21 million (Entergy 2013b).

This proposed modification is extensive, and the costs associated with it are large and most likely underestimated. Even with the uncertainty in the cost estimates, as discussed in Section 3.1.3.4, the NRC staff does not believe that Entergy's conclusion about the economic feasibility of this modification will be altered.

SAMA IP3-019

This modification involves the installation of pressure transmitters at 15 ISLOCA paths to measure pressure changes within an isolation boundary and to transmit the information to a location outside containment for remote display and monitoring (Entergy 2013b). The original cost estimate was \$2.8 million (Entergy 2009b). The refined cost estimate is \$6.4 million, which exceeds the estimated benefit with uncertainty of \$3.1 million by \$3.3 million (Entergy 2013b).

NRC Staff Observations:

- On the Implementation Estimate Work Sheet for QA/QC verification, a cost of \$15,000 is listed, but there is also a cost of \$15,000 for a subcontractor. It is not clear what this additional \$15,000 subcontractor cost is for.

- On page 1 of the Estimate Worksheet, Item 1 of the non-outage work appears to be a labor-only item, the cost being \$2,466. However, a cost of \$18,000 is also included as a material cost. For SAMA IP2-021, the material cost is \$2,466. It is not clear what comprises these material costs.
- There is not a materials cost for “testing,” but there is one in IP2-021, which is the similar SAMA for IP2.
- For the fire watch (during the outage), the FCTR is only 1.0, not 1.7. Because the work is being performed inside containment, a factor of 1.7 should have been used.

For these observations, the NRC staff determined that even if the cost estimate was decreased to remove the costs in the first two items or increased to reflect the factor of 1.7 for the fire watch in containment, the total cost would still be higher than the estimated benefit and would not alter Entergy’s conclusion about the economic feasibility of the proposed modification.

3.1.3.2 *The NRC Staff’s Review of 16 Potentially Cost-Beneficial SAMAs*

For the 16 SAMAs that Entergy identified as potentially cost beneficial, the NRC staff notes that only one, IP2-062, is slightly cost beneficial (i.e., cost beneficial by 10 percent). The remainder of the potentially cost-beneficial SAMAs are sufficiently cost beneficial such that most sensitivity studies would not render them not cost beneficial.

3.1.3.3 *Sensitivity Analysis*

Entergy stated that the cost estimates incorporate project contingencies consistent with AACE’s Recommended Practice (RP) No. 18R-97, “Cost Estimate Classification System – As Applied in Engineering, Procurement, and Constructions for the Process Industries” (Entergy 2013b). Entergy stated that although the AACE’s recommended practice applies to process industries, Entergy judged the cost-estimating principles in the guidance to be “reasonable and appropriate for estimating nuclear power plant engineering project costs” (Entergy 2014j).

AACE’s RP No. 18R-97 defines five classes of cost estimates—Class 1 through 5 (AACE 2005). Class 5, which is the least developed cost estimate, is described as generally being “prepared for any number of strategic business planning purposes, such as but not limited to market studies, assessment of initial viability, evaluation of alternate schemes, project screening, project location studies, evaluation of resource needs and budgeting, long-range capital planning,” and have a wide range in accuracy. Class 4 cost estimates are “prepared for a number of purposes, such as but not limited to, detailed strategic planning, business development, project screening at more developed stages, alternative scheme analysis, confirmation of economic and/or technical feasibility, and preliminary budget approval or approval to proceed to next stage,” and have fairly wide accuracy ranges. For the refined cost estimates, Entergy classified all of the estimates as either Class 4 or Class 5 (Entergy 2014a).

Figure 1 of RP No. 18R-97 entitled, “Cost Estimate Classification Matrix for Process Industries,” suggests that the expected accuracy range for a Class 5 cost estimate, after application of contingency, can be low by -20 percent to -50 percent and high by +30 percent to +100 percent. In addition, for a Class 4 estimate, the typical accuracy ranges are -15 percent to -30 percent on the low side, and +20 percent to +50 percent on the high side.

Using the information from RP No. 18R-97, the NRC staff performed a sensitivity analysis assuming the accuracy range for Class 5 cost estimates to determine whether the uncertainty in the cost estimates would affect the outcome of the SAMA. The NRC staff used the highest high value of 100 percent and the lowest low value of 20 percent. The NRC staff applied the values to the total cost to be consistent with the approach taken by Entergy and with the guidance in

Revised and Supplemental SAMA Analyses

RP No. 18R-97, which states that the accuracy range is determined after application of the contingency.

Below is a summary table of the cost estimates.

Table 3–2. Summary of the NRC Staff Sensitivity Analysis

SAMAs	Benefit with Uncertainty	Corrected Estimated Cost (2014)^(a)	Estimated Cost if Low by 20%	Estimated Cost if High by 100%
IP2 SAMAs				
IP2-009	\$13,363,217	\$1,741,724	\$2,090,069	\$870,862
IP2-021	\$4,408,109	\$4,632,227	\$5,558,672	\$2,316,114
IP2-022	\$2,255,716	\$7,692,784	\$9,231,341	\$3,846,392
IP2-028	\$2,856,939	\$2,154,767	\$2,585,720	\$1,077,384
IP2-044	\$4,948,485	\$3,073,130	\$3,687,756	\$1,536,565
IP2-053	\$1,388,873	\$1,471,234	\$1,765,481	\$735,617
IP2-054	\$11,772,170	\$458,843	\$550,612	\$229,422
IP2-056	\$102,574	\$1,704,938	\$2,045,926	\$852,469
IP2-060	\$2,684,920	\$721,303	\$865,564	\$360,652
IP2-061	\$5,799,982	\$943,792	\$1,132,550	\$471,896
IP2-062	\$1,789,822	\$1,662,692	\$1,995,230	\$831,346
IP2-065	\$11,772,170	\$1,859,587	\$2,231,504	\$929,794
IP2-GAG	\$13,000,000	\$453,745	\$544,494	\$226,873
IP3 SAMAs				
IP3-007	\$7,301,552	\$1,874,933	\$2,249,920	\$937,467
IP3-018	\$14,637,545	\$35,691,159	\$42,829,391	\$17,845,580
IP3-019	\$3,082,120	\$6,369,223	\$7,643,068	\$3,184,612
IP3-052	\$361,446	\$138,378	\$166,054	\$69,189
IP3-053	\$722,892	\$344,599	\$413,519	\$172,300
IP3-055	\$5,903,118	\$1,601,888	\$1,922,266	\$800,944
IP3-061	\$6,317,929	\$2,282,668	\$2,739,202	\$1,141,334
IP3-062	\$6,317,929	\$496,071	\$595,285	\$248,036
IP3-GAG	\$19,000,000	\$453,745	\$544,494	\$226,873

^(a) Source: Entergy 2014j

As can be seen from Table 3–2, if the cost estimates are high by as much as 100 percent, then SAMAs IP2-021 and IP2-053 would become potentially cost beneficial. Similarly, if the cost estimates are low by as little as 20 percent, then SAMA IP2-062 would no longer be potentially cost beneficial. The economic feasibility of no other SAMAs was affected by the sensitivity analysis.

The NRC staff performed other sensitivity analyses, such as eliminating the site encumbrance premium. The results of those sensitivity analyses are the same as the one presented in Table 3–2 above—the economic feasibility of SAMAs IP2-021, IP2-053, and IP2-062 are the only SAMAs affected.

3.1.3.4 Conclusion of the NRC Staff’s Review of Entergy’s Refined Cost Estimates

Entergy developed a conceptual design and implementation cost estimates in accordance with its accepted design engineering practices. The cost estimates were based on actual billed labor rates adjusted to 2014 dollars. Entergy applied certain cost factors to account for NRC-imposed site access restrictions and overhead costs consistent with its fleet administrative procedures for project cost estimations. Additionally, Entergy included project contingencies consistent with ACEC guidance. In response to an NRC staff RAI, Entergy corrected the refined cost estimates. These corrections did not alter Entergy’s conclusion about the economic feasibility of the proposed modifications. The NRC staff finds Entergy’s use of ACEC Class 4 and Class 5 cost estimates, which are commonly used for project planning and viability screening, appropriate for the use in a SAMA cost-benefit analysis. Further, based on its review of the refined cost estimates, the NRC staff believes that the approach used and the costs provided are reasonable.

Based on the refined cost estimates, Entergy determined that 6 of the 22 SAMAs are no longer cost beneficial—SAMAs IP2-021, IP2-022, IP2-053, IP2-056, IP3-018, and IP3-019. The NRC staff reviewed these six SAMAs and identified some minor discrepancies or unexplained costs. However, the inclusion or exclusion of these costs would not alter Entergy’s conclusion about the economic feasibility of the proposed modifications.

Notwithstanding the reasonableness of Entergy’s cost estimates, the NRC staff believes that for two of the SAMAs that have been identified as no longer cost beneficial (IP2-021 and IP2-053), the incremental difference by which the SAMAs are not cost beneficial, when viewed in the context of uncertainties in the cost estimates, is too small to exclude them from further consideration. In this regard, the corrected refined estimated cost for SAMA IP2-021 is approximately \$4.63 million. When compared to the benefit with uncertainty of \$4.41 million, the SAMA is not cost beneficial by approximately \$224,000, which represents less than a 5-percent difference. The corrected refined cost estimate for SAMA IP2-053 is approximately \$1.47 million. When compared to the benefit with uncertainty of \$1.39 million, the SAMA is not cost beneficial by approximately \$82,000, which represents less than a 6-percent difference.

Even a Class 2 estimate, which ACEC describes as a detailed estimate used to monitor project costs, can be high by as much as 20 percent or low by as much as 15 percent. Based on the uncertainty inherent in cost estimating, the NRC staff recommends that Entergy retain SAMAs IP2-021 and IP2-053 for further consideration.

3.1.4 Review of Entergy’s Deferral of Certain Cost-Beneficial SAMAs Pending Implementation of Fukushima Dai-ichi Action Items

The NRC is conducting a comprehensive safety review of requirements and guidance associated with severe accident mitigation measures for all power reactors. On March 12, 2012, the NRC issued Order EA-12-049, “Order to Modify Licenses with Regard to

Requirements for Mitigation Strategies for Beyond-Design Basis External Events” (NRC 2012b). That Order applies to all power reactors and requires additional measures and strategies by licensees to increase the capability to mitigate certain beyond-design-basis events to assure adequate protection of public health and safety, including during extended loss of alternating current power events. The required strategies include additional ways to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities.

As noted by Entergy, certain NRC-mandated actions, as well as the nuclear power industry’s initiatives to address the challenges faced at Fukushima Dai-ichi, are likely to have an impact on certain SAMA candidates previously found to be potentially cost beneficial. For instance, Nuclear Energy Institute (NEI) report 12-06, “Diverse and Flexible Coping Strategies (FLEX) Implementation Guide,” identifies upgrading to low leak reactor coolant pump seals as a method to improve reactor coolant system inventory control (NEI 2012). Such an upgrade may address SAMAs IP2-065 and IP3-061 to upgrade the alternate safe shutdown system to allow timely restoration of seal injection and cooling. Therefore, Entergy states, and the NRC staff agrees, that any potential accident mitigation improvement achieved by these SAMAs may be addressed, at least in part, through the NRC’s generic process reviewing all plants’ current licensing bases regarding their ability to deal with beyond-design-basis events.

As identified by Entergy, other SAMAs potentially affected by ongoing Fukushima Dai-ichi action items include IP2-009 and IP3-007 to create a reactor cavity flooding system, IP2-028 to provide a portable diesel-driven battery charger, and IP2-044 to use the fire water system as backup to maintain steam generator inventory. These SAMAs involve actions to maintain reactor core cooling and inventory, including during extended loss of alternating current power events. The NRC staff agrees with Entergy that deferring further consideration of these SAMAs is reasonable to avoid redundancies that could arise between implementation of Order EA-12-049 and implementation of these SAMAs.

Entergy has implemented the following SAMAs that were determined to be potentially cost beneficial: (1) IP3-052 to open the city water supply valve for alternative auxiliary feedwater pump suction, (2) IP3-053 to install an excess flow valve to reduce the risk associated with hydrogen explosions, and (3) IP2 and IP3-GAG to install steam generator safety valve gagging devices.

In addition, Entergy asserts that the remaining six SAMAs determined to be potentially cost beneficial should be deferred because of the likelihood that the benefits associated with these SAMAs will be substantially reduced due to the risk reduction achieved by implementing SAMAs IP3-052, IP3-053, IP2-GAG, and IP3-GAG, as well as the plant improvements associated with completing the required actions to respond to Order EA-12-049. These six remaining potentially cost-beneficial SAMAs include IP2-054 to install a flood alarm in the 480-volt switchgear room, IP2-060 to provide added protection against flood propagation from stairwell 4 into the 480-volt switchgear room, IP-061 to provide added protection against flood propagation from the deluge room into the 480-volt switchgear room, IP2-062 to provide a hard-wired connection to a safety injection pump from the alternate safe shutdown system power supply, IP3-055 to provide a hard-wired connection to a safety injection or RHR pump from the 10 CFR Part 50, Appendix R, bus (MCC 312A), and IP3-062 to install a flood alarm in the 480-volt switchgear room.

The NRC staff notes that when any SAMA that was previously determined to be potentially cost beneficial is implemented, the risk profile from which the SAMA analysis is derived will necessarily change. Therefore, after the initial SAMA analysis is completed, decisions to implement potentially cost-beneficial SAMAs should be viewed as a dynamic process. In the case of Entergy’s SAMA process, the implementation of the four SAMAs mentioned and the

implementation of plant improvements associated with Order EA-12-049 will lower the plant's risk profile and, therefore, will tend to lower the benefits associated with the remaining six SAMAs previously determined to be potentially cost beneficial. Therefore, the NRC staff finds that Entergy's decision to defer actions related to the implementation of certain SAMAs until the risk profile for each plant is re-evaluated following the completion of both voluntary and required plant improvements designed to reduce the risk of a severe accident is reasonable.

3.1.5 Conclusions

The following discussion relates to the NRC staff's evaluation of Entergy's revised cost estimates as they compare to the benefit with uncertainty documented in the 2010 FSEIS.

The NRC staff has previously found Entergy's SAMA analysis to be reasonable, as described in Section G.7 of the 2010 FSEIS. In a letter dated May 6, 2013, Entergy submitted revised cost estimates for SAMAs that were previously identified as potentially cost beneficial (Entergy 2013b). Based on the refined cost estimates, Entergy determined that 6 of the 22 SAMAs previously determined to be potentially cost beneficial would no longer be cost beneficial. These SAMAs are identified as IP2-021, IP2-022, IP2-053, IP2-056, IP3-018, and IP3-019. The NRC staff reviewed Entergy's revised cost estimates and identified some minor discrepancies or unexplained costs. The NRC staff has concluded that, for two of the SAMAs that were identified as no longer being cost beneficial (IP2-021 and IP2-053), the incremental difference by which the SAMAs are not cost beneficial is too small to exclude them from further consideration.

In addition to providing refined cost estimates, Entergy's letter dated May 6, 2013, discussed the deferral of certain cost-beneficial SAMAs pending implementation of action items related to the NRC's comprehensive safety assessment in response to the events impacting Fukushima Da-ichi (Entergy 2013b). The NRC staff reviewed the assessment of Entergy's decision regarding deferring action for these SAMAs and concludes that it is reasonable to defer actions regarding SAMAs IP2-009, IP2-028, IP2-044, IP2-065, IP3-007, and IP3-061 because these SAMAs would act to reduce similar risks that are being addressed by NRC-issued Order EA-12-049 (NRC 2012b). In addition, the NRC staff agrees with Entergy that because of the dynamic nature of a SAMA analysis, it is reasonable to defer action on SAMAs IP2-054, IP2-060, IP2-061, IP2-062, IP3-055, and IP3-062 until the risk profile for each plant is re-evaluated following the completion of both voluntary and required plant improvements designed to reduce the risk of a severe accident.

The NRC staff concurs with Entergy's identification of areas in which risk can be further reduced in a cost-beneficial manner through the implementation of SAMAs IP3-052, IP3-053, IP2-GAG, and IP3-GAG, which were identified as being potentially cost-beneficial SAMAs. Given the small margin by which SAMAs IP2-021 and IP2-053 were determined to not be cost beneficial, the NRC staff has determined that further evaluation of these SAMAs by Entergy would be appropriate. However, neither these SAMAs, nor those being deferred, relate to adequately managing the effects of aging during the period of extended operation. Therefore, neither these SAMAs, nor any of the other SAMAs that have been determined to be cost beneficial, need to be implemented as part of license renewal pursuant to 10 CFR Part 54.

3.2 Supplemental SAMA Sensitivity Analyses for MACCS Decontamination Time and Cost Inputs

On May 4, 2016, the Commission issued a decision (CLI-16-07) in the IP2 and IP3 license renewal proceeding, in which it directed the staff to supplement the Indian Point SAMA analysis

with additional sensitivity analyses. Specifically, the Commission held that documentation was lacking for two inputs (TIMDEC—the time required to complete decontamination to a specified level, and CDNFRM—the cost per person of decontaminating non-farmland to a specific level) used in the MACCS2 computer analyses, and that uncertainties in those input values could potentially affect the SAMA analysis cost-benefit conclusions. The Commission therefore directed the staff to perform additional sensitivity analyses. The purpose of these sensitivity analyses is to address potential uncertainties associated with these input values by “demonstrating whether and to what extent variations in an uncertain input value might affect the overall cost-benefit conclusions” of the SAMA analysis (NRC 2016a).

The staff issued an RAI (NRC 2016g) to Entergy relating to this Commission decision. In response to this RAI (Entergy 2017d), Entergy completed several new MACCS2 sensitivity analyses, documented as Cases 1–8 in Enclosure 1 to the RAI response. In the subset of these cases used to support the RAI response, Entergy escalated the VALWNF and VNFRM input parameters to 2005 values to produce a “revised baseline,”¹ used the TIMDEC value of 1 year (365 days) and CDNFRM of \$100,000/person (the maximum values specified in the Commission decision) for the decontamination factor (DF) of 15, applied to all release categories; and also re-ran these cases with an updated deposition velocity (VDEPOS) value, for supplemental information. New offsite economic cost risk (OECR) and population dose risk (PDR) values also were calculated.

Most of the increases in the OECR and PDR fell within the bound of the “Benefit with Uncertainty” included as Tables 4 and 5 in Entergy’s 2009 SAMA Reanalysis (Entergy 2009b), on which the NRC staff evaluation is based, as documented in Appendix G to FSEIS Supplement 38. The ratio of the sensitivity benefit to the “Baseline Benefit” (including internal and external events) ranged from 1 to 2 with an average of 1.49. The ratio of the sensitivity benefit to the “Benefit with Uncertainty” ranged from 0.48 to 1.38 with an average of 0.86. Three of the benefit increases from the sensitivity were larger than the bound of the “Benefit with Uncertainty,” but the cost-benefit conclusions about two of these SAMAs did not change (SAMAs IP3-018 and IP3-019). However, SAMA IP3-057, “Provide backup cooling water source for the CCW heat exchangers,” became potentially cost beneficial with a sensitivity benefit of \$118,434 and the 2007 estimated implementation cost of \$109,000. The supplemental sensitivity analysis, using a best estimate of the most representative single deposition velocity, would make SAMA IP3-057 not potentially cost beneficial.² In addition, Entergy noted that the implementation cost would likely increase from \$109,000, if it was reassessed today, which also would tend to make this SAMA less likely to be cost beneficial. The NRC staff reviewed Entergy’s RAI response and finds the addition of only IP3-057 to the list of potentially cost-beneficial SAMAs, based on the MACCS2 sensitivity analyses, to be acceptable.

On March 31, 2017, Entergy submitted an updated RAI response with additional MACCS sensitivity analyses (Entergy 2017e) to evaluate a reduced operating term—11 years for IP2 and 10 years for IP3. This updated RAI response reflects Entergy’s February 8, 2017, amendment to the Indian Point Energy Center license renewal application (LRA) modifying the

¹ Entergy’s original SAMA analysis had not escalated these values to 2005, the base year for the analysis.

² NRC staff notes that the following statement in the RAI response is not completely accurate: “the value of 0.003 m/sec is documented by the NRC’s recent SOARCA [State-of-the-Art Reactor Consequences Analyses] study...to be the dominant or average value for use in SOARCA.” To clarify, 0.003 m/s is estimated to be the most representative single deposition velocity based on the SOARCA results, which used 10 deposition velocities. Nonetheless, Entergy’s sensitivity analyses with this alternate VDEPOS value provides useful supplemental information.

proposed terms of the renewed licenses from 20 years for each unit to the periods ending April 30, 2024, for IP2, and April 30, 2025, for IP3. The effect of the shorter license renewal time periods is to reduce the benefit terms by about one-third on average. SAMA IP3-057 is no longer potentially cost beneficial when evaluated for the reduced operating term. SAMAs IP2-028 and IP2-062 are only potentially cost beneficial for the reduced operating term when considering NRC staff's sensitivity analysis of the 2013 updated implementation cost.

Table 3-3 shows the potentially cost-beneficial SAMAs from Table G-6 of the FSEIS with the addition of SAMAs IP3-057, IP2-GAG, and IP3-GAG, and the following information for a 20-year renewal period: (1) revised baseline benefit (Case 4 from the first RAI response), (2) revised baseline with uncertainty (Case 4 from the first RAI response), (3) sensitivity case using TIMDEC value of 1 year and CDNFRM of \$100,000/person for DF=15 with the revised baseline (Case 5 from the first RAI response), and (4) estimated cost. Table 3-4 shows the Phase II SAMA candidates and the same information as in Table 3-3, for the reduced 11-year and 10-year renewal periods for Units 2 and 3, respectively (from the updated RAI response). Considering the NRC staff's evaluation of Entergy's 2014 revised and corrected cost estimates for certain SAMAs, as discussed in Section 3.1, those SAMAs that are no longer potentially cost beneficial are shown in gray italics in both Table 3-3 for a 20-year license renewal term and Table 3-4 for the reduced license renewal terms. The potentially cost-beneficial SAMAs for a 20-year license renewal period are IP2-009, IP2-021, IP2-028, IP2-044, IP2-060, IP2-061, IP2-062, IP2-065, IP2-GAG for Unit 2, and IP3-007, IP3-052, IP3-053, IP3-055, IP3-057, IP3-061, IP3-062, IP3-GAG for Unit 3. These same SAMAs are potentially cost beneficial for the reduced license renewal period, with the exception of IP3-057, which no longer appears to be as potentially cost beneficial.

Table 3–3. Potentially Cost-Beneficial SAMAs from FSEIS, Benefit for 20-year License Renewal Term

SAMA	Baseline Benefit (Internal and External Events)	Baseline Benefit with Uncertainty	Benefit Sensitivity for TIMDEC and CDNFRM	Cost
IP2-009 – Create a reactor cavity flooding system	6,592,922	13,879,837	9,414,955	1,741,724 ^a
IP2-021 – Install additional pressure or leak monitoring instrumentation for ISLOCAs	2,216,549	4,666,419	4,106,084	4,632,227 ^a 2,316,114 ^b
IP2-022 – <i>Add redundant and diverse limit switches to each containment isolation valve</i>	1,112,364	2,341,820	2,053,042	7,692,784 ^a
IP2-028 – Provide a portable diesel-driven battery charger	1,397,945	2,943,043	1,921,453	2,154,767 ^a
IP2-044 – Use fire water system as backup for steam generator inventory	2,432,328	5,120,691	3,201,230	3,073,130 ^a
IP2-053 – Keep both pressurizer PORV block valves open	659,715	1,388,873	823,311	1,471,234 ^a 735,617 ^b
IP2-054 – Install flood alarm in the 480 VAC switchgear room.	5,796,276	12,202,686	8,045,722	458,843 ^a
IP2-056 – <i>Keep RHR heat exchanger discharge motor operated valves (MOVs) normally open</i>	48,723	102,574	48,723	1,704,938 ^a
IP2-060 – Provide added protection against flood propagation from stairwell 4 into the 480 VAC switchgear room	1,316,236	2,771,024	1,790,665	721,303 ^a
IP2-061 – Provide added protection against flood propagation from the deluge room into the 480 VAC switchgear room	2,877,688	6,058,291	3,965,602	943,792 ^a
IP2-062 – Provide a hard-wired connection to an SI pump from ASSS power supply	891,064	1,875,925	1,234,616	1,662,692 ^a
IP2-065 – Upgrade the ASSS to allow timely restoration of seal injection and cooling	5,796,276	12,202,686	8,045,722	1,859,587 ^a
IP2-GAG – Use a gagging device to close a stuck open main steam safety valve following a steam generator tube rupture	N/A	13,000,000	N/A	453,745 ^a
IP3-007 – Create a reactor cavity flooding system	5,275,716	7,645,965	7,521,459	1,874,933 ^a

SAMA	Baseline Benefit (Internal and External Events)	Baseline Benefit with Uncertainty	Benefit Sensitivity for TIMDEC and CDNFRM	Cost
IP3-018 – Route the discharge from the main steam safety valves through a structure where a water spray would condense the steam and remove most of the fission products	3,517,144 10,587,078 ^c	5,097,310 15,343,591 ^d	5,905,474 20,710,748 ^c	35,691,159 ^a
IP3-019 – Install additional pressure or leak monitoring instrumentation for ISLOCAs	2,316,779	3,357,650	4,526,876	6,369,223 ^a
IP3-052 – Open city water supply valve for alternative AFW pump suction	308,809	447,549	439,514	138,378 ^a
IP3-053 – Install an excess flow valve to reduce the risk associated with hydrogen explosions	486,913	705,671	677,029	344,599 ^a
IP3-055 – Provide hard-wired connection to an SI or RHR pump from the Appendix R bus (MCC 312A)	4,263,267	6,178,648	5,938,664	1,601,888 ^a
IP3-057 – Provide backup cooling water source for the CCW heat exchangers	59,023	85,541	118,434	109,000 ^e
IP3-061 – Upgrade the ASSS to allow timely restoration of seal injection and cooling	4,536,430	6,574,536	6,342,530	2,282,668 ^b
IP3-062 – Install flood alarm in the 480 V switchgear room.	4,536,430	6,574,536	6,342,530	496,071 ^a
IP3-GAG – Use a gagging device to close a stuck open main steam safety valve following a steam generator tube rupture.	N/A	19,000,000	N/A	453,745 ^a

^(a) Based on Entergy's 2014 revised and corrected cost estimates for a subset of SAMA candidates (Entergy 2014j).

^(b) Based on NRC staff sensitivity analysis estimated cost if "High by 100%" from Table 3-2 above.

^(c) TI-SGTR Sensitivity Benefit.

^(d) TI-SGTR Sensitivity Benefit with Uncertainty.

^(e) Based on original 2009 SAMA analysis, the latest estimate available for this SAMA.

Table 3-4. Potentially Cost-Beneficial SAMAs from FSEIS, Benefit for 11-year (Unit 2) and 10-year (Unit 3) License Renewal Terms

SAMA	Baseline Benefit (Internal and External Events)	Baseline Benefit with Uncertainty	Benefit Sensitivity for TIMDEC and CDNFRM	Cost
IP2-009 – Create a reactor cavity flooding system	4,699,096	9,892,834	6,710,496	1,741,724 ^a
IP2-021 – Install additional pressure or leak monitoring instrumentation for ISLOCAs	1,576,633	3,318,227	2,923,396	4,632,227 ^a 2,316,114 ^b
IP2-022 – Add redundant and diverse limit switches to each containment isolation valve	791,232	1,665,751	1,461,698	7,692,784 ^a
IP2-028 – Provide a portable diesel-driven battery charger	981,942	2,067,247	1,355,072	2,154,767 ^a 1,077,384 ^b
IP2-044 – Use fire water system as backup for steam generator inventory	1,638,970	3,450,463	2,187,003	3,073,130 ^a
IP2-053 – Keep both pressurizer PORV block valves open	418,865	881,821	535,468	1,471,234 ^a 735,617 ^b
IP2-054 – Install flood alarm in the 480 VAC switchgear room	4,073,523	8,575,839	5,676,813	458,843 ^a
IP2-056 – Keep RHR heat exchanger discharge motor operated valves (MOV's) normally open	28,309	59,597	28,309	1,704,938 ^a
IP2-060 – Provide added protection against flood propagation from stairwell 4 into the 480 VAC switchgear room	925,309	1,948,019	1,263,457	721,303 ^a
IP2-061 – Provide added protection against flood propagation from the deluge room into the 480 VAC switchgear room	2,022,186	4,257,234	2,797,595	943,792 ^a
IP2-062 – Provide a hard-wired connection to an SI pump from ASSS power supply	625,478	1,316,795	870,344	1,662,692 ^a 831,346 ^b
IP2-065 – Upgrade the ASSS to allow timely restoration of seal injection and cooling	4,073,523	8,575,839	5,676,813	1,859,587 ^a
IP2-GAG – Use a gagging device to close a stuck open main steam safety valve following a steam generator tube rupture	N/A	13,000,000	N/A	453,745 ^a
IP3-007 – Create a reactor cavity flooding system	3,525,169	5,108,940	5,025,747	1,874,933 ^a

SAMA	Baseline Benefit (Internal and External Events)	Baseline Benefit with Uncertainty	Benefit Sensitivity for TIMDEC and CDNFRM	Cost
IP3-018 – Route the discharge from the main steam safety valves through a structure where a water spray would condense the steam and remove most of the fission products	2,350,112 7,074,156 ^c	3,405,960 10,252,400 ^d	3,954,946 13,383,669 ^c	35,691,159 ^a
IP3-019 – Install additional pressure or leak monitoring instrumentation for ISLOCAs	1,543,236	2,236,574	3,019,996	6,369,223 ^a
IP3-052 – Open city water supply valve for alternative AFW pump suction	230,939	295,564	291,274	138,378 ^a
IP3-053 – Install an excess flow valve to reduce the risk associated with hydrogen explosions	320,542	464,554	447,576	344,599 ^a
IP3-055 – Provide hard-wired connection to an SI or RHR pump from the Appendix R bus (MCC 312A)	2,802,997	4,062,314	3,922,476	1,601,888 ^a
IP3-057 – Provide backup cooling water source for the CCW heat exchangers	32,228	46,707	71,926	109,000 ^e
IP3-061 – Upgrade the ASSS to allow timely restoration of seal injection and cooling.	2,983,117	4,323,358	4,189,932	2,282,668 ^a
IP3-062 – Install flood alarm in the 480 VAC switchgear room.	2,983,117	4,323,358	4,189,932	496,071 ^a
IP3-GAG – Use a gagging device to close a stuck open main steam safety valve following a steam generator tube rupture.	N/A	19,000,000	N/A	453,745 ^a

^(a) Based on Entergy's 2014 revised and corrected cost estimates for a subset of SAMA candidates (Entergy 2014j).

^(b) Based on NRC staff sensitivity analysis estimated cost if "High by 100%" from Table 3-2 above.

^(c) TI-SGTR Sensitivity Benefit.

^(d) TI-SGTR Sensitivity Benefit with Uncertainty.

^(e) Based on original 2009 SAMA analysis, the latest estimate available for this SAMA.

3.3 Revisions to the 2010 FSEIS Resulting from Entergy's Completed Engineering Project Cost Estimates for SAMAs Previously Identified as Potentially Cost Beneficial and Entergy's Supplemental MACCS2 Sensitivity Analyses in Response to Commission Order CLI-16-07

After line 5 on page 5-12 in Section 5.2.6 of the FSEIS, the following text is to be added:

5.2.6.1 Conclusions Based on Information Submitted after May 6, 2013

In a letter dated May 6, 2013, Entergy submitted revised cost estimates for SAMAs previously identified as potentially cost beneficial (Entergy 2013b). Based on the refined cost estimates, Entergy determined that 6 of the 22 SAMAs previously determined to be potentially cost beneficial were no longer deemed to be cost beneficial. These SAMAs are identified as IP2-021, IP2-022, IP2-053, IP2-056, IP3-018, and IP3-019. The NRC staff reviewed Entergy's revised cost estimates and identified some minor discrepancies or unexplained costs. The NRC staff has concluded that for two of the SAMAs that were identified as no longer being cost beneficial (IP2-021 and IP2-053), the incremental difference by which the SAMAs are not cost beneficial is too small to exclude them from further consideration.

In addition to providing refined cost estimates, Entergy's letter dated May 6, 2013, discussed the deferral of certain cost-beneficial SAMAs pending implementation of action items related to the NRC's comprehensive safety assessment in response to the events impacting the Fukushima Dai-ichi Nuclear Power Plant (Entergy 2013b). The NRC staff reviewed Entergy's assessment regarding deferring action for these SAMAs and concludes that Entergy's determination to defer actions related to the implementation of SAMAs IP2-009, IP2-028, IP2-044, IP2-065, IP3-007, and IP3-061 is reasonable since these SAMAs would act to reduce risks that are similar to risks that are being addressed by NRC Order EA-12-049 (NRC 2012b). In addition, the NRC staff agrees with Entergy that because of the dynamic nature of a SAMA analysis, it is reasonable to defer action on SAMAs IP2-054, IP2-060, IP2-061, IP2-062, IP3-055, and IP3-062 until the risk profile for each plant is re-evaluated following the completion of both voluntary and required plant improvements designed to reduce the risk of a severe accident.

In letters dated February 1, 2017, and March 31, 2017, Entergy submitted supplemental MACCS2 sensitivity analyses to address, respectively, Commission Order CLI-16-07 and the shortened license renewal period requested in Entergy's February 8, 2017, amendment to its license renewal application. Based on this supplemental information, IP3-057 would be potentially cost beneficial for a 20-year license renewal period but not for the shortened license renewal period requested in the February 8, 2017 amendment.

The NRC staff concurs with Entergy's identification of areas in which risk can be further reduced in a cost-beneficial manner through the implementation of SAMAs IP3-052, IP3-053, IP2-GAG, and IP3-GAG, which were identified as being potentially cost-beneficial SAMAs. Given the small margin by which SAMAs IP2-021 and IP2-053 were determined not to be cost beneficial, the NRC staff has determined that further evaluation of these SAMAs by Entergy would be appropriate. However, neither the potentially cost-beneficial SAMAs, nor those being deferred, relate to adequately managing the effects of aging during the period of extended operation. Therefore, they need not be implemented as part of license renewal pursuant to 10 CFR Part 54.

After line 41 on page G-49 in Section G.7 of the FSEIS, the following text is to be added:

G.7.1 Conclusions Based on Information Submitted after May 6, 2013

In a letter dated May 6, 2013, Entergy submitted revised cost estimates for SAMAs previously identified as potentially cost beneficial (Entergy 2013b). Based on the refined cost estimates, Entergy determined that 6 of the 22 SAMAs previously determined to be potentially cost beneficial were no longer deemed to be cost beneficial. These SAMAs are identified as IP2-021, IP2-022, IP2-053, IP2-056, IP3-018, and IP3-019. The NRC staff reviewed Entergy's revised cost estimates and identified some minor discrepancies or unexplained costs. The NRC staff has concluded that for two of the SAMAs that were identified as no longer being cost beneficial (IP2-021 and IP2-053), the incremental difference by which the SAMAs are not cost beneficial is too small to exclude them from further consideration.

In addition to providing refined cost estimates, Entergy's letter dated May 6, 2013, discussed the deferral of certain cost-beneficial SAMAs pending implementation of action items related to NRC's comprehensive safety assessment in response to the events impacting the Fukushima Dai-ichi Nuclear Power Plant (Entergy 2013b). The NRC staff reviewed Entergy's assessment regarding deferring action for these SAMAs and concludes that Entergy's determination to defer actions related to the implementation of SAMAs IP2-009, IP2-028, IP2-044, IP2-065, IP3-007, and IP3-061 is reasonable since these SAMAs would act to reduce risks that are similar to risks being addressed by NRC Order EA-12-049 (NRC 2012b). In addition, the NRC staff agrees with Entergy that because of the dynamic nature of a SAMA analysis, it is reasonable to defer action on SAMAs IP2-054, IP2-060, IP2-061, IP2-062, IP3-055, and IP3-062 until the risk profile for each plant is re-evaluated following the completion of both voluntary and required plant improvements designed to reduce the risk of a severe accident.

In letters dated February 1, 2017, and March 31, 2017, Entergy submitted supplemental MACCS2 sensitivity analyses to address,

respectively, Commission Order CLI-16-07 and the shortened license renewal period requested in Entergy's February 8, 2017, amendment to its license renewal application. Based on this supplemental information, IP3-057 would be potentially cost beneficial for a 20-year license renewal period but not for the shortened license renewal period requested in the February 8, 2017, amendment.

The NRC staff concurs with Entergy's identification of areas in which risk can be further reduced in a cost-beneficial manner through the implementation of SAMAs IP3-052, IP3-053, IP2-GAG, and IP3-GAG, which were identified as being potentially cost-beneficial SAMAs. Given the small margin by which SAMAs IP2-021 and IP2-053 were determined not to be cost beneficial, the NRC staff has determined that further evaluation of these SAMAs by Entergy would be appropriate. However, neither these SAMAs, nor those being deferred, relate to adequately managing the effects of aging during the period of extended operation. Therefore, they need not be implemented as part of license renewal pursuant to 10 CFR Part 54.

4.0 REVISED IMPINGEMENT AND ENTRAINMENT ANALYSIS

This section addresses Entergy Nuclear Operations, Inc.'s (Entergy's) February 19, 2014, letter and attached report prepared by AKRF, Inc. (AKRF) (Entergy 2014b; AKRF 2014), which Entergy stated contained new information, data, analyses, and observations that potentially change some of the U.S. Nuclear Regulatory Commission (NRC) staff's conclusions in the 2010 final supplement environmental impact statement (FSEIS), as supplemented in Supplement 1 (FSEIS Volume 4) in June 2013 (NRC 2013b). Entergy asserted that this new information and analysis indicated that potential impacts to certain aquatic species as a result of projected impingement and entrainment at Indian Point Nuclear Generating Unit Nos. 2 and 3 (IP2 and IP3) during the license renewal period would change, but that the NRC staff's general conclusion for aquatic resources would "not be affected by this submission." The NRC staff had concluded in the FSEIS that impingement and entrainment impacts were MODERATE. In reviewing Entergy's submission, the NRC staff considered written statements in Entergy's letter and AKRF's report, explicit and implicit assumptions in the analysis, analytic methods, and other new material.

Entergy's submission is a reassessment of the NRC staff's analysis of the effects of impingement and entrainment at IP2 and IP3 on aquatic resources in the Hudson River. After reviewing Entergy's submittal, the NRC staff concluded that it did not agree with all aspects of Entergy's submission. This section summarizes the results of the NRC staff's detailed review (see Appendix A) and discusses parts of AKRF's analysis with which the NRC staff disagreed. The NRC staff attempted to reproduce AKRF's analysis, requested the data needed to reproduce the analysis, found inconsistencies in those data, and requested corrected data. The NRC staff then conducted an independent analysis of the new data and other information. Following the December 2015 publication of the draft supplement to the FSEIS for public comment (NRC 2015g), the NRC staff updated its analysis in response to the public comments and new information received during the comment period.

In the 2013 FSEIS supplement, the NRC staff assessed what was then new and significant information on aquatic resources and presented its evaluation of this information, along with revisions to the text, tables, and figures in the 2010 FSEIS. The NRC staff's evaluation in this second supplement is a "standalone" presentation that references information in previous FSEIS volumes, and does not contain redline-strikeout text, figures, or tables to replace information and statements presented in the 2010 FSEIS or the 2013 FSEIS supplement. Except where it is necessary to differentiate between the volumes, the NRC staff collectively refers to the 2010 FSEIS, as modified by the 2013 FSEIS supplement, as the "FSEIS" in this chapter. The NRC staff refers to this current FSEIS supplement as the "present analysis."

4.1 Background

By letter dated April 23, 2007, Entergy submitted an application and associated environmental report pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 54 and 10 CFR Part 51, to renew the operating licenses for IP2 and IP3, for review by the NRC. The NRC staff documented its findings related to the environmental review of Entergy's license renewal application (LRA) in Supplement 38 to NUREG-1437 (FSEIS, Volumes 1-3), issued in December 2010 (NRC 2010).

In 2011, the NRC staff received new data, analyses, and comments from several sources that, upon evaluation, resulted in changes to some of the NRC staff's conclusions in the 2010 FSEIS. Two sources provided information that changed the NRC staff's conclusions in the FSEIS

regarding the effects of impingement and entrainment at IP2 and IP3. First, in comments to the NRC, dated March 29, 2011, Entergy (Entergy 2011c; AKRF 2011b) provided new information regarding the entrainment, impingement, and field data that it had previously provided to the NRC for its aquatic resources impact assessment (Entergy 2007c), a December 2007 supplement to its LRA. Second, comments submitted on behalf of Entergy (Goodwin Proctor 2011; AKRF 2011a) on the FSEIS and the NRC staff's Essential Fish Habitat Assessment contained related new information. In part, these documents corrected some units in an Entergy (2008b) data submission that were used in the FSEIS. The NRC staff found that the new information necessitated some changes to the impingement and entrainment impact findings in FSEIS Sections 4.1.2 through 4.1.3 and Appendices H and I. In June 2013, the NRC staff issued a final supplement (Volume 4) to the FSEIS (NRC 2013b). The 2013 FSEIS supplement included corrections to impingement and entrainment data that had been presented in the 2010 FSEIS, among other matters.

By letter dated February 19, 2014, Entergy (2014b) submitted a letter with an attached report (AKRF 2014), which Entergy stated contained new information that potentially changed the NRC staff's conclusions in the FSEIS regarding IP2 and IP3 entrainment and impingement impacts on certain fish species, although its submission would not affect the NRC staff's general conclusion. Entergy stated that, as a result of the new information and the AKRF report, which relies on different data than that which was used in the FSEIS, the following findings for four fish species would change:

- blueback herring would change from "Large" to "Small,"
- hogchoker would change from "Large" to "Moderate,"
- rainbow smelt would change from "Moderate-Large" to "Small," and
- white perch would change from "Large" to "Small."

Entergy did not submit the underlying data for the AKRF report from which the NRC staff might independently verify the analysis.

The NRC staff, by letter dated August 28, 2014 (NRC 2014d), issued a request for additional information (RAI) based on its review of Entergy's February 19, 2014, submittal. On September 16, 2014, the NRC staff held a conference call with Entergy to clarify its request (NRC 2014g), and on September 26, 2014, the NRC staff issued a revised letter requesting additional information (NRC 2014e) that replaced the August 28, 2014, letter to Entergy.

Entergy responded to the RAI in October 2014 (Entergy 2014i; ASA and AKRF 2014). In its quality assurance review of the data supplied by Entergy, the NRC staff found inconsistencies within the 2014 information and between the 2014 and 2008b information and data submissions. The NRC staff also found that it could not reproduce the intermediate analysis tables and results in the AKRF (2014) submission with the October 2014 data submitted by Entergy.

On November 24, 2014, the NRC staff sent Entergy a draft of second-round RAIs for clarification. On December 11, 2014; January 13, 2015; and February 12, 2015, the NRC staff conducted conference calls with Entergy and its biological contractors to clarify the data and the availability of data requested in the draft RAI (NRC 2015a, 2015d). On February 18, 2015, the NRC sent a second-round RAI to Entergy (NRC 2015b).

Entergy replied to the RAI with replacement data files and other information on April 6, 2015 (Entergy 2015c). Attachments to the cover letter included a letter from Goodwin Proctor to Entergy (Goodwin Proctor 2015) and reports by Entergy's biological contractors (Heimbuch et al. 2015; AKRF 2015) with specific RAI response information.

Heimbuch et al. (2015) explained the differences and inconsistencies in the information sent to the NRC in 2008 and 2014, and Entergy's April 2015 submission included replacement data sets with corrected information. AKRF (2015) provided corrected tables of intermediate and final analysis results to replace the tables in Entergy's original submission (AKRF 2014; Entergy 2014b).

The differences in the data sets result from the following: (1) the NRC staff requested that data be summarized by sampling week (also called river run), in response to which Entergy's different contractors used different algorithms to assign individual samples to sampling week; (2) samples were coded to identify valid samples for subsequent analysis, but Entergy's various contractors used somewhat different criteria to identify valid samples; (3) the NRC staff requested "total count" information, which was calculated somewhat differently for the 2008 and 2014 data submissions; (4) some errors in data or programming resulted in differences in the number of samples, the volume sampled, or counts of fish in the 2007, 2008, and 2014 data submissions; and (5) in some instances, particularly in the early years of the sampling programs, life stage categories (i.e., conversion of length categories into age classes) that the investigators consider synonymous today were handled differently. As a result, there was a 5.4 percent difference between the data sets received in 2007 and 2008 and the data that the NRC staff received in 2014. These differences do not include the differences observed in the total counts (the 2014 data did not include the early life stages in the total count) and the differences observed in the age class. After the NRC staff obtained the final corrected data sets, it finalized its independent analysis of the new data.

The NRC staff published a draft of this FSEIS supplement for public comment in December 2015 (NRC 2015g). Some of the comments received during the public comment period resulted in updates within this final supplement. For example, Entergy (2016a) submitted additional population data for Atlantic menhaden. Accordingly, this final supplement reanalyzes this species using the newly available data (see Appendix A). In addition, Section 4.5 of this final supplement includes an expanded discussion of uncertainty, which the staff added to the supplement in part based on public comments from Entergy (2016a, 2016b), the New York State Department of Environmental Conservation (NYSDEC) (2016), and Riverkeeper, Inc. (2016). The NRC staff's specific responses to public comments related to aquatic resources appear in Appendix B.2 of this document.

As described in Section 2.2 of this supplement, on January 8, 2017, the Indian Point Closure Agreement (NYS et al. 2017) (herein referred to as "Closure Agreement") was signed by the State of New York (including NYSDEC), Riverkeeper, and Entergy. Pursuant to the terms of that agreement, on April 24, 2017, the NYSDEC (2017c, 2017d) issued a final State Pollutant Discharge Elimination System (SPDES) permit (with an effective date of May 1, 2017) and associated Final Environmental Impact Statement and State Environmental Quality Review Act findings, and a Clean Water Act Section 401 Water Quality Certification. In Section 4.4, the NRC staff updated this final supplement to include relevant information from the Closure Agreement, the final SPDES permit, and the NYSDEC's Final Environmental Impact Statement as each relates to the potential impacts of impingement and entrainment on aquatic resources that would result from IP2 and IP3 license renewal.

4.2 Entergy's New Information

Entergy's (2014b) letter to the NRC identified "new information from regulators charged with overseeing fisheries that are relevant to NRC staff's subsidiary findings for certain fish species" in the FSEIS and summarized a report finding by Entergy's contractor, AKRF (2014), attached to the letter with respect to "Entergy's identification and correction of an inadvertent discrepancy

in NRC staff's use of certain Entergy data files to reach these subsidiary findings" regarding certain fish species in the FSEIS. This section summarizes information that Entergy (2014b) specifically identifies as new. Each summary is followed by the NRC staff's assessment as to whether the information is new to the FSEIS and whether the information may change previous FSEIS conclusions. Section 4.3 of this supplement addresses the AKRF technical report.

Entergy identified three sources of new information from "public documents issued by regulators after issuance of the FSEIS that bear directly on species analyzed by NRC staff in the FSEIS." The information pertains to 2 species (blueback herring, *Alosa aestivalis*, and rainbow smelt, *Osmerus mordax*) of the 18 representative important species (RIS) addressed by the NRC's impingement and entrainment analysis. Entergy's sources of information and its reasons for stating that the NRC staff should reconsider its assessment of the two species are as follows:

- the National Marine Fisheries Service's (NMFS) Endangered Species Act of 1973, as amended (ESA), listing determination for blueback herring (78 FR 48944) and the Atlantic States Marine Fisheries Commission (ASMFC) supporting material, which Entergy maintains "cannot readily be reconciled with a LARGE impact finding from a specific [cooling water intake system], and therefore suggest that reconsideration of that finding is warranted;"
- a NYSDEC review of the Hudson River blueback herring population and conclusion, in Entergy's words, that "the population, although variable, was stable, even with existing mortality imposed through in-river fishing harvests," which Entergy asserts underscores "the importance of reconsideration of a LARGE finding for blueback herring;" and
- a report by the National Oceanographic and Atmospheric Administration (NOAA) that a rainbow smelt "population has not existed in the Hudson River for several decades (at least), which in Entergy's opinion cannot be reconciled with a finding of *future* LARGE impacts to that species during the license renewal period, and therefore suggest that reconsideration of that finding is warranted."

Entergy's New Information Source (1). In February 2014, Entergy (2014b) stated that the NMFS "considered, but ultimately refused to list as threatened or endangered, blueback herring, including within the Hudson River." The NRC staff disagrees with Entergy's characterization of NMFS's findings. NMFS's listing determination considered the two species of river herring—alewife and blueback herring—and found that "both species are at low abundance compared to historical levels, and monitoring both species is warranted." The NMFS found significant data deficiencies for both species and uncertainties associated with the available data. Further, although many restoration and conservation efforts are ongoing and new management measures are being initiated or considered, it is not possible to quantify the positive benefits for those efforts. Rather than refusing to list blueback herring as Entergy asserts, the NMFS concluded that "based on the best scientific and commercial information available, we have determined that listing blueback herring as threatened or endangered under the ESA is not warranted at this time." Furthermore, the NMFS concluded that "[g]iven the uncertainties and data deficiencies for both species, we commit to revisiting both species in 3 to 5 years." The NMFS further stated that the 3- to 5-year time period will allow for "time to complete ongoing scientific studies (e.g., genetic analyses, ocean migration patterns, climate change impacts) and for the results to be fully considered" and "for the assessment of data to determine whether the preliminary reports of increased river counts in many areas along the coast in the last 2 years represent sustained trends" (78 FR 48994). Thus, rather than "refusing" to list the species, NMFS has determined not to list the species at this time and will revisit this decision after sufficient time has passed to resolve certain data deficiencies and to complete further analysis.

Presently, NMFS considers both alewife and blueback herring to be “Species of Concern,” and NMFS and the ASMFC have formed a River Herring Technical Working Group to assist in developing more complete information on the two species and in developing and implementing a conservation plan to restore river herring throughout its Atlantic coast range.

In its letter, Entergy (2014b) stated that “NMFS and ASMFC ranked all cooling water intake structure impacts, such as [impingement and entrainment], in conjunction with a variety of other industrial impacts that may occur throughout the species’ range, as a cumulative “medium low” threat to blueback herring throughout its range.” AKRF (2014) stated that in the listing document:

[...] NMFS concluded that water withdrawals and outfalls (including pumped storage, irrigation, thermal discharges, industrial pollutants and atmospheric deposition) collectively posed only a “medium low” threat to blueback herring. The number one threat was listed as “dams and other barriers”. Behind that, “climate change,” “water quality (chemical),” “incidental catch”, and “predation”, ranked as medium threats. The NMFS’s findings are consistent with the change in impact conclusion for blueback herring of “Large” to “Small” for IP2 and IP3.

The NRC staff disagrees with Entergy and AKRF’s characterization. The NMFS listing determination presents tables of “qualitative ranking of threats” not only for blueback herring throughout its range but also for the four individual stock complexes that comprise the entire rangewide population: the Canadian, the northern New England, the southern New England, and the Mid-Atlantic stock complexes. Hudson River blueback herring belong to the southern New England stock complex. Threats are ranked numerically from 1 to 5 as follows: 1 – low, 2 – medium/low, 3 – medium, 4 – medium/high, and 5 – high.

The NMFS conclusions that AKRF cites are for the entire population of blueback herring, however, and not the southern New England stock complex to which Hudson River blueback herring belong. For the southern New England stock complex and the threat category “Water Withdrawal/Outfall (physical and temp.)” into which large cooling water withdrawals such as operation of IP2 and IP3 falls, the mean rank is 2.6, which is the third greatest of the 22 potential threats ranked, and the mode rank is “2,3”, which indicates that the mode is equally split between medium/low and medium. The southern New England stock ranking is more appropriate for Hudson River blueback herring and higher than that characterized by Entergy and AKRF. This information does not support Entergy’s (2014b) statement that the NRC’s finding for blueback herring should be changed from “Large” to “Small.”

At this time, ASMFC expressed difficulty in parsing the relative magnitudes of the various threats to river herring. In its River Herring Benchmark Stock Assessment, ASMFC (2012a) observed:

Multiple factors are likely responsible for river herring decline such as overfishing, inadequate fish passage at dams, predation, pollution, water withdrawals, acidification, changing ocean conditions, and climate change. It is difficult to partition mortality into these possible sources and evaluate importance in the decline of river herring.

In its blueback herring factsheet summarizing the results of its investigations, ASMFC (2015) considers both “water withdrawal facilities” and “thermal and toxic discharges” as two of seven identified threats to blueback herring habitat. ASMFC’s recommendations to improve the habitat quality include “[a]lter water withdrawal rates or water intake velocities to reduce alosine mortality” and “[l]ochy water withdrawal facilities along the river where impingement will be low.”

These recommendations are directly related to the threat posed by water withdrawal facilities, such as IP2 and IP3.

Therefore, the NRC staff disagrees with Entergy's (2014b) assertion that NMFS's listing document for blueback herring (78 FR 48944) and ASMFC's supporting material support a change in the NRC staff's findings for this species from "Large" to "Small." Entergy's proposed change is supported by the AKRF analysis, which uses a different set of years than what was used in the FSEIS. As a result of the new data and information that Entergy submitted in support of the AKRF report, the NRC staff reassessed impacts to blueback herring and other species. The results of the NRC staff's independent analysis appear in Appendix A and are summarized in Section 4.3 of this supplement.

Entergy's New Information Source (2). Although Entergy (2014b) identified NYSDEC information separately from its New Information Source (1), the NYSDEC report on the status of New York river herring stocks (Hattala et al. 2011) was a submission to the ASMFC and much of the information appears as Hattala et al. (2012) in Volume 2 of the ASMFC (2012a, 2012b) River Herring Benchmark Stock Assessment that serves as supporting material for the NMFS listing document (78 FR 48944). Entergy (2014b) identified both the listing document and the ASMFC (2012a, 2012b) report as New Information Source (1), although it essentially simply repeats information in Entergy's New Information Source (2).

Hattala et al. (2011) assessed the information from the Hudson River utilities' Beach Seine Survey (BSS 1974–2009) and Fall Shoals Survey (FSS 1979–2009) monitoring programs, the same sampling programs that the NRC staff analyzed in the FSEIS (see Section 2.2.5.3 of the 2010 FSEIS and Appendix A of this supplement for additional discussion of the various surveys conducted as part of the Hudson River Monitoring Program). Hattala et al. (2011, 2012) used a geometric mean young-of-year (YOY) index to assess trends in the Hudson River blueback herring and did not perform a regression analysis. The conclusion for blueback herring is identical in both documents and is described in Hattala et al. (2012) as follows:

From 1980 through 1994, the NYSDEC geometric mean YOY annual index for blueback herring averaged about 24 fish per haul, with only one year (1981) dropping below 10 fish per haul...After 1994, the mean dropped to around 17 fish per haul, and then began the same high-low pattern observed for alewife. The [...] survey data indicate that yoy blueback abundance was also higher in the 1970s and has declined erratically since then to the present. [Table and figure references omitted.]

Furthermore, Hattala et al. (2012) observed:

The underlying reason for the wide variation in yoy river herring indices is not clear. The same erratic trend that occurs since 1998 is also evident for American shad (Hattala and Kahnle 2007). The trend in all three alosines may indicate a change in overall stability in the system.

This conclusion regarding stability is similar to the conclusion that the NRC staff reached.

In the Sustainable Fishing Plan for New York river herring stocks, Hattala et al. (2011) concluded that "[g]iven the inconsistent measures of stock status described above, we do not feel that the data warrant a complete closure of the Hudson River fishery at this time." The NYSDEC therefore proposed a 5-year restricted fishery in the main-stem Hudson River, a partial closure of the fishery in tributaries, and annual stock monitoring, as well as a sustainability target for juvenile indices.

The Hattala et al. (2011) report, which is the NYSDEC's report on the status of New York river herring stocks, contradicts Entergy's (2014b) statements that the NYSDEC finds "the blueback herring population, although variable, was stable" with "declining trend that neither NMFS, nor NYSDEC determined to be real."

Entergy's New Information Source (3). Entergy's sources of new information and its reasons for stating that the NRC staff should reconsider the assessment of rainbow smelt are as follows:

A consortium of regulators, including from the National Oceanic and Atmospheric Administration, in conjunction with fisheries regulators from Massachusetts, New Hampshire and Maine (collectively, "NOAA"), performed a comprehensive analysis of the migratory range of rainbow smelt. NOAA employed current datasets, and determined that the anecdotal Hudson River population (in the 1870's) has been effectively extirpated, in part because smelt's habitat range long ago shifted north, and no longer includes the Hudson River (all, for identified reasons unrelated to [impingement and entrainment]). See, e.g., *Rainbow Smelt: An Imperiled Fish in a Changing World* (2010); *A Regional Conservation Plan for Anadromous Smelt* (2012) (reporting its comprehensive data analysis from 2006 through 2012, including its analysis of Hudson River data collected by Entergy and its predecessors). NOAA's determination that a population has not existed in the Hudson River for several decades (at least) cannot be reconciled with a finding of *future* LARGE impacts to that species during the license renewal period, and therefore suggest that reconsideration of that finding is warranted.

The NRC staff identified rainbow smelt as one of 18 RIS to use in assessing the impacts of IP2 and IP3 (NRC 2010). The NRC staff selected the 18 RIS from those species "[...] identified in past analyses conducted by NYSDEC, the NRC, and the current and past owners of IP2 and IP3. The RIS identified in this section are meant to represent the overall aquatic resource and reflect the complexity of the Hudson River ecosystem by encompassing a broad range of attributes, such as biological importance, commercial or recreational value, trophic position, commonness or rarity, interaction with other species, vulnerability to cooling system operation, and fidelity or transience in the local community" (NRC 2010). Once common in the Hudson River, rainbow smelt declined abruptly in the Hudson River after 1994. In the 1985 through 2011 data sets used in the weight of evidence (WOE) analysis (Appendix A), rainbow smelt YOY last occurred in the Long River Survey (LRS), FSS, and BSS in 1995, 1998 (one fish), and 1993, respectively, roughly midway through the period analyzed in this supplement. The Hudson River population appears to have been extirpated in the mid-1990s.

Although Entergy asserts that the extirpation of rainbow smelt from the Hudson River and a shift in the range of the species possibly due to climate change constitute new information, the NRC staff addressed these issues in the FSEIS (NRC 2010) and described the disappearance of rainbow smelt in the Hudson River as follows:

Once a prevalent fish in the Hudson River, an abrupt population decline in the Hudson River was observed from 1994, and the species may now have no viable population within the Hudson River. The last tributary run of rainbow smelt was recorded in 1988, and the Hudson River Utilities' Long River Ichthyoplankton Survey show that PYSL [post-yolk-sac larvae] essentially disappeared from the river after 1995 (Daniels et al. 2005). When present, the largest abundances of eggs and YSL [yolk-sac larvae] occurred from Poughkeepsie to the Catskills, and the largest abundances

of PYSL, YOY, and older individuals were distributed from approximately Yonkers to Hyde Park (Table 2–5, Figure 2–6). Rainbow smelt runs in the coastal streams of western Connecticut declined at about the same time as in the Hudson River (Daniels et al. 2005). Smelt landings in waters south of New England have dramatically decreased, although the reasons for this are unknown. Daniels et al. (2005) note slowly increasing water temperatures in the Hudson River and suggest that the disappearance of rainbow smelt from the Hudson River may be a result of global warming. Rainbow smelt were observed in both impingement and entrainment samples obtained from IP2 and IP3.

Therefore, the NRC staff finds that the information on extirpation of rainbow smelt from the Hudson River and a shift in the range of the species possibly due to climate change does not constitute new information.

At the time when Indian Point Nuclear Generating Unit No. 1 (IP1), IP2, and IP3 were under construction and beginning operation, rainbow smelt were common in the Hudson River. The former owner of IP2 and IP3 included rainbow smelt, then called American smelt, in its Environmental Reports (Con Edison 1971a, 1971b) among ubiquitous species that “comprise the numerically most important species in the study area.” In a draft environmental impact statement for the effects of power plant operation on the Hudson River environment, CHGE et al. (1999) noted that during the period of 1974 through 1997, rainbow smelt larvae were the sixth most common of 44 species reported in Hudson River ichthyoplankton sampling.

Early on, government agencies and the Hudson River electric-generating utilities specifically identified Hudson River rainbow smelt as a target species for assessing the effects of power plant operation. The former owners of IP2 and IP3, along with owners of other operating power plants on the Hudson River (CHGE et al. 1999), included rainbow smelt among 17 selected (target) species (16 fish and one crab) for assessing the effects of power plant operation on Hudson River biology. The Atomic Energy Commission (AEC) (1972), the predecessor to the NRC, chose rainbow smelt as an indicator species for the effects of IP2 impingement and entrainment. The AEC (1972) found that “[t]hose species most likely to be affected include the tomcod, bay anchovy, blueback herring, alewife, American eel, smelt, American shad, white perch, and striped bass” and predicted that “[a]mong the anadromous fishes, the alewife, blueback herring, smelt, American shad, tomcod, and striped bass may be significantly affected by Plant operation.”

Hudson River rainbow smelt were identified as a target species for assessing the effects of impingement and entrainment for several reasons. Rainbow smelt are among Hudson River fish species whose “recruitment rates and standing crops of several species may be appreciably lowered in response to the increased mortality caused by entrainment of eggs and larvae and of impingement of young-of-the-year” (AEC 1972). The AEC (1972) voiced concern not only because of the direct mortality from impingement and entrainment, but also because of changes in the food web that supports the indicator species. Changes due to entrainment that occur in planktonic and epibenthic invertebrates, which are the principal food organisms for many fishes, could affect the availability of the food for rainbow smelt and other fish populations (AEC 1972). For rainbow smelt and other vulnerable species, the increased mortality or decreased reproductive success would reduce their ability to endure additional mortality from other causes and result in distinct reductions in population size (AEC 1972). Rainbow smelt stocks are generally confined to their natal estuaries and nearby coastal areas. Therefore, it is unlikely that rainbow smelt of Hudson River origin contribute significantly to other coastal stocks or that other stocks would influence the abundance of the Hudson River population (CHGE et al. 1999).

The rainbow smelt population declined noticeably in the Hudson River after 1994 and it appears to have been extirpated sometime within the following 3 years.

The NRC staff disagrees with Entergy's assertion that a population that "[...] has not existed in the Hudson River for several decades (at least) cannot be reconciled with a finding of *future* LARGE impacts to that species during the license renewal period." The NRC staff defined its use of RIS in the FSEIS as follows:

The RIS identified in this section are meant to represent the overall aquatic resource and reflect the complexity of the Hudson River ecosystem by encompassing a broad range of attributes, such as biological importance, commercial or recreational value, trophic position, commonness or rarity, interaction with other species, vulnerability to cooling system operation, and fidelity or transience in the local community.

The NRC staff's use of RIS follows common practice and reflects the past use of RIS to assess impacts to Hudson River aquatic communities. The Hudson River is home to many species. For example, Waldman et al. (2006) found that as of 2005, 212 fish species had been reported from the Hudson River drainage; Strayer (2006) reported approximately 300 species of macrobenthic invertebrates alone from the tidal-freshwater portion of the Hudson River estuary; and Cerrato (2006) reported 328 marine benthic species from the Lower Hudson River Bay Complex. Because all of these species cannot be analyzed, investigators select a small number of RIS to represent the entire aquatic community.

The NRC staff explained its use of RIS in the FSEIS (NRC 2010, page 4–10):

Because the Hudson River estuary represents a complex system with hundreds of aquatic species, the NRC staff chose to focus its analysis of impact on a subset of RIS historically used to monitor the lower Hudson River (as indicated in Section 2.2.5.4 of this SEIS). By focusing on a subset of species that are representative of many of the species that exist in the lower Hudson River fish community, the NRC staff can more-easily analyze impacts to the Hudson River community, and the NRC staff can make use of a large body of sampling data compiled over many years. The NRC staff acknowledges that the simplification inherent in relying on RIS may introduce some additional uncertainty, but the NRC staff finds that the utility of the RIS approach (due to the availability of large, long-term data sets; applicability to species with similar characteristics; and comparability to other Hudson River studies) in evaluating communitywide effects outweighs the uncertainties associated with using it.

A **Monte Carlo Analysis** is a mathematical simulation that is run several hundred times in order to characterize the probability of a certain outcome. The model is based on repeated random sampling and provides distributions, or likelihoods, for a range of outcomes.

The fate of an RIS helps inform the impact determination because it stands as a surrogate for other species in the aquatic community that share life history attributes. If an RIS was once abundant and has since been extirpated, it can stand as a warning to further investigate the other species sharing similar attributes that might also suffer adverse impacts. In this way, the RIS are sentinel species.

The NRC staff finds that Entergy's asserted new information on rainbow smelt already had been taken into account by the NRC staff; therefore, it is not new information with regard to the

FSEIS. Because both government agencies and the electric generating utilities identified rainbow smelt early in Hudson River monitoring as a vulnerable population that would serve as an indicator for a wide range of aquatic resources, knowledge of past impacts to this species can help predict future impacts to the greater Hudson River aquatic ecology. Knowledge that this species has been extirpated can help predict future impact of other similarly vulnerable species. Therefore, the NRC staff finds that the extirpation of Hudson River rainbow smelt alone does not warrant changing the finding from “Moderate-Large” to “Small.” However, Entergy’s proposed change is supported by the AKRF analysis, which uses a different set of years than what was used in the FSEIS. As a result of the new information that Entergy submitted in support of the AKRF report, the NRC staff reassessed impacts to rainbow smelt and other RIS. The results of the NRC staff’s independent analysis are summarized in the following sections. Additionally, the NRC staff has added a discussion of uncertainty in Section 4.5 of this supplement that addresses the uncertainty of attributing population changes to specific factors, both generally to all aquatic populations and specifically to the rainbow smelt.

4.3 NRC Staff’s Independent Weight of Evidence Analysis of the AKRF Reports and Updated Field Data

The AKRF (2014, 2015) reports update the NRC staff’s FSEIS WOE aquatic impact analysis by incorporating newly available field data collected in the LRS, FSS, and BSS from 2006 through 2011 to provide more current results. AKRF excluded data collected in those programs from 1979 through 1984 that the NRC staff used in the FSEIS, partly justifying the exclusion as due to a change in sampling gear for the bottom and shoal strata in the FSS in 1984 and 1985 (no gear change occurred for the channel stratum) and partly due to interannual changes in the sample week numbers in the early years of the surveys. AKRF largely employed the methods that the NRC used in the FSEIS and found that using the altered data sets (1979 through 2005 versus 1985 through 2011) changed the NRC staff’s (2010, 2013b) FSEIS findings for some species.

The NRC staff reviewed AKRF’s (2014, 2015) reports and conducted an independent analysis that considered the assumptions and methods in the FSEIS, AKRF’s comments and methods, and the updated data. The NRC staff’s present analysis, initially conducted for the draft supplement to the FSEIS and updated in this final supplement in response to public comments and other new information described below, appears in Appendix A and differs somewhat from the analyses in the FSEIS (NRC 2010, 2013b), Entergy’s (2014b) and AKRF’s (2014) submissions, and Entergy’s (2015c) and AKRF’s (2015) submissions in response to NRC staff (2015b) RAIs (Table 4–1). The NRC staff’s present independent analysis uses data from 1985 through 2011 for both the population trend analyses and for the regression and variability parameters used in the Monte Carlo strength of connection (SOC) analysis (see text box), as does AKRF (2014, 2015), but it incorporates field data updated by Entergy following submission of the AKRF report (reviewed in Section 4.1). In addition, another difference between AKRF’s and the NRC staff’s present analyses is that AKRF selected periods of consistent sampling based on sample week number, whereas the NRC staff uses month designations because of differences in the available data sets.

The present analysis also incorporates Entergy’s (2016a) newly provided population data for Atlantic menhaden; an expanded discussion regarding uncertainty related to field sampling and statistical analyses; and relevant information included in the January 8, 2017, Closure Agreement (NYS et al. 2017), the final SPDES permit (NYSDEC 2017c), and NYSDEC’s (2017d) related Final Environmental Impact Statement.

Table 4–1. Differences in WOE Methodology among the FSEIS, Entergy, and the NRC Staff’s Present Analysis

Method	Analysis Feature	FSEIS ^(a)	Entergy ^(b)	Present Analysis
Population Trends	Years of data analyzed	1979 through 2005	1985 through 2011	1985 through 2011
	Survey sampling periods used	LRS: all weeks sampled FSS: weeks 27 through 43 BSS: weeks 22 through 43	LRS: weeks 17 through 27 FSS: weeks 29 through 42 BSS: weeks 28 through 42	LRS: May through July FSS: July through October BSS: July through October
	Regression methods used	Linear and segmented regression adjusted based on an FSS gear change analysis; regression with and without extreme values	Linear and segmented regression; no FSS gear change analysis	Linear regression with and without extreme values; no FSS gear change analysis
	Riverwide catch per unit effort (CPUE) calculation	Total catch (all sampling events all lifestages)/total volume sampled	Total YOY caught within designated weeks/volume sampled	Total YOY caught within designated months/volume sampled
	Utilities’ Riverwide Abundance Index years analyzed	1979 through 2005	1985 through 2011	1974 through 2011
Strength of Connection (SOC)	Years used for the estimated slope and standard error of RIS density and regression mean square error	1979 through 2005	1985 through 2011	1985 through 2011
	Years used to calculate the coefficient of variation of the population density	1979 through 2005	1985 through 1996	1985 through 2011
	Levels of classification for SOC	Low or High	Low or High	Low or High or Unresolved
	Conditional entrainment mortality rate (EMR) parameter values	Updated in NRC (2013b) due to error in units reported to NRC	Original NRC (2010) values, not updated as in NRC (2013b)	Updated in NRC (2013b) due to error in units reported to the NRC

Revised Impingement and Entrainment Analysis

Method	Analysis Feature	FSEIS ^(a)	Entergy ^(b)	Present Analysis
Weight of Evidence (WOE)	Impact levels	Small, Moderate, and Large	Small, Moderate, and Large	Small, Moderate, Large, Unresolved, and Endangered Species Act effect determinations for Federally listed species

^(a) NRC 2010, 2013b

^(b) AKRF 2014, 2015; Entergy 2015c

In the FSEIS, the population trend analysis conducted by the NRC staff applied both linear and segmented regression on the 1979 through 2005 LRS, FSS, and BSS data. AKRF also used both regression types in its analysis. The 2010 FSEIS states that the segmented regression analysis was used to account for possible delayed population responses. IP1 began operation in 1963 and was shut down on October 1, 1974; IP2 was initially licensed for operation on September 28, 1973; and IP3 was initially licensed for operation on December 12, 1975. Because several of the RIS live for decades, and because possible indirect effects through trophic and interspecific interactions take time, delayed population effects in the 1979 through 2005 population data are possible. Delayed effects, however, are less likely to appear 6 years later in the updated period of analysis of 1985 through 2005; therefore, the NRC staff's present independent analysis uses only linear regression to assess population trends. This differs from AKRF's analysis, which generally followed the procedure, although not exactly the reasoning, in the staff's FSEIS analysis. Further, in the FSEIS, the regression analyses are split (pre- and post-gear change) based on a determination of whether FSS population trends could be affected by a 1985 change in gear. The NRC staff's present analysis, with the exception of the utilities' abundance indices, and AKRF's (2014, 2015) analysis are based on data following the gear change, and both have eliminated the assessment of a potential gear-change effect in the FSS.

In the FSEIS, one of the riverwide measures of abundance, catch per unit effort (CPUE), was calculated for each RIS and sampling survey as the annual total fish caught for all life stages of that species, divided by the total volume sampled. AKRF (2014) suggested a potential confounding effect of sampling design changes with estimates of annual abundance. The NRC staff's present analysis calculates the riverwide CPUE as the total YOY fish caught within the restricted sampling period divided by the volume sampled, which avoids potential confounding effects.

The new data (Entergy 2015c) includes utilities' abundance indexes calculated from multiple sampling surveys for several RIS, whereas Entergy's previous submittals included only one abundance index for each RIS for analysis in the FSEIS. In the present analysis, for each RIS, the NRC staff used the utilities' abundance index associated with the survey that had the greatest median riverwide CPUE from 1985 through 2011 (Appendix A, Table A-3).

In the FSEIS, riverwide population trends based on the abundance index used the years 1979 through 2005. For the present analysis, the NRC staff used all available years (1974 through 2011) in the regression because the early data (1974 through 1979) were used in published studies elsewhere (e.g., Daniels et al. 2005; O'Connor et al. 2012). As a result, in the present analysis, more RIS population trends were analyzed using the LRS data than were analyzed in the FSEIS.

The FSEIS assumed that because Atlantic tomcod are winter spawners with young that migrate down the river and the LRS is the earliest survey in the year, the LRS would be appropriate only

for Atlantic tomcod. In examining the data for the present analysis, the NRC staff found that based on the highest CPUE, sometimes the LRS is also the most appropriate index for other species. The LRS is the earliest sampling survey conducted, and it employs the smallest net mesh size. Also, the CPUE of YOY for any RIS is probably affected by the metamorphosis of the larvae to the YOY stage and the high early numbers of YOY before the mortality that occurs before the start of other sampling programs. In contrast, the FSS and BSS, which occur later in the year, may sample YOY RIS when populations have been reduced by mortality and when catch efficiency may be reduced at the end of the sampling periods as fish grow and are more able to avoid the sampling gear. The NRC staff has determined that these processes would explain why the LRS is sometimes the most appropriate survey for calculating an abundance index for some RIS. In the present analysis, all available YOY RIS with greater than eight annual observations for any given sampling survey were analyzed by the NRC staff for the Population Trend line of evidence (LOE). The NRC staff applied this criterion in both the FSEIS and the present analysis for determining which RIS population trends to analyze for the FSS and BSS data.

In its SOC analysis, AKRF used the parameter values from the NRC staff's 2010 FSEIS (NRC 2010) rather than the updated values from the 2013 FSEIS supplement (NRC 2013b). The NRC staff's present analysis updates the staff's previous SOC analysis by using the updated 1985 through 2011 data for consistency of years across its analysis. Also, in selecting the River Segment 4 population trends to include in the SOC analysis for each RIS, the NRC staff chose the trend with the greatest median YOY CPUE among the Hudson River Estuary monitoring surveys using updated 1985 through 2011 data, which for two species was a different monitoring program than in the 2010 FSEIS or 2013 FSEIS supplement. In the present analysis, the NRC staff also included the category "Unresolved" for those RIS for which a Population Trend LOE could not be established and too little data were available to model the SOC. Previously, the FSEIS and AKRF's analyses assumed the impact level to be "Small" where this occurred. The NRC staff's present analysis differs from AKRF's in these ways.

The NRC staff finds that four species have experienced statistically significant declines consistently across measures of abundance: American shad, Atlantic tomcod, blueback herring, and rainbow smelt (Table 4–2). Of these RIS, blueback herring and rainbow smelt had a high SOC, and the NRC staff concludes that for these RIS there is a "Large" potential for IP2 and IP3 cooling system operation to impact these RIS during the relicensing period. Three RIS show a variable population trend response across measures of abundance: bluefish, hogchoker, and white catfish. Of these RIS, only hogchoker had a high SOC. The final RIS impact finding (WOE conclusion) for hogchoker changed from "Large" in the FSEIS to "Moderate" in the present analysis because of a change in the Population Trend LOE. The change results from the difference in time periods considered. The present analysis does not include early years (1974–1984) when hogchoker abundance was relatively higher than in years common to both analyses (1985–2005) and includes later years (2006–2011) when abundance increased in some years (see Appendix A, Addendum A-1). Considering all years and all measures of abundance, the hogchoker population abundance curve appears to be "u-shaped," which would explain the variable results of linear regressions used in the present Population Trend LOE.

Because of undetected declines in population trend combined with low SOC, the NRC staff concludes that license renewal would have a "Small" potential impact level for 10 RIS: alewife, American shad, Atlantic tomcod, bay anchovy, bluefish, spottail shiner, striped bass, weakfish, white catfish, and white perch. Because of undetected declines in population trend, combined with an unresolved SOC, impacts could not be independently resolved for Atlantic menhaden, gizzard shad, blue crab, Atlantic sturgeon, and shortnose sturgeon. In the FSEIS, the NRC staff

assigned species with unresolved SOC assessments a value of “Low” rather than “Unresolved,” the same description that is used for an unresolved Population Trend LOE, because these species generally occurred in low numbers in entrainment and impingement samples. Assigning an impact level of “Low” to unresolved SOC assessment for these species in the FSEIS resulted in a final RIS impact finding (WOE conclusion) of “Low.” In the present analysis, the NRC staff assigned a WOE impact value of “Unresolved” in such cases to make the decision rules for both LOEs the same, to remove an assumption in the SOC analysis, and to more clearly communicate a lack of resolution in the SOC analysis where it occurred. Differences in three individual species (alewife, weakfish, and white perch) conclusions for the level of impact between the current analysis and the FSEIS are related to the years of data used in the analysis, in a manner similar to that described above for hogchoker (Table 4–2).

Atlantic and shortnose sturgeon are both listed under the ESA. In Supplement 1 to the FSEIS, the NRC (2013b) described the unresolved impacts to Atlantic and shortnose sturgeon as “Small.” The NRC staff has received no information that would further resolve these impact levels. However, in 2013, the NRC amended its regulations at Table B–1 of Appendix B to 10 CFR Part 51 (2013a) and issued Revision 1 to NUREG–1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) (NRC 2013a). Based on the amended regulations and guidance contained in the revised GEIS, the NRC now expresses its findings for ESA-listed species in language prescribed by the ESA rather than as “SMALL,” “MODERATE,” or “LARGE.” Section 7.1.4 of this supplement to the FSEIS revises the NRC staff’s National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. 4321 et seq.), findings for ESA-listed species, including the staff’s findings for Atlantic and shortnose sturgeon. As stated in Section 7.1.4, the NRC’s revised NEPA finding for each of the two sturgeon species is that IP2/IP3 license renewal “may affect, but [is] not likely to jeopardize the continued existence of” those species based on the outcome of formal consultation with the NMFS. To be consistent, the NRC staff incorporates this revised NEPA finding in the WOE results for the two Federally listed species (see Table 4–2).

Table 4–2. WOE Impacts of I&E at IP2 and IP3 on Hudson River RIS in the FSEIS, Entergy’s Analysis, and the Present Analysis

Species	FSEIS ^(a)	Entergy ^(b)	Present Analysis
Alewife	Moderate	Small	Small ^(f)
American Shad	Small	Small	Small
Atlantic Menhaden	Small ^{(c)(d)}	Small ^{(c)(d)}	Unresolved ^(c)
Atlantic Sturgeon	Small ^{(c)(d)}	Small ^{(c)(d)}	May affect, but not likely to jeopardize the continued existence of ^{(c)(d)(e)}
Atlantic Tomcod	Small	Small	Small
Bay Anchovy	Small	Small	Small
Blueback Herring	Large	Small	Large
Bluefish	Small	Small	Small
Gizzard Shad	Small ^{(c)(d)}	Small ^{(c)(d)}	Unresolved ^{(c)(d)}
Hogchoker	Large	Moderate	Moderate
Rainbow Smelt	Moderate-Large	Moderate	Large
Shortnose Sturgeon	Small ^{(c)(d)}	Small ^{(c)(d)}	May affect, but not likely to jeopardize the continued existence of ^{(c)(d)(e)}
Spottail Shiner	Small	Small	Small
Striped Bass	Small	Moderate	Small
Weakfish	Moderate	Small	Small ^(f)

Species	FSEIS ^(a)	Entergy ^(b)	Present Analysis
White Catfish	Small	Small	Small
White Perch	Large	Small	Small ^(f)
Blue Crab	Small ^{(c)(d)}	Small ^{(c)(d)}	Unresolved ^{(c)(d)}

^(a) NRC 2013b

^(b) Entergy 2015c

^(c) Population Trend LOE could not be established.

^(d) SOC could not be established using Monte Carlo simulation.

^(e) In Supplement 1 to the FSEIS, the NRC staff described the unresolved impacts to Atlantic and shortnose sturgeon as “Small.” In Section 7.1.4 of this supplement, the NRC staff revises its NEPA finding for these species as a result of the revised GEIS (NRC 2013a) and the outcome of formal consultation with the NMFS for IP2 and IP3 license renewal. The NRC staff incorporated these revised findings into its final RIS impact findings and WOE results.

^(f) Change in conclusion from FSEIS may be related to the difference in years of data used in the analysis.

4.4 Engineered Design and Operational Controls Required in Entergy’s State Pollutant Discharge Elimination System Permit

On April 24, 2017, the NYSDEC (2017c) issued a renewed SPDES permit for IP2 and IP3 with an effective date of May 1, 2017. The permit allows Entergy to continue to withdraw cooling water and discharge wastewater to the Hudson River, and it requires Entergy to minimize impacts to aquatic resources through the following four fish protection measures:

- Entergy must schedule and take its annual planned refueling and maintenance outage at one unit, which in recent years has averaged approximately 30 unit days, between February 23 and August 23.
- Entergy must continue to operate the existing fish impingement mitigation measures, such as the Ristroph screens and the fish return sluiceway.
- Entergy will maintain cooling water flow at the minimum necessary for efficient operations.
- Entergy must continue to conduct long-term Hudson River fish monitoring.

These four conditions are similar to the requirements described within the Hudson River Settlement Agreement (HRSA) (1980), the four subsequent consent orders, and the 1987 SPDES permit that was administratively continued from 1992 through 2017 (NYSDEC 2017a, 2017c). However, the NYSDEC expanded the allowable timeframe for the mitigative outages in the 2017 SPDES permit: the mitigative outage timeframe in the original HRSA was from May 10 through August 10, whereas the 2017 SPDES permit states that the outages may occur between February 23 and August 23. When the actual outages occur is one source of annual variation that will affect entrainment rates. For instance, if outages occur in early February, when entrainment is relatively low, rather than in May, when entrainment is high for many species, the outages would not be as effective in reducing entrainment. See Section 4.5.2 for a more detailed discussion regarding intake flow and entrainment uncertainty.

In August 2014, EPA published a final rule establishing requirements under Section 316(b) of the Clean Water Act of 1977, as amended (CWA) (33 U.S.C. 1251 et seq.) for cooling water intake structures at existing facilities (Phase II Rule; 79 FR 48300). The final Phase II rule requires existing facilities to implement the best technology available (BTA) to reduce

impingement and entrainment. Four approaches to reduce impingement and entrainment mortality include: (1) flow reduction, (2) including technologies in the cooling water intake design that gently exclude organisms or collect and return organisms without harm, (3) relocating the facility's intake to a less biologically rich area in a water body, and (4) reducing the intake velocity (79 FR 48300). In the 2017 IP2 and IP3 SPDES permit, the NYSDEC (2017c) determined that the terms within the January 8, 2017, Closure Agreement and conditions in the SPDES permit constitute BTA for minimizing adverse environmental impact based on the four fish protective measures listed above.

Given that these fish protection measures are similar to or continued from the requirements described in the previous IP2 and IP3 SPDES permit, and given that the NYSDEC (2017c) determined that Entergy will be operating the BTA to minimize impingement and entrainment impacts, the NRC staff concludes that flow rates and other efforts to reduce impingement and entrainment will be similar to those in the past. However, the NRC staff notes that many sources of uncertainty will influence the intensity of impingement and entrainment impacts even with Entergy's implementation of these fish protection measures. Section 4.5 of this supplement discusses uncertainty in detail.

4.5 Uncertainty Associated with the Impingement and Entrainment Analysis

The NRC staff used a retrospective assessment of the past impingement and entrainment impacts to provide a prospective assessment of potential future impacts. While this approach is valuable in assessing unknown impacts, the NRC staff's analysis inherently includes some degree of uncertainty. Uncertainty generally increases with natural variability, inconsistent or infrequent sampling, and poorer quality data. The following sections address the main sources of uncertainty related to the NRC staff's analysis for IP2 and IP3 license renewal for both past studies and future predictions.

4.5.1 Uncertainty Related to Past Aquatic Studies

One method of detecting impacts from past activities on fish populations is to compare the population size or density before and during operations to determine whether changes have occurred and if such changes can be attributed to power plant operations. Ideally, sampling would occur both before and after operations began, in locations that could be affected by power plant operations, as well as at control sites that would be beyond the influence of plant operations. Under such a scenario, if power plant operations were to affect fish populations, fish abundances likely would be lower post-operation as compared to fish abundances before operations near the plant, whereas the decline would not occur or would not occur at the same rate at the control sites beyond the operational influence of the power plant. However, several factors regarding sampling and data quality can confound the results of statistical tests applied to examine changes in populations over time, as described below. In addition, multiple stressors can add uncertainty regarding the individual contribution of a single stressor to declines in a fish population.

4.5.1.1 Sampling Quality

Ecological sampling quality is highest when a consistent methodology is repeated over long time periods. Variations in sampling equipment, the frequency and timing of sampling events, and sampling locations, decrease the ability of statistical tests to accurately detect changes in population structures. For example, a test may detect a change in population size, but the change may be due to inconsistencies in sampling methodology if new sampling gear, sampling sites, or other procedures change.

The analysis in this FSEIS supplement includes uncertainty because most recent population studies do not use the same methodology before and during operations. Specifically, the Hudson River Biological Monitoring Program's collection methodology changed in 1985 when researchers began using a different type of gear to collect fish (see Appendix A for more details). The more recent gear type in use and associated collection methods are more efficient at capturing certain species (e.g., bay anchovy, American shad, and weakfish) (NYPA 1986). Therefore, analyzing population trends before and after 1985 could be confounded by this gear change. For instance, statistical tests analyzing population sizes over the time period 1979 through 2011 could detect population changes that did not actually occur or did not occur to the same extent as indicated in the statistical test because the observed population shift was the result of the change in gear type rather than the result of an actual shift in population size. To remove this potentially confounding factor, the NRC staff analyzed population trends in the present analysis from 1985 through 2011 to ensure that the same gear and sampling methodology occurred throughout the time period being examined.

Nonetheless, the NRC staff acknowledges that by not including the earlier data (1979–1984), the statistical analyses do not examine whether a species declined soon after IP2 and IP3 operations began until the 1985 gear change. The NRC staff examined this source of uncertainty in Appendix A.3.4.1 and determined that seven RIS showed a significant decline between 1979 and 1985, including alewife, Atlantic tomcod, bay anchovy, blueback herring, bluefish, weakfish, and white perch. For these species, a lack in population decline from 1985 through 2011 may be because the populations already had declined before 1985.

4.5.1.2 *Data Quality*

Data quality, both in terms of accuracy and sufficiency, can also influence the degree of uncertainty within an analysis. For entrainment studies, a common issue related to data quality is the ability to accurately identify the species of fish eggs and larvae due to morphological similarities among species within the same family in early life stages. Reliable identification is also difficult with poor-quality specimens, such as fish that have decayed or are otherwise degraded. In the IP2 and IP3 entrainment study, many specimens within the herring family could only be identified to the family level, as previously described in the 2010 FSEIS (NRC 2010). For some seasons and life stages, individuals identified as "Herring Family" and "*Alosa* species" make up a substantial portion of total entrainment. If these herrings were identified to species, the conditional entrainment mortality rates of those species likely would be higher and the SOC analysis would be more likely to discern adverse entrainment effects for these species. Thus, the entrainment estimates for species within the herring family may underestimate entrainment rates because some specimens likely were reported within the "Herring Family" category rather than reported to the species level. RIS within the herring family include alewife, American shad, Atlantic menhaden, blueback herring, and gizzard shad.

Insufficient data also increase uncertainty because statistical analyses are more likely to detect significant trends with more data points. For the IP2 and IP3 entrainment study, several RIS (Atlantic sturgeon, shortnose sturgeon, and blue crab) had too few catches or observations; therefore, insufficient data were reported for the NRC staff to conduct statistical analyses for these species. In such cases, the NRC staff did not have enough data to detect a population trend or to model the SOC. Some statistical analyses were inconclusive, even in cases where sufficient data were available to detect a population trend, in part because of the low number of reported entrainment observations. In such cases, the NRC staff was able to make a population trend finding but was unable to model the SOC. This uncertainty was the main factor in why the NRC staff determined that the impacts of impingement and entrainment were "unresolved" for Atlantic menhaden and gizzard shad.

4.5.1.3 *Attributing Causes to Population Changes*

When a statistical test indicates that a population has declined, ecologists often review the local and regional environmental history to better understand the likely stressors contributing to the decline. Ecological communities within the Hudson River are complex systems that have been exposed to a variety of anthropogenic (e.g., impingement, entrainment, thermal, and chemical effluents) and natural (e.g., low recruitment, parasites, predation) stressors. These stressors often interact with one another, whereby the effects of multiple stressors may be synergetic or more intense than if the ecological community were exposed to individual stressors during separate and discrete time periods. These complex, interrelated factors add uncertainty when attributing population declines to specific stressors. Often, there is some level of uncertainty regarding which stressors contributed to a decline, the relative contribution of each stressor, and how multiple stressors may have interacted to contribute to a decline.

Aquatic resources near IP2 and IP3 are exposed to a variety of interacting stressors, including the impacts from multiple power plants (impingement, entrainment, and thermal stress); climate change; habitat loss; competition and predation; fishing pressure; declines in water quality; disease; and parasites (see Section 4.8.1 of the 2010 FSEIS (NRC 2010)). Therefore, although IP2 and IP3 operations may have contributed to the decline of some species, it is likely that other anthropogenic and natural stressors also influenced such declines.

The documented decline in rainbow smelt in the Hudson River after 1994 (see Section 4.2), for example, was likely the interactive result of multiple stressors. In its comments on the draft supplement to the FSEIS, Entergy (2016a) provided new information documenting the concomitant decline of rainbow smelt and the increase of the microsporidian parasite *Glugea hertwigi*. While the parasite might have increased the rate at which this species declined, it is likely that the parasite was one of multiple stressors. The NRC staff documented a long-term decline in rainbow smelt, as well as variable population levels since IP2 and IP3 began operations, which suggests that IP2 and IP3 operations have had a destabilizing effect on rainbow smelt populations (see Appendix A in this supplement and Appendices H and I in the 2010 FSEIS (NRC 2010)). High population variance is often an indicator of population and ecosystem instability and a warning of possible local population extinction (e.g., Pimm et al. 1988; O'Grady et al. 2004; Carpenter and Brock 2006). Given the smaller, more vulnerable population size, infestation of a parasite or other disease could be more likely to cause a population to crash as compared to a healthier, larger population in which the loss of many individuals would have a smaller proportional impact. In addition, *Glugea hertwigi* cyst growth may increase with increasing water temperature, such as near IP2's and IP3's thermal discharge (Delisle 1969). Therefore, it is likely that the interacting stressors of IP2 and IP3 operation and the microsporidian parasite *Glugea hertwigi* resulted in the collapse of the rainbow smelt population. However, the NRC staff acknowledges that there is uncertainty regarding the relative contribution of each of these factors, as well as other past and present biological and physical stressors.

The NRC staff also notes that other studies have documented multiple, interacting stressors at power plants that have resulted in the decline of aquatic organisms. For example, at the Diablo Canyon Power Plant, predation by sea otters initially lowered population levels of black abalone in the 1970s and 1980s (PG&E 2014). Soon thereafter, the plant's thermal effluent further stressed the black abalone population near the plant discharge in Diablo Cove. Further, in the 1990s, Pacific Gas & Electric Company documented a rapid decline of black abalone due to withering syndrome. Several studies have documented that mortality from withering syndrome occurs more often or more rapidly in warmer waters (e.g., Lafferty and Kuris 1993; Raimondi et al. 2002; Ben-Horin et al. 2013). Therefore, it is likely the combined, synergistic effect of all three factors—(1) lowered abundance levels from intense predation, making the

population more vulnerable to future population stressors; (2) thermal stress from exposure to the Diablo Canyon discharge; and (3) population crashes due to withering syndrome—led to the decline in black abalone near the Diablo Canyon Power Plant. Similarly, the combined effects of the microsporidian parasite *Glugea hertwigi*, impingement and entrainment at IP2 and IP3 and at other Hudson River power plants, and thermal effects from power plant discharges could have interacted to cause the rainbow smelt population to collapse.

4.5.2 Uncertainty Related to Future Predictions

As previously described, the NRC staff's analysis uses a retrospective assessment of the impacts to the aquatic ecosystem resulting from IP2 and IP3 operations in order to provide a prospective assessment for future impacts. This prospective assessment requires the staff to assume that many of the environmental and operational conditions during the past will continue during the license renewal period. One of the main operational conditions that can impact entrainment is the cooling water intake flow rate, because entrainment tends to be positively correlated with flow rates. In some cases, the volume of water withdrawn from a waterbody can be used as a proxy for the rate of entrainment through the cooling system of a nuclear power plant. Such a proxy for the entrainment rate typically assumes equal distribution of planktonic organisms throughout the waterbody and that the volume of water withdrawn would be proportional to the percent of planktonic organisms entrained into the cooling system (EPA 2002a; NRC 2013b).

The NRC staff notes that using water flow as a proxy for entrainment is a broad generalization that is more accurate for certain species, depending on organism distribution, movement, and reproductive patterns. For example, EA (1984) conducted a study at IP2 and IP3 that examined the correlation between entrainment and water withdrawal. EA (1984) determined that when the intake flow rate decreased 35 percent, entrainment decreased 38.6 percent for striped bass, 40.9 percent for white perch, 47.5 percent for bay anchovy, and 30.9 percent for Atlantic tomcod. However, entrainment only decreased by 17.3 percent for American shad and 7.6 percent for other clupeids. Nonetheless, the NRC staff determined that broadly examining past withdrawal rates and comparing it to future withdrawal limits is one way to estimate the relative level of entrainment impacts in the future.

From 1981 through 1991, HRSA (1980) governed water withdrawals at IP2 and IP3, which required IP2 and IP3 to conduct mitigative outages or to temporarily stop withdrawing water from the Hudson River to reduce entrainment. The withdrawal limitations applied during the period between May 10 and August 10 correspond with the time period when the majority of entrainment occurs at IP2 and IP3 (EA 1984, 1985; NYSDEC 2003). The HRSA (1980) stated that the operators of IP2 and IP3 would use their best reasonable efforts to operate dual intake pumps such that the intake flow rates ranged from 1,452 million gallons per day (mgd) (2,246 cubic feet per second (cfs)) to 2,419 mgd (3,743 cfs) depending on the time of year (Table 4–3). Based on the flow rates described in the HRSA, the average daily intake over the course of a year would be 1,836 mgd (2,841 cfs). The HRSA allowed Entergy to achieve the lower flow rates at IP2 and IP3 by conducting mitigative outages or by implementing a temporary cessation in withdrawing water for 42-unit days within the May 10 to August 10 window, or by setting the dual intake pumps to only withdraw a percentage of the maximum intake flow.

Table 4–3. Estimated Intake Flow Rates Under the 1980 Hudson River Settlement Agreement

Dates	Flow Rate (mgd) ^(a)
January 1-May 15	1,452
May 16-22	1,613
May 23-31	1,935
June 1-8	2,105
June 9-September 30	2,419
October 1-31	2,105
November 1-December 31	1,451

^(a)Flow rate assumes combined flow for two units.
To convert million gallons per day (mgd) to cubic feet per second (cfs), multiply by 1.547.

Source: HRSA 1980

The HRSA (1980) acknowledged that the actual intake flow may differ from the flow rates listed in Table 4–4 because of water quality standards, river water temperature, or other operational or environmental conditions. For example, EA (1984, 1985) describes the actual intake flow rates at IP2 and IP3 from May 3 through August 15, 1983, and from May 3 through August 11, 1984, respectively (see Table 4–4). The average intake flow during the mitigative flow period for these years was 1,434 mgd (2,218 cfs) in 1983 and 1,498 mgd (2,317 cfs) in 1984 (EA 1984, 1985).

Table 4–4. Intake Flow Rates during the Mitigative Flow Periods, 1983 and 1984

Dates ^(a)	1983 Flow Rate ^(b) (mgd) ^(c)	1984 Flow Rate ^(b) (mgd) ^(c)
May 3-15	1,151	2,030
May 16-22	1,210	2,107
May 23-31	1,379	2,249
June 1-8	1,726	1,586
June 9-August 15	1,218	1,417

^(a)In 1983, EA (1984) reported flow rates from May 3 through August 15. In 1984, EA (1985) reported flow rates from May 3 through August 11.

^(b)Flow rates are for both IP2 and IP3.

^(c)To convert million gallons per day (mgd) to cubic feet per second (cfs), multiply by 1.547.

Sources: EA 1984, 1985

Between 1992 and 1998, four subsequent consent orders issued by the Supreme Court of the State of New York for IP2 and IP3 generally incorporated the mitigative outage requirements (NYSDEC 2003, 2017a). In addition, the 1987 SPDES permit for IP2 and IP3, which was administratively continued through 2017 following its expiration in 1992, incorporated the mitigative outage requirements described in the HRSA (1980) (NYSDEC 2017a).

More recent flow data are available through the State of New York (2017), which publishes withdrawal rates for facilities with the capacity to withdraw 100,000 gallons or more per day (0.1 mgd; 0.15 cfs) of surface or groundwater, including IP2 and IP3. From 2009 through 2015, the average daily withdrawal rate at IP2 and IP3 ranged from 1,963 to 2,068 mgd (3,037 to 3,200 cfs) and the maximum daily withdrawal ranged from 2,477 to 2,521 mgd (3,832 to 3,901 cfs) (see Table 4–5).

Table 4–5. Withdrawal Rates at IP2 and IP3, 2009 through 2015

Year	Day Withdrawal (mgd) ^(a)	
	Average	Maximum
2009	1,986	2,491
2010	1,963	2,512
2011	2,024	2,489
2012	2,068	2,521
2013	2,029	2,477
2014	2,022	2,484
2015	2,064	2,514

^(a) To convert million gallons per day (mgd) to cubic feet per second (cfs), multiply by 1.547.

Source: NYSDEC 2017b

As described in Section 4.4, Entergy’s 2017 SPDES permit lists two conditions that limit the intake flow rate for IP2 and IP3. The SPDES permit specifically requires Entergy (1) to schedule and take its annual planned refueling and maintenance outage at one unit, which in recent years has averaged approximately 30 unit days, between February 23 and August 23 each year and (2) to maintain cooling water flow at the minimum necessary for efficient operation. These conditions are similar to the requirements described in the HRSA (1980), the four subsequent consent orders, and the 1987 SPDES permit (NYSDEC 2017a, 2017d). However, the timeframe for the mitigative outages has been expanded. In the original HRSA, the timeframe was from May 10 through August 10 whereas the 2017 SPDES permit states that the outage may occur between February 23 and August 23. As described in Section 4.4, the timing of these outages, which determines when the intake flow is reduced, is one source of uncertainty that is likely to influence entrainment levels differently each year. For example, if an outage occurs in early February one year, when spawning and entrainment is relatively low, and then in May another year, when spawning and entrainment is high for many species, the outages would be more effective at reducing entrainment during the second year because the outages would coincide with peak spawning and entrainment periods. Therefore, even if the annual average flow rates remain similar across years, entrainment may vary depending on when the outages occur and whether the outages overlap with peak spawning and entrainment periods. The NRC staff notes that the timing of these outages and whether they coincide with peak spawning and entrainment periods has always been a source of uncertainty, but this source of uncertainty has increased now that the allowable time period for the outages has been expanded in the 2017 SPDES permit.

5.0 NEW ENVIRONMENTAL ISSUES RESULTING FROM THE REVISION OF 10 CFR PART 51

In accordance with the requirements in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 51, “Environmental protection regulations for domestic licensing and related regulatory functions,” the U.S. Nuclear Regulatory Commission (NRC) staff prepared the final supplemental environmental impact statement (FSEIS) for Indian Point Nuclear Generating Unit Nos. 2 and 3 (IP2 and IP3) as a supplement to NUREG–1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) (NRC 2013a). The NRC staff originally issued the GEIS in 1996, and issued Addendum 1 to the GEIS in 1999. The GEIS established 92 separate issues for the NRC staff to consider. Of these issues, the NRC staff determined that 69 are generic to all plants (Category 1), whereas 21 issues do not lend themselves to generic consideration (Category 2). Two other issues remained uncategorized: (1) environmental justice and (2) chronic effects of electromagnetic fields. These two issues must be evaluated on a site-specific basis. A list of all 92 issues can be found in Appendix B to 10 CFR Part 51.

On June 20, 2013, the NRC published a final rule (*Federal Register* (FR) (78 FR 37282)), which revised the agency’s regulations in 10 CFR Part 51. Specifically, the final rule updated the potential environmental impacts associated with the renewal of an operating license for a nuclear power reactor for an additional 20 years. A revised GEIS (NRC 2013a), which updates the 1996 GEIS, provides the technical basis for the final rule. The revised GEIS specifically supports the revised list of issues in the National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. 4321 et seq.), and associated environmental impact findings for license renewal in Table B–1 in Appendix B to Subpart A of the revised 10 CFR Part 51. The revised GEIS and final rule reflect lessons learned and knowledge gained during previous license renewal environmental reviews. In addition, public comments received on the draft revised GEIS and rule and those received during previous license renewal environmental reviews were reexamined to validate findings on existing environmental issues and to identify new ones.

The final rule identifies 78 environmental impact issues; 17 of these issues will require plant-specific analysis. The final rule consolidates similar Category 1 and 2 issues, changes some Category 2 issues into Category 1 issues, and consolidates some of those issues with existing Category 1 issues. The final rule also adds new Category 1 and 2 issues.

The final rule became effective July 22, 2013, after its publication in the *Federal Register* (78 FR 37282). Compliance by license renewal applicants is required for license renewal Environmental Reports (ERs) submitted later than 1 year after publication (i.e., applications submitted after June 20, 2014). Because Entergy Nuclear Operations, Inc. (Entergy), submitted its ER before the effective date of the final rule, it is not required to submit an ER that complies with the final rule. However, under NEPA, the NRC must consider and analyze potentially significant impacts, including impacts described in the final rule as new Category 2 issues and, to the extent there is any new and significant information, the potentially significant impacts described in the final rule as new Category 1 issues. Table 5–1 lists the environmental issues added to the scope of license renewal subsequent to publication of the FSEIS; the following sections document the NRC staff’s evaluation of those issues.

Table 5–1. Revised 10 CFR Part 51 Issues

Issues	2013 GEIS Section	Category
Air quality impacts (all plants)	4.3.1.1	1
Geology and soils	4.4	1
Effects of dredging on surface water quality	4.5.1.1	1
Radionuclides released to groundwater	4.5.1.2	2
Effects on terrestrial resources (noncooling system impacts)	4.6.1.1	2
Exposure of terrestrial organisms to radionuclides	4.6.1.1	1
Cooling system impacts on terrestrial resources (plants with once-through cooling systems or cooling ponds)	4.6.1.1	1
Exposure of aquatic organisms to radionuclides	4.6.1.2	1
Effects of dredging on aquatic organisms	4.6.1.2	1
Impacts of transmission line ROW management on aquatic resources	4.6.1.2	1
Human health impacts from chemicals	4.9.1.1.2	1
Physical occupational hazards	4.9.1.1.5	1
Minority and low-income populations	4.10.1	2
Cumulative impacts	4.13	2

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51; NRC 2013a

In addition to the issues identified in Table 5–1, the NRC staff has included in this supplement an updated evaluation of greenhouse gas (GHG) emissions at IP2 and IP3 and an analysis of the cumulative impacts of GHG emissions on climate. Although the NRC did not add the issues of GHG emissions and climate change as part of the update to Table B–1 in Appendix B to Subpart A of the revised 10 CFR Part 51, the Commission’s Memorandum and Order in CLI-09-21 direct the NRC staff to “include consideration of carbon dioxide and other GHG emissions in its environmental reviews for major licensing actions under [NEPA]” (NRC 2009b). Accordingly, the NRC staff conducts plant-specific analyses in each license renewal review of the impacts of GHG emissions over the course of the license renewal term (NRC 2013a).

5.1 Air Quality Impacts (All Plants)

The NRC approved a revision to its environmental regulations in 10 CFR Part 51, including revisions to the list of issues and associated environmental impact findings for license renewal in Table B–1 in Appendix B to Subpart A of the revised 10 CFR Part 51. With respect to air quality, the final rule amended Table B–1 by changing the issue, “Air quality during refurbishment (nonattainment and maintenance areas),” from a Category 2 (site-specific) issue to a Category 1 (generic) issue and renamed the issue, “Air quality impacts (all plants).” The Category 1 issue, “Air quality impacts (all plants),” considers air quality impacts from continued operation and refurbishment associated with license renewal and has an impact level of SMALL. The 2010 FSEIS (NRC 2010) considered the air quality impacts during refurbishment, but the air quality impacts from continued operation were not discussed. The discussion is revised below to address air quality impacts from continued operation during the license renewal term.

5.1.1 Revisions to Section 2.1.5.1, “Nonradioactive Waste Streams,” and Section 2.2.4.3, “Air Quality,” of the FSEIS

Section 2.2.4.3 of the 2010 FSEIS (NRC 2010) describes the ambient air quality in the region where IP2 and IP3 are located and in the vicinity of the site. The NRC staff (NRC 2014i) issued a request for additional information (RAI) requesting that Entergy identify any new and significant information pertinent to the Category 1 issue, “Air Quality impacts (all plants).” Entergy’s response (Entergy 2015a) provided updated information on IP2 and IP3 air permits and air quality designations in the region where IP2 and IP3 are located and new information on the air permit compliance history at IP2 and IP3. As a result of this information, the NRC staff has updated Section 2.1.5.1 and Section 2.2.4.3 of the FSEIS as described below.

Lines 6-7 on page 2-23 in Section 2.1.5.1 of the FSEIS are revised as follows:

Emissions are managed in accordance with **the combined** IP2 and IP3 air quality permits ~~3-5522-00011/00026 and 3-5522-00105/00009,~~ **respectively** (Entergy ~~2007a~~**2015a**).

After line 4 on page 2-30 in Section 2.2.4.3 of the FSEIS, the following text is to be added:

IP2 and IP3 are located in Westchester County, New York, which is part of the New Jersey–New York–Connecticut Interstate Air Quality Control Region (40 CFR 81.13). Air Quality Control Regions (AQCRs) include inter/intrastate counties that share a common airshed. With respect to NAAQS, Westchester County is designated a nonattainment area for ozone (O₃), and a maintenance area for carbon monoxide (CO) and particulate matter less than 2.5 microns in diameter (PM_{2.5}).

Lines 6-8 on page 2-30 in Section 2.2.4.3 of the FSEIS are revised as follows:

The 50-mi (80-km) radius includes **designated** nonattainment areas for the ozone (O₃) 8-hour standard, **and** particulate matter less than 10 microns in diameter (PM₁₀), ~~and particulate matter less than 2.5 microns in diameter (PM_{2.5})~~ **and designated maintenance areas for carbon monoxide (CO) and particulate matter less than 2.5 microns in diameter (PM_{2.5}).**

Lines 11-26 on page 2-30 in Section 2.2.4.3 of the FSEIS are modified as follows:

~~The currently designated nonattainment areas for Connecticut counties within a 50-mi (80-km) radius of the site are as follows:~~

- ~~• Fairfield and New Haven*—O₃ and PM_{2.5}~~
- ~~• Litchfield—O₃~~

~~The currently designated nonattainment areas for New Jersey counties within a 50-mi (80-km) radius of the site are as follows:~~

- ~~• Bergen, Essex, Hudson, Morris, Passaic, Somerset, and Union*—O₃ and PM_{2.5}~~
- ~~• Sussex*—O₃~~

~~The currently designated nonattainment areas for New York counties within a 50-mi (80-km) radius of the site are as follows:~~

- ~~Bronx, Kings, Nassau, Orange, Queens, Richmond, Rockland, Suffolk, and Westchester*—O₃ and PM_{2.5}~~
- ~~Dutchess and Putnam—O₃~~
- ~~New York*—O₃, PM₁₀, and PM_{2.5}~~

~~Note that the counties labeled with an “*” are part of the EPA-designated “New York—New Jersey—Long Island Nonattainment Area” (EPA 2006a).~~

The currently designated nonattainment and maintenance counties for Connecticut, New Jersey, and New York counties within a 50-mi (80-km) radius of IP2 and IP3 are identified in Table 2-0.

Table 2-0. Nonattainment and Maintenance Areas for Connecticut, New Jersey, and New York Counties within a 50-mi (80-km) Radius of IP2 and IP3

State	County	Designation	
		Nonattainment Area	Maintenance Area
Connecticut	Fairfield	O ₃	CO and PM _{2.5}
	Litchfield	O ₃	CO
	New Haven	O ₃	PM _{2.5}
New Jersey	Bergen	O ₃	CO and PM _{2.5}
	Essex	O ₃	CO and PM _{2.5}
	Hudson	O ₃	CO and PM _{2.5}
	Middlesex	O ₃	CO and PM _{2.5}
	Morris	O ₃	PM _{2.5}
	Passaic	O ₃	CO and PM _{2.5}
	Somerset	O ₃	PM _{2.5}
	Sussex	O ₃	
	Union	O ₃	CO and PM _{2.5}
	Warren	O ₃	
New York	Bronx	O ₃	CO and PM _{2.5}
	Dutchess	O ₃	
	Kings	O ₃	CO and PM _{2.5}
	Nassau	O ₃	CO and PM _{2.5}
	New York	O ₃ and PM ₁₀	CO and PM _{2.5}
	Orange	O ₃	PM _{2.5}
	Putnam	O ₃	

Queens	O ₃	CO and PM _{2.5}
Richmond	O ₃	CO and PM _{2.5}
Rockland	O ₃	CO
Suffolk	O ₃	CO
Westchester	O ₃	CO and PM _{2.5}

Source: EPA 2015a

Lines 27-30 on page 2-30 in Section 2.2.4.3 of the FSEIS are revised as follows:

~~New York State air permits for IP2 and IP3, 3-5522-00011/00026 and 3-5522-000105/00009, respectively, regulate emissions from boilers, turbines, and generators. These permits restrict nitrogen oxides (NO_x) emissions to 23.75 tons (t) (22 metric tons (MT)) per year per station by restricting engine run time and fuel consumption.~~

The New York State Department of Environmental Conservation (NYSDEC) issued a combined IP2 and IP3 air permit (Air State Facility Permit No. 3-5522-00011/00026) in December 2014 (NYSDEC 2015a). The air permit regulates air emissions from combustion sources at IP2 and IP3 and restricts nitrogen oxide emissions to 24.5 tons (22.2 metric tons) per year. Permitted air emission sources at IP2 and IP3 include gas turbines and heating boilers. These are operated infrequently during testing and maintenance activities (Entergy 2015a). NYSDEC Air State Facility Permits are issued to facilities that are not considered to be a major source of air pollutants (i.e., a source that directly emits or has the potential to emit 100 tons per year (91 metric tons per year) or more of a regulated pollutant); therefore, IP2 and IP3 are considered minor air emission sources (Entergy 2015a; NYSDEC 2015b). IP2 and IP3 have been in compliance with the Air State Facility Permit and have not received any notice of violations over the last 5 years (2010 to 2014) (Entergy 2015a; EPA 2015b).

Entergy operates emergency power internal combustion engines (i.e., diesel generators) that are exempt from the combined IP2 and IP3 air permit (Air State Facility Permit No. 3-5522-00011/00026). These exempt sources are operated infrequently and for short durations during maintenance testing (Entergy 2015a). Exempt sources are subject to national emission standards for hazardous air pollutants for internal combustion engines contained in 40 CFR Part 63, Subpart ZZZZ. In accordance with 6 NYCRR Subpart 201-3, Entergy maintains records of operation run times of exempt sources to ensure that they do not exceed the limits set for emergency internal combustion engines.

After line 2 on page 2-31 in Section 2.2.4.3 of the FSEIS, the following text is to be added:

EPA recommends that emission sources located within 62 mi (100 km) of a Class I area be modeled to consider adverse

impacts (EPA 1992). Considering the distance to the nearest Class I area and the minor amount of air emissions from the site, there is little likelihood that ongoing activities at IP2 and IP3 adversely affect air quality and air quality-related values (e.g., visibility or acid deposition) in any of the Class I areas.

5.1.2 Revisions to Section 3.2.3, “Air Quality during Refurbishment (Nonattainment and Maintenance Areas)”

As a result of the change of the issue from Category 2 to Category 1 and updated information pertaining to the air quality designations in the region where IP2 and IP3 are located, the NRC staff has removed and revised its discussion in Section 3.2.3 of the IP2 and IP3 2010 FSEIS (NRC 2010) regarding air emissions resulting from refurbishment activities and is addressing the impacts from continued operation and refurbishment associated with license renewal together in Section 5.1.3 of this supplement.

Lines 7-42 on page 3-9 and lines 1-5 on page 3-10 in Section 3.2.3 are deleted; these impacts are addressed in Section 5.1.3 of this supplement:

~~3.2.3 Air Quality During Refurbishment (Nonattainment and Maintenance Areas)~~

~~Air quality during refurbishment (nonattainment and maintenance areas) is a Category 2 issue. Table B-1 of Appendix B to 10 CFR Part 51, Subpart A, notes the following:~~

~~Air quality impacts from plant refurbishment associated with license renewal are expected to be small. However, vehicle exhaust emissions could be cause for concern at locations in or near nonattainment or maintenance areas. The significance of the potential impact cannot be determined without considering the compliance status of each site and the numbers of workers expected to be employed during the outage.~~

~~The May 14, 2008, RAI response from Entergy (Entergy 2008b) indicates that the replacement of reactor vessel heads and CRDMs for IP2 and IP3 will result in minor impacts to air quality. Citing the GEIS, Entergy states that the only potential sources of impacts to air quality would be (1) fugitive dust from site excavation and grading for construction of any new waste storage facilities and (2) emissions from motorized equipment and workers' vehicles. Entergy indicates that the bulk of air quality impacts during the postulated refurbishment activity would result from exhaust emissions released by onsite motorized equipment and workers' vehicles (Entergy 2008b). These effects include temporary increases in atmospheric concentrations of nitrogen oxides (NO_x), carbon monoxide (CO), sulfur dioxide (SO₂), volatile organic compounds (VOCs), ammonia, and particulate matter (PM). A table summarizing the attainment status of the counties within the immediate area of IP2 and IP3 shows nonattainment of the National Ambient Air Quality Standards (NAAQS) for 8—ozone in Dutchess, Orange, Putnam, Rockland, and Westchester Counties. There is nonattainment of the NAAQS for particulate matter, 2.5 microns or less in diameter (PM_{2.5}) in Orange, Rockland, and Westchester Counties. Westchester County is designated as a maintenance county for CO. Based on a conservative assumption that 400 additional vehicles would travel to and from the site each day during a 65-day~~

~~outage period (conservative because Entergy projects that only 300 additional workers over 60 days could accomplish the replacement activities), Entergy estimated that air emissions of VOCs, CO, and NO_x would increase by 0.95 tons (0.86 metric tons (MT)), 16.1 tons (14.6 MT), and 1.02 tons (0.926 MT), respectively (Entergy 2008b). The regulatory conformity thresholds for VOCs, CO, and NO_x are 50 tons (45 MT), 100 tons (90.7 MT), and 50 tons (45 MT), respectively, as indicated in 40 CFR 51.853(b). A comparison of Entergy's conservative estimates for vehicle emissions versus the associated regulatory conformity levels indicates that none of the thresholds would be exceeded. Based on this analysis, the NRC staff finds that air quality impacts during the postulated reactor vessel head and CRDM replacement would be SMALL.~~

5.1.3 Category 1—Air Quality Impacts (All Plants)

As discussed in the 2013 GEIS (NRC 2013a), air emissions resulting from refurbishment activities at locations in or near air quality nonattainment or maintenance areas would be short lived and would cease after refurbishment activities are completed. Operating experience has shown that the scale of refurbishment activities has not resulted in exceedance of the *de minimis* thresholds for criteria pollutants. Furthermore, sources of air emissions during normal plant operation result from operation of fossil fuel-fired equipment, such as diesel generators, boilers, and fire pumps. Operation of fossil fuel-fired equipment must comply with State and local regulatory air quality permitting requirements. Fossil fuel-fired equipment is operated infrequently and for short duration during testing and maintenance and are generally low emitters of criteria pollutants. Therefore, the impacts on ambient air quality from the operation of this equipment are minimal.

The NRC staff (NRC 2014i) issued an RAI requesting that Entergy identify any new and significant information pertinent to the Category 1 issue, "Air Quality impacts (all plants)," and to describe Entergy's air permit compliance history. In summary, Entergy responded (Entergy 2015a) that the New York State Department of Environmental Conservation (NYSDEC) issued a combined IP2 and IP3 air permit (Air State Facility Permit No. 3-5522-00011/00026) in December 2014. Previously, IP2 and IP3 had separate air quality permits issued by NYSDEC. Air emission sources at IP2 and IP3 are operated infrequently during testing and maintenance activities (Entergy 2015a). Furthermore, IP2 and IP3 are considered minor air emission sources because emissions are below 100 tons (91 metric tons (MT)) per year (NYSDEC 2015a). Over the previous 5 years (2010 to 2014), there have been no notices of violations associated with IP2's and IP3's air permits, and operation of these air emission sources is maintained within the opacity, fuel sulfur content, operational run times, and fuel usage limits established in the air permit (Entergy 2015a).

Entergy (Entergy 2008e, 2015a) indicated that refurbishment activities may include reactor vessel head and control rod drive mechanism replacement. Sources of air emissions from refurbishment activities would result from fugitive dust from site excavation and grading for construction of any new waste storage facilities, motorized equipment, and worker vehicles (Entergy 2008e). Fugitive emissions and exhaust emission from motorized equipment will be temporary, localized (occurring only in the immediate vicinity of construction areas), and short in duration. Therefore, worker vehicle exhaust emissions would be the main contributor to air quality impacts. With respect to the National Ambient Air Quality Standards (NAAQS), Westchester County, where IP2 and IP3 are located, is designated a nonattainment area for ozone (O₃) and a maintenance area for carbon monoxide (CO) and particulate matter less than 2.5 microns (PM_{2.5}). New York is part of the ozone transport region (OTR). The OTR is established in Section 184 of the Clean Air Act of 1970, as amended (CAA)

(42 U.S.C. 7651 et seq.), and it requires those States in the OTR to take steps to control interstate transport of air pollutants that form ozone. Ozone is formed when nitrogen oxides and volatile organic compounds (VOCs) combine in the presence of heat and sunlight; hence, VOCs and nitrogen oxides are precursors that contribute to the formation of ozone.

U.S. Environmental Protection Agency (EPA) regulations at Subpart B of 40 CFR Part 93 require Federal agencies to conduct an applicability analysis if a proposed action occurs in a NAAQS nonattainment area or maintenance area to determine whether emissions of criteria pollutants would exceed threshold emissions levels (40 CFR 93.153(b)). If threshold levels are exceeded, a conformity determination may need to be performed. As a result of the nonattainment and maintenance counties identified and OTR designation of New York, the increase in ozone precursors (VOCs and nitrogen oxides), carbon monoxide, and particulate matter emissions and their precursors (nitrogen oxides and sulfur dioxide) that may result from the additional workforce needed during refurbishment activities were estimated to determine whether emissions would be likely to exceed established threshold emission levels in nonattainment or maintenance areas.

Entergy estimates that an additional 500 peak workers (250 workers for each replacement) for 60 days would be needed for refurbishment-related activities (Entergy 2008e). It is assumed that the additional workforce needed would travel from areas within the 50-mile (mi) (80-kilometer (km)) radius of IP2 and IP3 (which is a reasonable assumption because IP2 and IP3 employees reside in Dutchess, Orange, Putnam, and Rockland Counties, which are within 50 mi (80 km) of IP2 and IP3 (Entergy 2008e)), and each of the 500 workers would travel 100 mi (160 km) daily commuting to and from IP2 and IP3. This travel would result in an estimated additional 500 vehicles and 50,000 vehicle mi (80,000 vehicle km) per day within the region and a total of 3,000,000 vehicle mi (5,000,000 vehicle km) during the 60-day refurbishment timeframe. Using the vehicle emission factors presented in EPA (2008) and Cai et al. (2013), this results in an additional 3.4 tons (3.1 MT) of VOC, 31.1 tons (28.2 MT) of carbon monoxide, 2.3 tons (2.1 MT) of nitrogen oxides, 0.08 tons (0.07 MT) of sulfur dioxide, and 0.01 tons (0.01 MT) of PM₅. The regulatory conformity thresholds for VOCs and nitrogen oxides for designated nonattainment areas are 50 tons (45 MT) and 100 tons (91 MT), respectively (40 CFR 51.853(b)). The regulatory conformity threshold for carbon monoxide and PM_{2.5} and precursors (nitrogen oxides and sulfur dioxide) for designated maintenance areas are 100 tons (91 MT) for each pollutant (40 CFR 51.853(b)). Therefore, the additional emissions from workers during refurbishment will not exceed the regulatory conformity thresholds. Consequently, the additional vehicular emissions from the additional workforce will not be significant.

The NRC staff did not identify any new and significant information related to air quality during its review of the Entergy's response to the NRC staff's RAIs and other available information. Therefore, the NRC staff finds that there are no impacts beyond those discussed in the 2013 GEIS, which concludes that the impacts to air quality during the license renewal term would be SMALL.

5.2 Geology and Soils

Geology and Soils is a Category 1 (generic) issue. This section describes the current geologic environment of the IP2 and IP3 site and vicinity, including landforms, geology, soils, and seismic conditions, as well as the potential impacts of the proposed action (license renewal).

Physiography and Geology and Soils

The IP2 and IP3 site is located in Westchester County, New York. In Westchester County, the bedrock consists of closely folded igneous and metamorphic rocks. The principal bedrock units in the County are (1) the Fordham gneiss, (2) the Inwood Marble, and (3) the Manhattan schist. Outcrops of bedrock are numerous, but the bedrock surface in most of the county is covered by unconsolidated deposits of till and outwash of Pleistocene age that range in thickness from a few feet to as much as 200 feet (ft) (61 meters (m)) (Perlmutter 1960).

The IP2 and IP3 site is within the Manhattan Prong physiographic province and is bordered on the west by the Hudson River. The province includes a portion of Staten Island, all of Manhattan Island, a small portion of western Long Island, and most of Westchester County. The province is characterized as a belt of worn-down complex mountains now almost reduced to a plain. The ridges and valleys of the worn-down mountains trend north-northeast and south-southwest, giving the entire area a gently fluted surface of moderate relief. The maximum relief is 800 ft (244 m) in the north, whereas in New York City, the relief is moderately low (NYSDOT 2013).

The topography is predominantly controlled by bedrock overlain by glacial and alluvial deposits. The geology of the bedrock is extremely complex. The rocks have been described as ancient sedimentary rocks that have been intensely metamorphosed, recrystallized, and thoroughly reorganized. Resistant rocks of schist, gneiss, and granodiorite form the ridges, whereas marble, which is less resistant to erosion, forms the valleys. Numerous lakes and reservoirs that supply the Metropolitan New York City area dot the surface of central and western Westchester County (NYSDOT 2013).

The soils at the IP2 and IP3 site are formed from glacial deposits that overlay the bedrock. They are loamy soils that are often rocky to very rocky and occur on steep slopes. As such, the soils are not considered to be suitable for prime farmland. The IP2 and IP3 site was excavated into the bedrock with the areas between site structures generally covered with construction and fill material. Where possible, buffer zones were forested. A significant portion of the IP2 and IP3 site is urban land. Soil stabilization measures and erosion preventive practices are in place to prevent erosion and sedimentation impacts to the IP2 and IP3 site and vicinity. Any site activity that disturbs one or more acres would require a construction storm water permit from NYSDEC. The construction storm water permit would specify any best management practices (BMPs) that should be taken to reduce soil erosion (Entergy 2015a; USDA 2015).

The Inwood Marble is the first bedrock unit encountered over most of the IP2 and IP3 site. It consists of metamorphosed beds of dolostones and limestones that steeply dip 30 to 70 degrees to the southeast. Because the beds of the Inwood Marble are steeply dipping, it is found at a considerable depth beneath the IP2 and IP3 site. Near the IP2 and IP3 site, a measured section of rock recorded more than 830 ft (253 m) of Inwood Marble. The Inwood Marble is underlain by the Lowerre Quartzite and the Fordham Gneiss (Entergy 2014c, 2014d; GZA 2008; Merguerian 2010; USNY 1970; Williams 2008). The bedrock units are fractured, and the IP2 and IP3 site contains three known major groups of faults (GZA 2008).

With the exception of the Inwood Marble, the IP2 and IP3 site is not known to contain any economic geologic (mineral) or energy deposits. Just outside the southeast site boundary, the Inwood Marble has been mined as a source of limestone (Verplanck Quarry). This quarry is no longer operational. On the opposite side of the Hudson River, the Inwood Marble unit is currently mined (Thomkins Cove Quarry) for use as aggregate (Applebome 2009; Merguerian 2010; TILCON 2015).

Seismic Setting

The area around New York City and IP2 and IP3 has experienced ground shaking from earthquakes originating locally and in other areas in the State of New York. The area has also experienced shaking from earthquakes originating in Canada, Pennsylvania, New Jersey, Connecticut, Massachusetts, and the New Madrid area of Southern Illinois (USGS 2015b, 2015c, 2015d, 2015e). Earthquakes with magnitudes as high as 5.2 have occurred throughout the lower Hudson region and in northern New Jersey. Since 1952, within a 50-mi (8-km) radius of the IP2 and IP3 site, earthquake magnitudes have ranged from 3.0 to 3.6 (Entergy 2015a). Although the largest earthquakes that have occurred in the New York City area since the 1930s were of about a magnitude 4, the longer historic record includes three earthquakes larger than a magnitude 5 (Sykes et al. 2008).

The area has a relatively low earthquake hazard, but because of the large population in the area, there is a high potential for an earthquake to affect many people (as opposed to areas of low population) (Sykes et al. 2008). Seismic hazard maps project that in any given 50-year period, there is a 2-percent chance the area will experience an earthquake that produces ground movement that exceeds 14 percent to 20 percent of a “G” (acceleration due to gravity) (USGS 2015a). Earthquake hazard maps by the Federal Emergency Management Agency indicate the area would likely experience moderate shaking from earthquakes. Moderate shaking would be felt by all of the populace. The shaking would result in slight damage, with some heavy furniture moved and with a few instances of fallen plaster (FEMA 2015).

Nuclear power plants, including IP2 and IP3, are designed and built to withstand site-specific ground motion based on their location and nearby earthquake activity. This seismic design basis is established during the initial siting process, using site-specific seismic hazard assessments. For each nuclear power plant site, applicants estimate a design-basis ground motion based on earthquake sources, wave propagations, and site responses, which is then accounted for in the design of the plant. In this way, nuclear power plants are designed to withstand the maximum credible earthquake for a given site. However, because methods of assessing seismic hazards evolve over time and scientific understanding of earthquake hazards improves (NRC 2014b), the NRC’s understanding of the seismic hazard for a given nuclear power plant may change over time. As new seismic information becomes available, the NRC evaluates the new information to determine whether any changes are needed at existing plants or to NRC regulations. The NRC’s evaluation of the impact of seismic activity on a nuclear power plant is an ongoing process that is separate from the license renewal process.

On December 23, 2011, the Consolidated Appropriations Act of 2012 (Public Law 112-74) was signed into law. Section 402 of the law directs the NRC to require reactor licensees to re-evaluate the seismic hazard at their sites against current applicable Commission requirements and thereafter, when appropriate, as determined by the Commission (NRC 2012a). In 2012, the NRC required all licensees to re-evaluate the seismic hazards at their sites, using updated seismic information and present-day regulatory guidance and methodologies (NRC 2012a). The purpose of that request was to gather information to update the seismic hazards analysis to enable the NRC staff to determine whether individual site licenses should be modified, suspended, or revoked (NRC 2014a).

For those nuclear power plants for which the re-evaluated seismic hazard exceeds the seismic design basis, licensees are required to implement interim seismic evaluations to demonstrate whether the plant can cope with the higher seismic hazard, whereas longer-term seismic risk evaluations are ongoing. The goal of the long-term risk evaluations is to determine whether there is sufficient seismic safety margin for beyond-design-basis ground motion so that the NRC can make risk-informed decisions (NRC 2014a). The NRC staff is currently reviewing Entergy’s

interim seismic evaluation for IP2 and IP3 (Entergy 2014c, 2014d), with respect to ongoing facility operations outside of the license renewal process; the licensee is expected to complete its long-term seismic risk evaluation by June 30, 2017 (NRC 2014a).

The NRC staff has not identified any new and significant information during its review of Entergy's RAI response or other available information. The NRC staff concludes that there are no impacts beyond those described in the 2013 GEIS, which concludes that the impacts to geology and soils during the license renewal term would be SMALL.

5.3 Effects of Dredging on Surface Water Quality

Section 2.1.3 of the December 2010 FSEIS (NRC 2010) describes the surface water intake structures and related once-through cooling and auxiliary systems that support IP2 and IP3. Section 2.2.3, "Water Quality," describes the general water quality of the Hudson River and the regulation of effluent discharges from IP2 and IP3 pursuant to the State Pollutant Discharge Elimination System (SPDES) permit administered by NYSDEC. Section 2.2.5, "Aquatic Resources," of the 2010 FSEIS describes that historic and ongoing dredge and fill activities have altered the aquatic environment and have affected flow patterns in the Hudson River; these activities are likely to continue to have an impact on the river system. Section 2.2.5.2 specifically notes that the U.S. Army Corps of Engineers (USACE) continues to maintain a shipping channel from the ocean to the Port of Albany and that dredging in some river segments occurs every 5 years.

The new Category 1 (generic) issue, "Effects of dredging on surface water quality," considers the potential effects on surface water quality resulting from the dredging of sediment deposits. At nuclear power plant sites, dredging may be conducted in the vicinity of surface water intakes, canals, and discharge structures in order to remove deposited sediment and maintain the function of plant cooling systems. Dredging also may be needed to maintain barge shipping lanes. As discussed in the 2013 GEIS (NRC 2013a), commonly employed mechanical, suction, or other dredging techniques may affect surface water quality by temporarily increasing the turbidity of the water column, with associated effects on aquatic life. Dredging can also mobilize heavy metals, polychlorinated biphenyls (PCBs), or other contaminants in the sediments. The frequency of dredging depends on the rate of sedimentation. The effects of maintenance dredging are generally localized and short in duration (NRC 2013a).

When conducted, dredging operations are performed under permits issued by the USACE and often under permits from State and other agencies as well. The USACE regulates the discharge of dredged or fill material, or both, under Section 404 of the Clean Water Act of 1977, as amended (CWA) (33 U.S.C. 1251 et seq.). Further, Section 401 of the CWA requires that the applicant for a Section 404 permit also obtain a Water Quality Certification from the State in which the activity will take place to ensure that the activities will comply with applicable State water quality standards. The impact of dredging has not been found to be a problem at operating nuclear power plants. In the 2013 GEIS, the NRC staff concluded that dredging has localized effects on water quality that tend to be short lived and that the impact of dredging on water quality is SMALL for all nuclear plants.

The new Category 1 (generic) issue, "Effects of dredging on surface water quality," was not considered in either the 2010 FSEIS (NRC 2010) or the June 2013 FSEIS supplement (NRC 2013b), and neither analysis specifically evaluated the impacts of maintenance dredging of the IP2 and IP3 surface water intake structures. Nevertheless, Section 3.2.2 of the 2010 FSEIS states that Entergy had identified no plans to conduct dredging activities at its dock facility and was not otherwise planning any other activities that would adversely affect the aquatic environment. In Section 4.23.1 of its ER (Entergy 2007a), Entergy had indicated,

without affirmatively stating that such activities were likely, that ongoing operational activities, such as “minimal maintenance dredging associated with the intake structures,” could have localized impacts on the aquatic environment of the lower Hudson River during the license renewal term.

By letter dated December 11, 2014, the NRC staff requested that Entergy provide a discussion of its dredging practices conducted over the past 5 years in relation to IP2 and IP3 operations and provide copies of current permits related to such activities (NRC 2014i). Entergy (2015a) responded, in part, that it has historically performed dredging associated with the IP2 and IP3 cooling water intake structures on an infrequent basis. Entergy last performed dredging in 1994 and stated that, given the infrequent nature of the activity, it may not perform additional dredging during the course of the license renewal period. Entergy also stated that it possesses no current permits from the USACE and NYSDEC to authorize dredging but that any future activities at IP2 and IP3 would be reviewed and permitted by the USACE and NYSDEC. In its response, Entergy concluded that since IP2 and IP3 would be required to comply with permit conditions specified in the USACE and NYSDEC permits, including appropriate mitigation measures, dredging impacts would be localized and SMALL.

As discussed above, operations experience from nuclear power plants for which dredging is conducted indicates that associated effects are localized and temporary in nature and result in a SMALL impact on ambient water quality. The NRC staff did not identify any new and significant information with regard to the effects of dredging on surface water quality based on review of the Entergy’s response to the NRC staff’s RAs and other available information. Furthermore, Entergy would be required to obtain a Section 404 permit from the USACE and authorization from NYSDEC before performing any future dredging activities at IP2 and IP3. Based on this information and foregoing considerations, the NRC staff concludes that there are no impacts beyond those described in the 2013 GEIS, which concludes that the effects on water quality from dredging during the license renewal term would be SMALL.

5.4 Radionuclides Released to Groundwater

The issue, “Radionuclides Released to Groundwater,” is a new Category 2 issue. This section provides the NRC staff’s assessment of any past inadvertent releases of radionuclides into the groundwater at IP2 and IP3. It includes a description of any past inadvertent releases and the projected impact to the environment (e.g., aquifers, rivers, lakes, ponds, and ocean) during the license renewal term. Specifically, this review evaluates the impact of inadvertent releases of radionuclides on groundwater and surface water quality over the period of license renewal (10 CFR 51.53 (c)(3)(ii)(P)).

5.4.1 Site Description and Hydrology

5.4.1.1 Hudson River

The IP2 and IP3 site is located on the eastern shore of the Hudson River at River Mile (RM) 43 (River Kilometer (Rkm) 69). At the IP2 and IP3 site, the river is approximately 4,500 ft (1,372 m) wide and 40 ft (12 m) deep. The flow of the Hudson River past the site is controlled more by tides than freshwater inflow. Eighty percent of the time, the tidal flow is approximately 80 million gallons per minute (gpm) (129 million liters per minute (L/min)). Depending on the tides and rate of fresh water flowing downstream, the Hudson River water at the IP2 and IP3 site is usually either saline or brackish (Entergy 2007a).

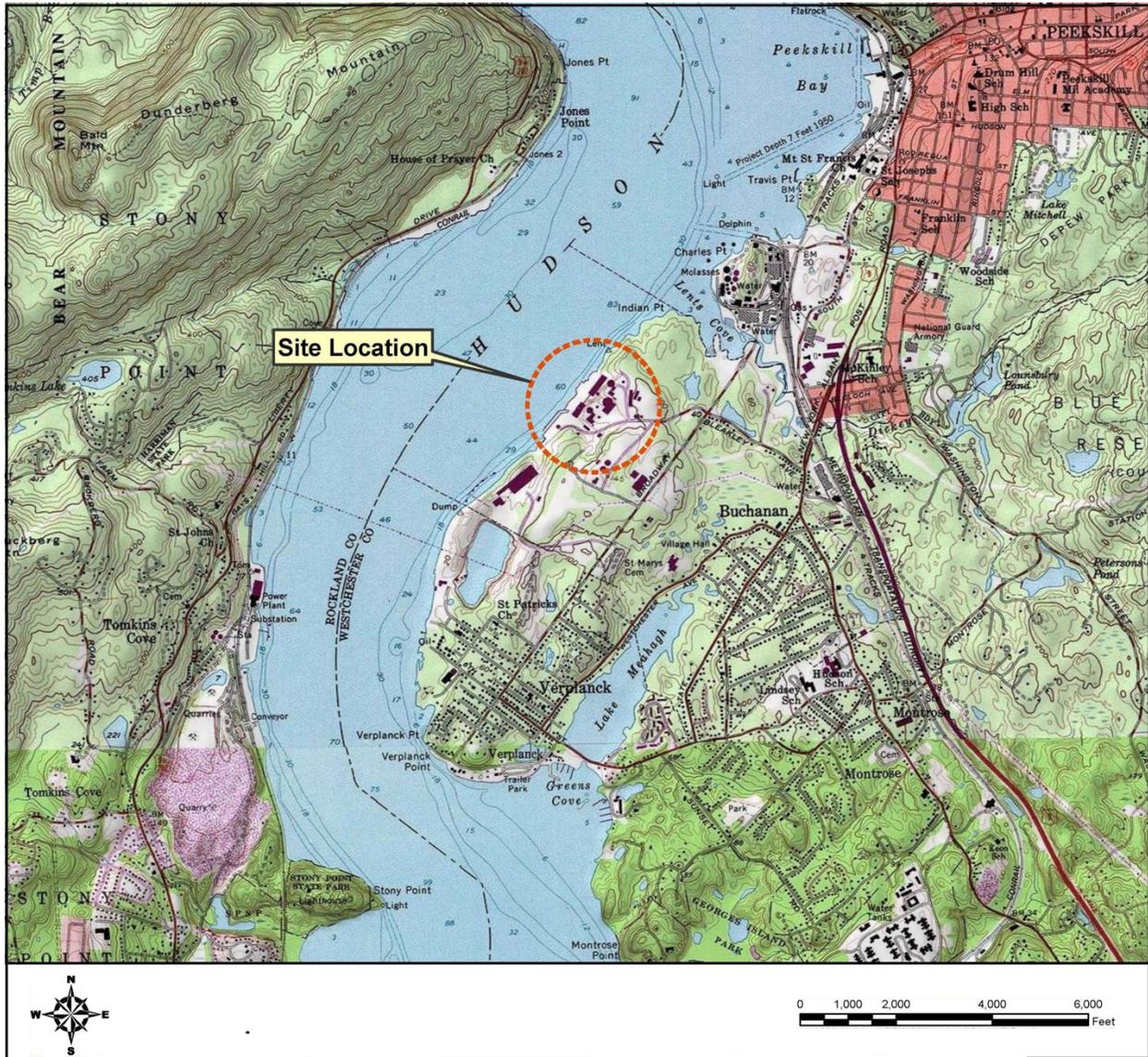
5.4.1.2 Groundwater

A detailed description of groundwater flow and radiological transport beneath the IP2 and IP3 site is contained in a site investigation report that documents a 2-year study conducted by an Entergy contractor from 2005 through 2007 (GZA 2008). This study includes data from numerous groundwater monitoring locations and geophysical, hydraulic, radiological, and water chemistry tests. An onsite monitoring network contains over 150 depth-specific sampling locations at 65 monitoring installations. The groundwater flow system beneath the site is also described in a U.S. Geological Survey (USGS) Report (Williams 2008). This report contains a description derived from geophysical and hydrologic tests performed by USGS staff using 24 onsite monitoring wells.

The IP2 and IP3 site is located in Westchester County, New York. Across the county, the bedrock consists of closely folded igneous and metamorphic rocks. Outcrops of bedrock are numerous, but the bedrock surface in most of the County is covered by unconsolidated deposits of glacial till and outwash (stream deposits). These deposits range in total thickness from a few feet to as much as 200 ft (61 m). Groundwater is produced from glacial deposits of till (nonstratified material deposited directly by glacial ice), outwash (gravel and sands deposited by glacial melt water), and foliated metamorphic rocks (schist and gneiss).

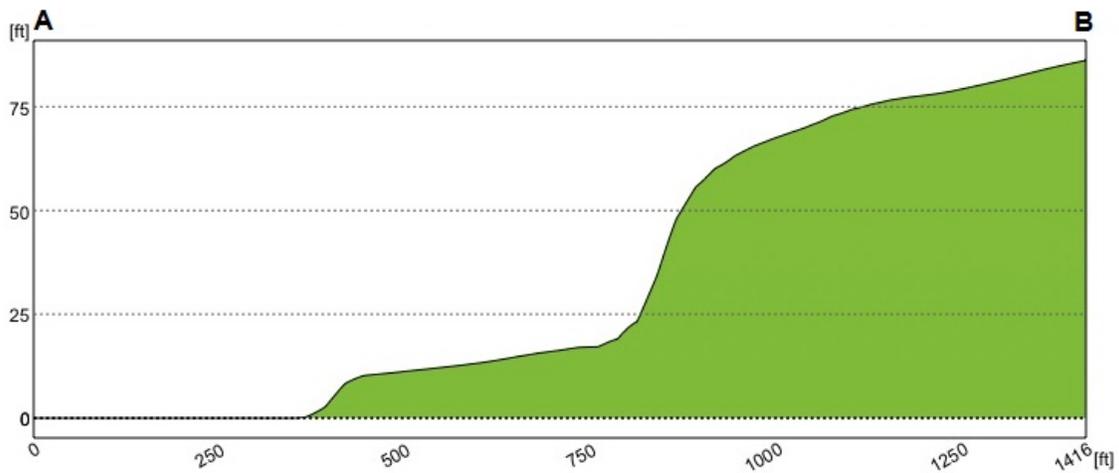
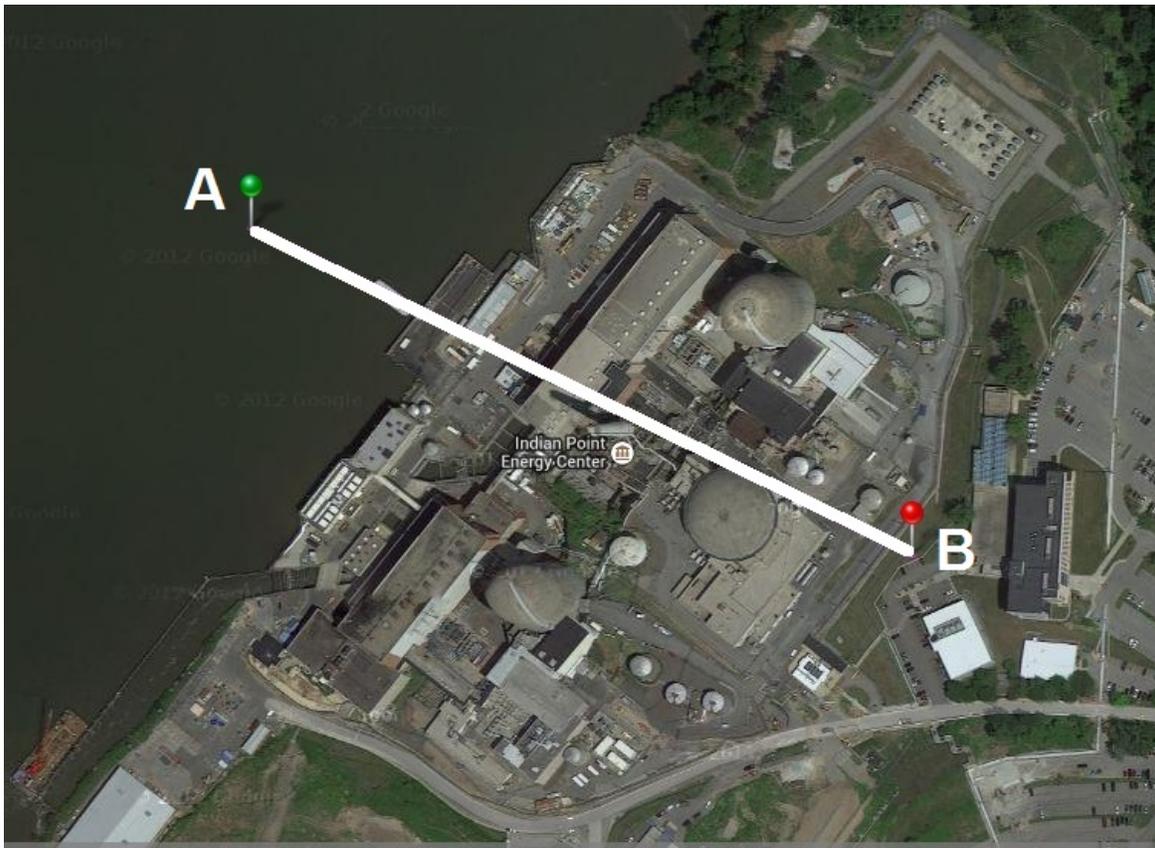
The IP2 and IP3 site is bordered on the northwest by the Hudson River. At the river, the elevation of the land surface is 10 ft (3 m) above the National Geodetic Vertical Datum of 1929 (NGVD-29). Moving east from the river, the land surface rises up to approximately 140 ft (43 m) NGVD-29 near the eastern site boundary (GZA 2008; Williams 2008). The site topography slopes generally toward the Hudson River. Surface drainage is toward the Hudson River (Entergy 2007a) (see Figure 5–1 and Figure 5–2).

Figure 5-1. Site Location and Topography



Source: Modified from Entergy 2015b

Figure 5–2. Topographic Cross-Section to Hudson River



Source: NRC staff generated

The Hudson River at the site is a tidally influenced estuary that usually experiences two high tides and two low tides each day. During high tides, the river water flows north, and during low tides, it flows south. At the site, tidally induced river water elevations can vary from -1.1 to 3.8 ft (-0.3 to 1.2 m) NGVD-29 (GZA 2008).

A cooling water discharge canal serves the reactor complex and runs parallel to the Hudson River along the plant site. The walls of the discharge canal are constructed of low structural

concrete, but the bottom of the canal consists of a 0.5-ft (0.2-m) thick mud slab in some areas and an open bedrock bottom in other areas. Therefore, the water in the discharge canal is likely in hydrologic communication with the underlying groundwater (GZA 2008).

At the site, surficial materials that overlay the bedrock range in thickness from 3.5 to 59 ft (1.1 to 18 m) below ground surface. Where not occupied by buildings or other physical structures, the land surface is covered by soils, glacial deposited material (till), river sediments, and engineered fill material. The engineered fill materials are made up of mixtures of sand, gravel, and silty clay. In areas adjacent to structures with foundations that are excavated into bedrock, the engineered fill is made up of concrete, compacted granular soils, and rock blasted from the bedrock (GZA 2008). Surficial materials in areas undisturbed by site construction activities consist of glacial till or silty clays, organic silt, clay, and sandy material overlain by granular fill. A 20- to 50-ft (6- to 15-m) thick sequence of river sediments (organic silts) occurs near the river (GZA 2008).

As discussed in Section 5.2, the Inwood Marble underlies the surficial materials and site structures. With the exception of the eastern and northern site boundaries (where it is overlain by the Manhattan schist), it is the first bedrock unit encountered. During plant construction, the Inwood Marble was extensively blast excavated. It consists of beds of metamorphosed dolostone and limestone that dip steeply at 30 to 70 degrees to the southeast. Because of its steep dip, the Inwood Marble extends to a considerable depth beneath the site. Near the site, more than 830 vertical ft (253 vertical m) of Inwood Marble has been mapped (Merguerian 2010). The Inwood Marble is underlain by the Lowerre Quartzite and the Fordham Gneiss (Entergy 2014c, 2014d; GZA 2008; Merguerian 2010; USNY 1970; Williams 2008).

With the exception of engineered fill material placed along the river, the water table occurs in the Inwood Marble (GZA 2008). The water table at the IP2 and IP3 site is recharged by precipitation. Precipitation at the site is approximately 36 inches (in.) (91 cm) per year. This level of precipitation is estimated to produce 10 in. (25 cm) per year of recharge to the water table (GZA 2008).

The rock matrix of the Inwood Marble has a very low porosity, and groundwater does not easily flow through it (GZA 2008). Site characterization activities have not detected evidence of any solution features (i.e., cavities or voids) that could store significant volumes of water or form preferential pathways for groundwater flow (GZA 2008). Therefore, within the Inwood Marble, fractures and faults create the void space and the pathways for groundwater storage and movement (GZA 2008). However, the aperture of the faults and fractures is generally very small. The void (porosity) of the fracture network is substantially less than 1 percent of the volume of the rock. Therefore, although the fracture network forms the groundwater pathways through the rock, it does not hold a large volume of water (Entergy 2012a; GZA 2008; Williams 2008).

Fracture aperture (width), spacing, and the degree of fracture interconnectivity are dominant variables in how groundwater flows through a fractured bedrock environment. The Inwood Marble contains three fracture sets that intersect each other. One set trends northeast-southwest, another trends north-south, and another trends east-west. The dip angles for these fracture sets range from 30 to 70 degrees. In addition to these fracture sets, the Inwood Marble contains numerous horizontally and vertically oriented fractures. Taken together, the fractures at the site create a fracture network both horizontally and vertically that has a high degree of connectivity. The fractures in the network appear to be spaced from 0.3 and 2.2 ft (0.1 and 0.7 m) apart and have an average spacing of 0.7 ft (0.2 m) (GZA 2008).

There are also three major groups of faults that have been identified at the site (GZA 2008). Depending on the amount of clay contained in the faults, they may act as barriers to

groundwater flow, or, with less clay, they may enhance flow through the network (Williams 2008). While there are some localized trends in fracture strike direction, there is an abundance of intersecting fractures. Fracture data analysis indicates the Inwood Marble is highly fractured, but does not contain large individual structures that can readily transmit groundwater across the site (GZA 2008).

At the IP2 and IP3 site, the elevation of the water table along the river bank is the same height as the water in the river. Moving away from the river, the top of the water table is found at increasing elevations as the topography increases, and it generally mirrors the surface topography. The reactor unit farthest from the river is Indian Point Nuclear Generating Unit No. 1 (IP1). Approximately 175 ft (53 m) southeast of IP1, the water table is approximately 50 ft (15 m) higher than the river at low tide (GZA 2008). Higher water levels on the north, east, and south boundaries of the site cause the groundwater in the Inwood Marble to flow toward the Hudson River.

All groundwater at the site either discharges directly to the Hudson River or discharges indirectly through facility drains to the discharge canal, which flows to the Hudson River. The rate of groundwater discharge to the river is influenced by groundwater recharge rates and river water levels (GZA 2008). On the west bank of the Hudson River, opposite the IP2 and IP3 site, groundwater also flows toward, and discharges to, the river (Heisig 2010; Williams 2008). The size and depth of the Hudson River and the direction of groundwater flow under and on each side of the river mean that it is extremely unlikely that onsite groundwater in the Inwood Marble could flow under the Hudson River to the other side (GZA 2008).

Groundwater elevations in the Inwood Marble respond to tidal changes in Hudson River water levels. As the distance from the river increases, changes in groundwater levels from tides decrease in magnitude and exhibit greater lag time (delayed response to changes in river water levels). Most of the impact of the tide on groundwater levels is confined to the fill material along the Hudson River. Tidally induced changes in groundwater levels are noticeable up to 400 ft (122 m) from the river; however, at greater distances from the river, tidally induced changes in water levels are very small and difficult to measure (GZA 2008). Tide and groundwater level data collected throughout 2007 indicate that the general direction of groundwater flow is toward the river for a range of tide elevations. The same analysis indicates that the rate of groundwater flow to the river appears to be greatest during the drier part of the year and during times of low tide (i.e., during times of low water levels in the river relative to groundwater elevations in the fracture network) (GZA 2008).

Laterally and vertically, the fracture network appears to have some preferred directions of groundwater flow (Entergy 2015b). Blasting the bedrock during facility construction may have created more fractures in the top of the Inwood Marble. The fracture network appears to be able to transmit groundwater easier within the upper 40 to 50 ft (12 to 15 m) of the network than at deeper depths. The presence of more fractures in the top of the Inwood Marble is supported by a statistical analysis of hydraulic conductivities of individual fractures, which showed higher hydraulic conductivities within the upper 40 ft (12 m) of the fracture network than below 40 ft (12 m). In addition, onsite measurements of fracture-network transmissivities are greater in the upper 50 ft (15 m) of the Inwood Marble than they are at deeper depths (GZA 2008). This means groundwater in the Inwood Marble can more readily flow through the fracture network near the surface than it can at deeper depths.

Although the groundwater flows laterally across the site and then into the Hudson River, some groundwater takes a longer pathway to the river. Most of the groundwater movement is believed to take place in the upper 50 ft (15 m) of the Inwood Marble where fractures can more readily transmit groundwater, but some of the groundwater flows downward, then moves

laterally across the site, and then moves upward and into either the discharge canal or the Hudson River. Vertical groundwater flow directions have been measured in 16 onsite monitoring wells. Vertical flow was found to be downward in eight wells and upward in four wells (Williams 2008). The four wells in which upward flow was observed are located near the Hudson River, whereas wells with downward vertical flow are generally located in the eastern part of the site that has a higher topographic relief (Williams 2008). Because the fracture network is less permeable with depth and the deeper pathways to the river are longer, groundwater moving through the deeper parts of the fracture network should take longer to reach the river.

The abundant fractures in the Inwood Marble suggest the fracture network can be appropriately modeled using an equivalent porous media model (as a nonhomogenous anisotropic, porous medium) (GZA 2008). Entergy has used an analytical equivalent porous media groundwater flow model based on a precipitation mass balance analysis to estimate groundwater flux beneath the site and into the discharge canal and the Hudson River. This analysis is based on the assumption that, on a long-term average, groundwater flowing through and discharging from the aquifer is equal to the watershed infiltration recharge. In September 2014, the model calculated that, over a 12-month period of time, the groundwater discharge rate to the Hudson River was 17 gpm (64 L/min). Of this amount, 3 gpm (11 L/min) flowed to the discharge canal, and 14 gpm (53 L/min) discharged directly to the Hudson River (Entergy 2014h, 2014k, 2015b).

5.4.1.3 *Water Resources*

Potable water sources near the IP2 and IP3 site are not presently derived from groundwater sources or the Hudson River (NRC 2010). There are no residential or municipal drinking water wells near IP2 and IP3 (Entergy 2012a; NYSDEC 2007; NRC 2010). Because municipal water is readily available in the area, it is unlikely that potable or irrigation wells will be installed near the site in the reasonably foreseeable future (GZA 2008).

There are no surface reservoirs near the plant. Drinking water in the area (Village of Buchanan and City of Peekskill) is obtained from surface water reservoirs located in Westchester County and the Catskills region of New York. The closest reservoir (Camp Field) is located 3.3 mi (5.3 km) north and upstream of the site. The other local public drinking water supply is the New Croton Reservoir, which is 6.3 mi (10.1 km) east of the site. Both of these public drinking water supplies are several watersheds away from IP2 and IP3 and are at much higher elevations (GZA 2008; NRC 2012e). Surface water samples collected from the drinking water reservoirs do not exhibit impacts from the site (GZA 2008).³

The site does not use groundwater either for plant operations or for potable water. Potable water is supplied to the site by the Village of Buchanan, New York, Public Water Supply system. Wells located at the site are used for monitoring purposes only (Entergy 2007a).

The Inwood Marble contains fresh water, but then becomes brackish in quality near the river (Entergy 2012a). On site, the hydraulic properties of the Inwood Marble will not support large yields of water to wells (Entergy 2012a; GZA 2008). Although wells drilled with conventional techniques might be able to produce enough water to supply an individual household, the low

³ The draft version of this supplement referenced a desalination facility that was proposed to be constructed and operated in the town of Haverstraw, referred to as the Haverstraw Water Supply Project, to provide desalinated (fresh) water from the Hudson River as a source of drinking water for Rockland County. On December 21, 2015, SUEZ Water announced that it had abandoned the project; therefore, all references to that project have been removed from the FSEIS supplement. For additional information, please see: <http://documents.dps.ny.gov/public/mattermanagement/casemaster.aspx?mattercaseno=13-w-0303>.

hydraulic conductivities and porosities of the fractures are insufficient to supply a public water system.

5.4.2 Radionuclides Released to Groundwater

Groundwater contamination in the Inwood Marble has been traced back to the IP1 and IP2 spent fuel pools. Historically, leaks from the IP1 spent fuel pool created contaminant plumes consisting of strontium-90 and tritium. Leaks from various sources associated with IP2 created another plume of tritium contamination (GZA 2008; NRC 2012e). Other radionuclides have been sporadically identified in the groundwater at discrete locations on site. However, no plumes of contamination have been found for these radionuclides (Entergy 2008c, 2009a, 2010a, 2011a, 2012b, 2013a, 2014f, 2014h, 2015b, 2015d, 2015f, 2016c, 2016d, 2017b; GZA 2008).

5.4.2.1 History of Releases

The following is a summary of radionuclide releases into the groundwater. Detailed descriptions are contained in Entergy 2012a, 2015b, 2015f, 2016d, 2016e, 2017b; GZA 2008; NRC 2012e.

IP1 Spent Fuel Pool Leak

The IP1 reactor ceased operation on October 31, 1974. Fuel was off-loaded from the reactor and placed into the IP1 spent fuel pools, which were kept full of water to keep the fuel cool. Leakage into the groundwater from one of the IP1 spent fuel pools was discovered in April 1990. Unlike the IP2 and IP3 fuel pools, which are lined on the inside with stainless steel, the inside walls of the IP1 spent fuel pools were made of epoxy-lined concrete. To manage the leak, foundation and curtain drains associated with the IP1 reactor building were used to capture contaminated groundwater from the IP1 spent fuel pools. The captured water was then processed through the plant's radioactive waste disposal system.

In 2006, it was discovered that some contaminated groundwater had bypassed the foundation and curtain drains and moved with the groundwater to the Hudson River. At the same time, the removal of spent fuel from the IP1 spent fuel pools began (Entergy 2014k, 2015a). At one point in the fuel removal process, water levels in the spent fuel pools and the fuel transfer canal had to be raised so that plant workers could safely remove the spent fuel from the pools. For a short time, the higher water levels caused increased leakage from the spent fuel pools into the groundwater. By 2008, all of the spent fuel and the water in the IP1 spent fuel pools had been removed (Entergy 2015b). This stopped all leakage of radionuclides from the IP1 spent fuel pools (Entergy 2012a).

Radionuclide Leaks Near IP2

In 1990, a small hole was detected in the IP2 spent fuel pool stainless steel liner. An estimated 50 gallons (189 liters) per day had been leaking through this hole. An epoxy seal was installed to plug the hole. Later in 1992, a steel box was welded over the epoxy-sealed hole to permanently seal the hole. In 2007, a pinhole leak was discovered in one corner of the IP2 spent fuel transfer canal. The pinhole leak was repaired that year. No further leaks from the IP2 spent fuel pool or the transfer canal have since been detected.

In April 2014, elevated tritium was detected in three monitoring wells (MW-30, MW-31, and MW-32) located near the building containing the IP2 spent fuel pool. The elevated levels of tritium are believed to have been caused by a floor drain that backed up during refueling activities in 2014. The backed-up water then came into contact with floor/wall joints that provided a pathway for the water to reach the groundwater (Entergy 2015b).

In February 2016, Entergy notified the NRC of a significant increase in groundwater tritium levels detected in late January in three monitoring wells (MW-30, MW-31, and MW-32) located near the IP2 Fuel Storage Building (NRC 2016b; Entergy 2016d). The highest concentration was detected at monitoring well MW-32. In the 1st quarter of 2016, tritium concentrations in this well increased from 18,900 picocuries per liter (pCi/L) to 8.97 million pCi/L (Entergy 2016d; NRC 2016b). The NRC onsite inspectors began an immediate review of this incident. On February 11, 2016, an NRC specialist inspector conducted a walkdown of IP2 radioactive waste drain systems and components. The specialist inspector also conducted additional onsite inspection activities on March 6–10, 2016, and reviewed Entergy's continuing investigation into the event. Representatives from NYSDEC, the New York State Department of Health (NYSDOH), and EPA, Region II, accompanied portions of these onsite inspection activities (NRC 2016b).

Following identification of the increased tritium in the groundwater, Entergy assembled a dedicated project manager and investigation team that included radiation protection, chemistry, operations, engineering, maintenance, hydrogeology, root cause investigation, and corrective action program staff. The initial Entergy investigation focused on what caused the contamination in the groundwater. The source of the contamination was determined to be from reverse osmosis water treatment equipment that was being used to filter water from the IP2 refueling water storage tank. The spill occurred within the plant's waste drain system that was transferring the reverse osmosis reject water to the waste holding tank within the liquid waste disposal system. As part of a further investigation into the spill from the reverse osmosis equipment, Entergy identified that another spill had occurred that was associated with refueling backup heat exchanger flush water. The same problem in the plant's waste drain system also caused this spill to reach the groundwater (Entergy 2017b). In addition, in the 3rd quarter of 2016, a maximum concentration of 76.7 pCi/L for cobalt-58 was reported for well MW-32 (Entergy 2017b).

By the 2nd quarter of 2016, tritium concentrations in the groundwater had significantly decreased as measured in wells near the source of contamination, although the concentration of tritium in some wells between IP2 and the river had increased. This is to be expected if the source of the contamination has been stopped. As the tritium moves toward the river, the concentrations in wells near the source should decrease, whereas wells along groundwater pathways toward and near the river should temporarily increase and then decrease as the plume of tritium moves from the area around IP2 toward the Hudson River. However, although concentrations in these wells should temporarily increase, dilution of tritium along the pathway and near the river should prevent these wells from exhibiting the same high tritium concentrations as the wells located near the source of the contamination.

To illustrate, in the 1st quarter of 2016, the highest tritium concentration was detected at monitoring well MW-32, which is located near the spill. By the 2nd quarter of 2016, tritium concentrations in this well had decreased from 8.97 million pCi/L as measured in the 1st quarter of 2016 to 2.9 million pCi/L. In the 3rd quarter of 2016, the maximum concentration had decreased to 136 pCi/L (Entergy 2017b). Although tritium concentrations in well MW-32 decreased in the 2nd quarter, tritium concentration increased in well MW-37. This well is located along the groundwater pathway from IP2 to the river. In the 1st quarter of 2016, the highest concentrations in this well were approximately 22,000 pCi/L. In the 2nd quarter, the highest tritium concentrations had increased to approximately 90,000 pCi/L (Entergy 2016d, 2016e); by the 3rd quarter, concentrations in well MW-37 had declined to 49,800 pCi/L (Entergy 2017b).

In the 2nd quarter of 2016, antimony-125 was detected in the same two wells adjacent to IP2 (wells MW-31 and MW-32). The maximum concentration of antimony-125 in monitoring well

MW-31 was 286 pCi/L. This concentration is close to what was reported in the 1st quarter of 2016 (271 pCi/L). In the 3rd quarter of 2016, the maximum concentration showed a measurable decrease and was reported as 136 pCi/L (Entergy 2017b). In the 2nd quarter, monitoring well MW-32 had a maximum concentration of 1,170 pCi/L, which is a decrease from the antimony-125 concentrations reported in the 1st quarter of 2016 (4,750 pCi/L) (Entergy 2016d, 2016e). By the 3rd quarter of 2016, the maximum concentration in well MW-32 had fallen significantly to 516 pCi/L (Entergy 2017b).

On January 17, 2017, the NRC issued a notice of violation with a finding of very low safety significance. Title 10 of the *Code of Federal Regulations* (10 CFR) Section 20.1406(c) requires, in part, that licensees shall, to the extent practical, conduct operations to minimize the introduction of residual radioactivity into the site, including the subsurface. The violation described two examples of Entergy's failure to conduct operations to minimize the introduction of residual radioactivity into the subsurface groundwater of the site. On two occasions between January 2016 and July 2016, Entergy failed to conduct operations to minimize the introduction of residual radioactivity into the subsurface of the site. Specifically, Entergy did not keep the floor drain systems clear of obstructions and interferences, and it had not verified the ability of the floor drains to handle the volume and flowrates for the drainage activities being conducted. As a result, repeated spills of contaminated water within the radiologically controlled area leaked into onsite groundwater (NRC 2017a).

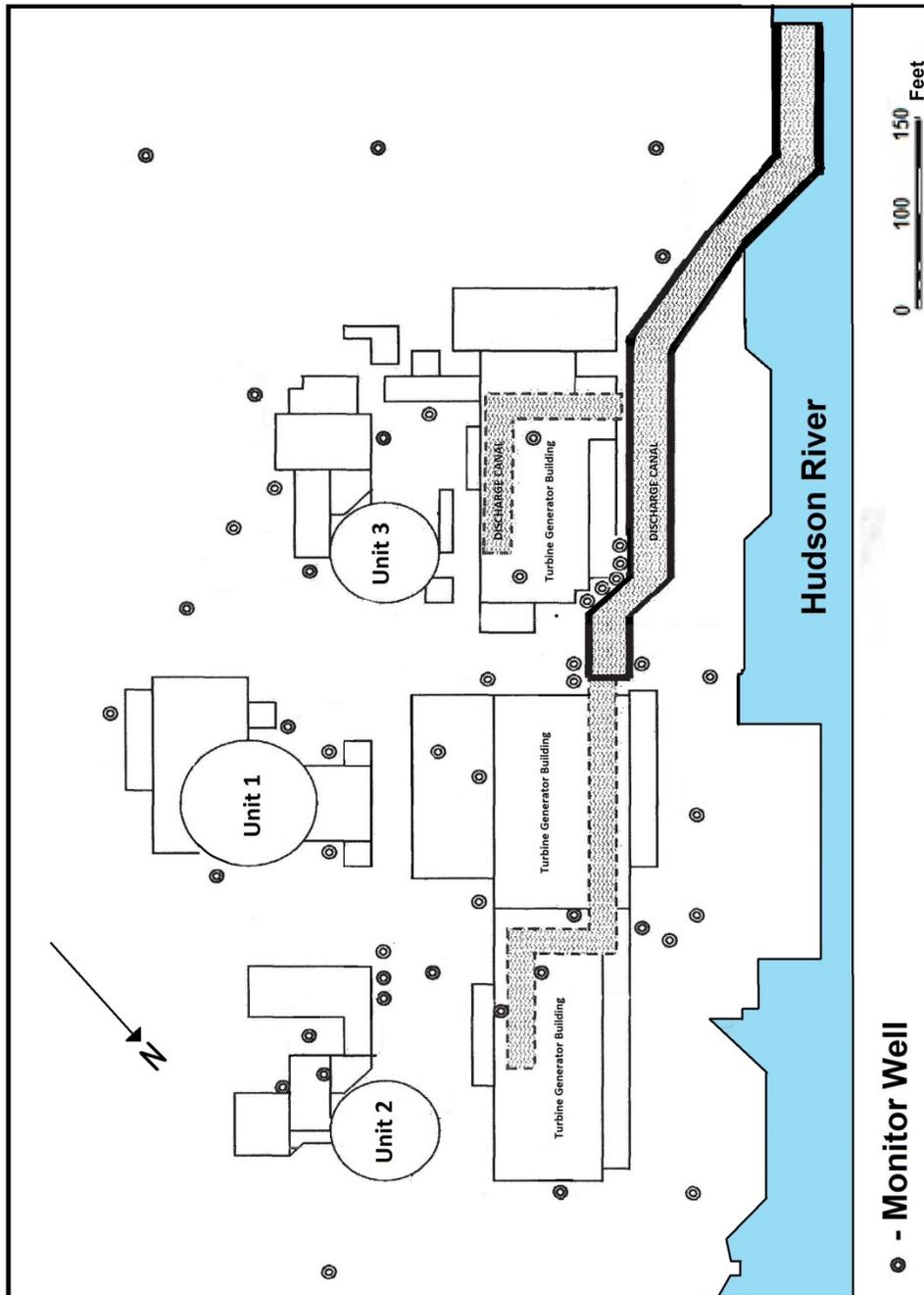
Entergy responded to the notice of violation on February 16, 2017, stating that repairs had been made to the IP2 floor drain system and a sump pump in the Fuel Storage Building. In addition, maintenance procedures have been changed to ensure periodic cleaning and inspection of the floor drain systems (Entergy 2017a).

5.4.2.2 *Extent of Groundwater Contamination*

Entergy has an onsite monitoring network containing over 150 depth-specific sampling locations at 65 monitoring installations, which allows the groundwater to be monitored and sampled at various depths from the groundwater surface to over 300 ft (91 m) below the top of the bedrock. To better characterize the groundwater, several of the wells in the network are completed through the floors and basements of buildings. Included in the overall groundwater monitoring program are approximately 75 storm drains and 25 sumps throughout the IP2 and IP3 site (GZA 2008; Entergy 2012a). Figure 5–3 shows monitor well locations located inside and near plant buildings.

An environmental impact statement reflects available information at the time it is prepared. This section was written to discuss the extent of groundwater contamination through the 3rd quarter of 2016. However, the NRC staff continues to monitor the onsite groundwater program. Quarterly reports for the 4th quarter of 2016, and the 1st quarter of 2017, show the same extent of groundwater contamination and cleanup trends, as described below.

Figure 5-3. Monitor Wells Located Near Plant Buildings



Sources: Modified from Entergy 2008c, 2015b

Radionuclide contamination is found above and in the water table. When contaminated water leaked into the Inwood Marble, it first flowed through the fractures of the Inwood Marble above the water table. As the contaminated water moved downward under gravity, it moved both vertically and laterally. As a result, it is believed that the leaks associated with IP2 contaminated the water table between IP2 and IP1 with tritium (Entergy 2014h, 2014k, 2015b).

The direction of groundwater flow in the water table prevents contaminated groundwater from migrating off the site property to the north, east, or south. Therefore, when leaked radionuclides

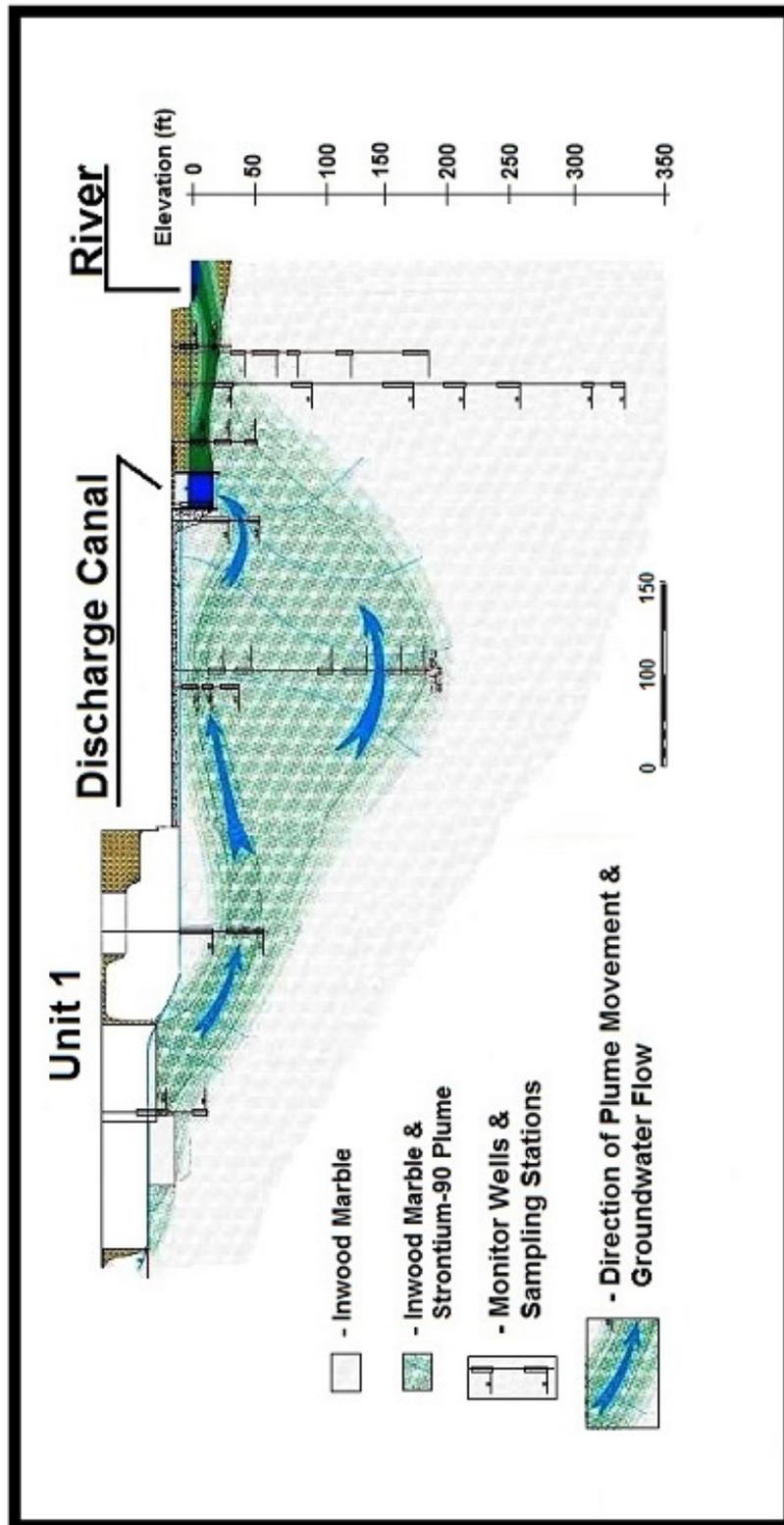
reached the water table, they moved downgradient with the groundwater toward the Hudson River (GZA 2008; NRC 2012e). As previously described, three plumes of contamination were created in the water table: (1) a tritium plume associated with IP2, (2) a tritium plume from the IP1 spent fuel pool, and (3) a strontium-90 plume from the IP1 spent fuel pool. These plumes come together with each other and extend to the Hudson River (GZA 2008; NRC 2012e). Over much of their areal extent, they occur under buildings and other plant structures. Before they reach the Hudson River, all three plumes are confined to the site and both vertically and laterally to the Inwood Marble.

As discussed above, most of the groundwater movement to the river takes place in the upper 50 ft (15 m) of the Inwood Marble where the fractures can more readily transmit groundwater. However, some of the groundwater flows downward in arching pathways, then moves laterally across the site, and then moves upward and into either the discharge canal or the Hudson River. Groundwater samples have confirmed that the plumes are largely within the upper 50 ft (15 m) of the Inwood Marble; and even when they are deeper, they are moving toward the river (Entergy 2015b). Figure 5-4 contains a vertical cross-section of the strontium-90 plume from IP1 to the river at the end of June 2014.

Groundwater contamination plume maps show the lateral extent of the plumes from their points of origin to their discharge locations near the Hudson River. They are calculated from annual average concentrations by averaging four quarters of data together. Figure 5-5 shows the lateral extent of both the IP2 and IP1 tritium plumes in the 4th quarter of 2014. Figure 5-6 shows the concentration of the tritium plumes as of the 4th quarter of 2015. Figure 5-7 shows the impact of the 2016 release on tritium groundwater concentrations in the 1st quarter of 2016. By the 3rd quarter of 2016, the tritium plume (Figure 5-8) from IP2 had elongated in shape toward the river with reduced concentrations near the source of the 2016 spill (Entergy 2016e). This suggests that the source of the tritium has been stopped and that the tritium in the groundwater is moving toward the river.

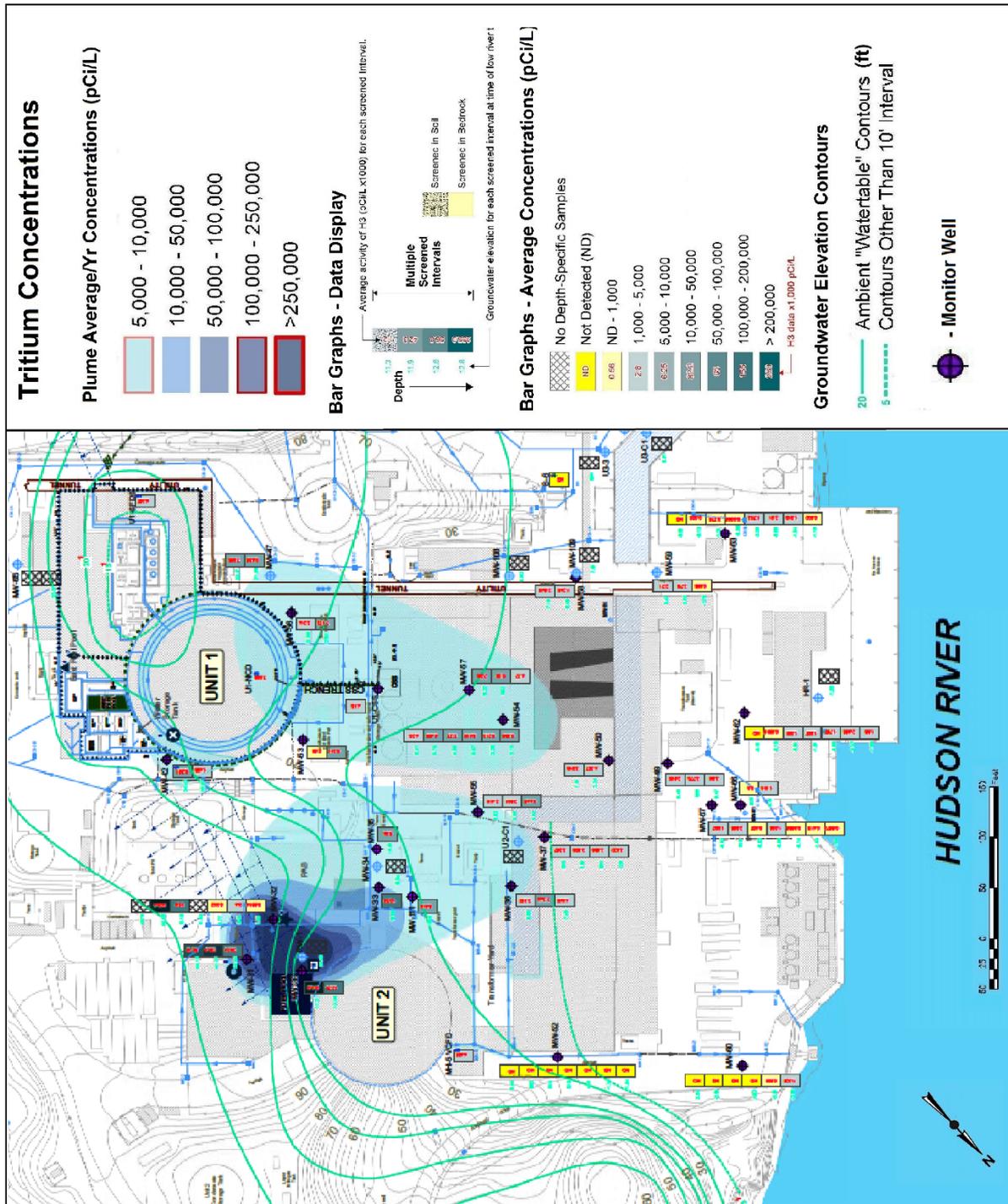
Figure 5-9 shows the lateral extent of the strontium-90 plume in the 4th quarter of 2014. Figure 5-10 shows the lateral extent of the strontium-90 plume in the 1st quarter of 2016. In the 3rd quarter of 2016 (Figure 5-10), the strontium-90 plume shows decreased concentrations in the upper one half of the plume (away from the river and near IP1), but it generally covers the same area as it did in the 4th quarter of 2014 (Entergy 2016d, 2016e, 2017b). Groundwater monitoring data confirm that both tritium and strontium-90 groundwater contamination move toward the Hudson River. Contamination has not been detected moving off the site in any other direction (Entergy 2014h, 2014k, 2015b, 2015f, 2016a, 2016d, 2016e, 2017b).

Figure 5-4. Cross-Section of Strontium-90 Plume from IP1 to the Hudson River



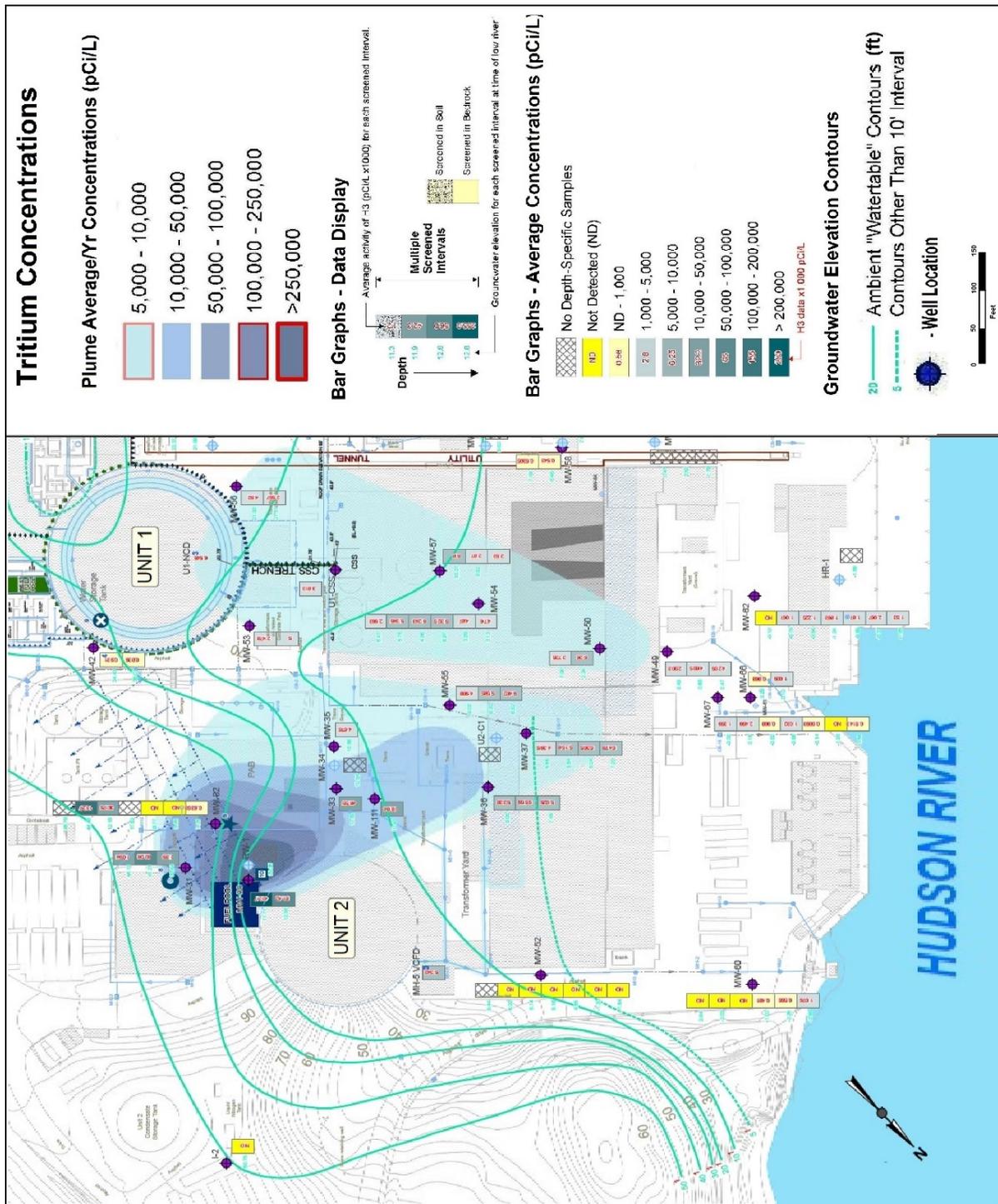
Source: Modified from Entergy 2015b

Figure 5–5. IP2 and IP1 Tritium Plumes in the 4th Quarter of 2014



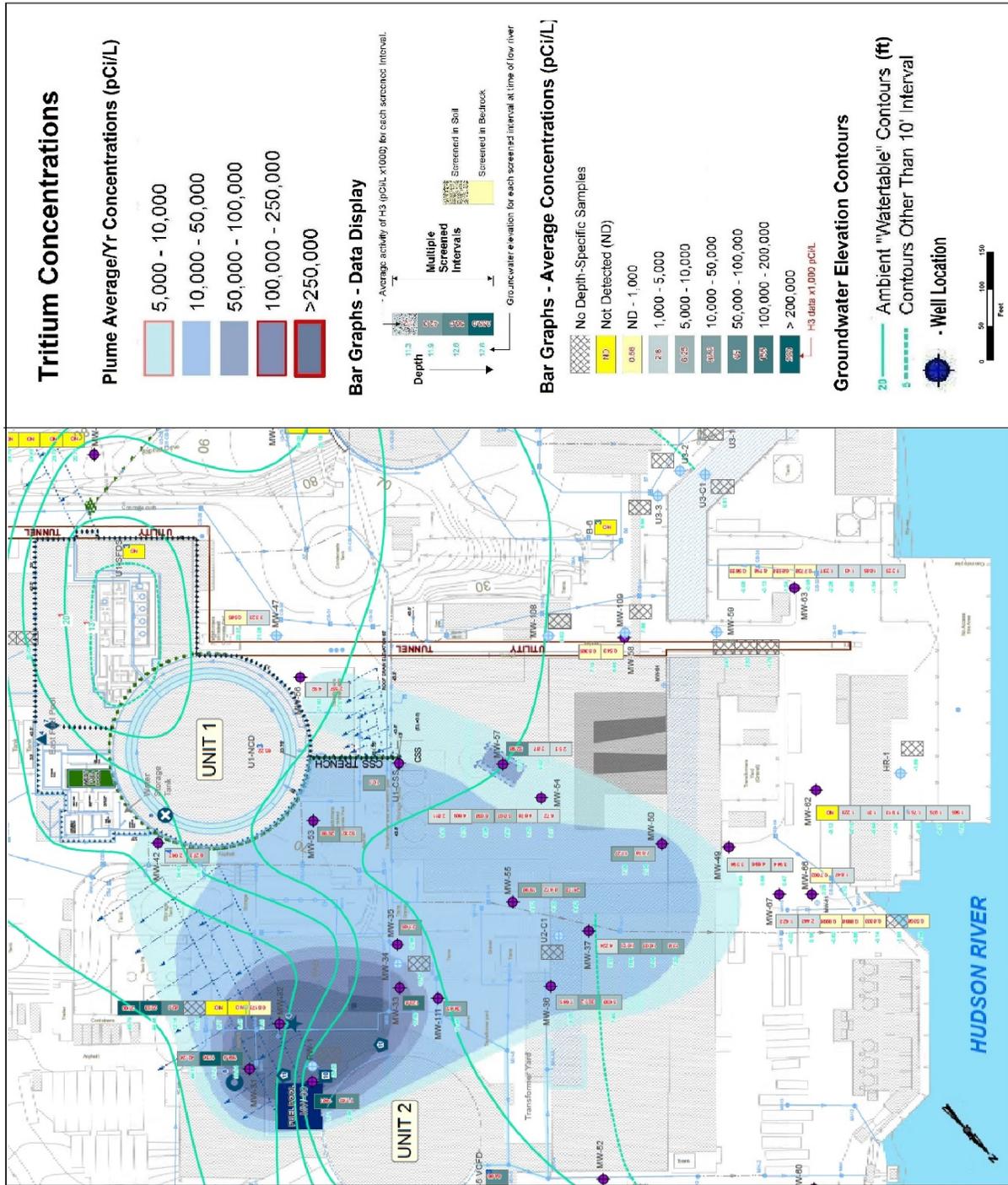
Source: Modified from Entergy 2015f

Figure 5–6. IP1 and IP2 Tritium Plume in the 4th Quarter of 2015



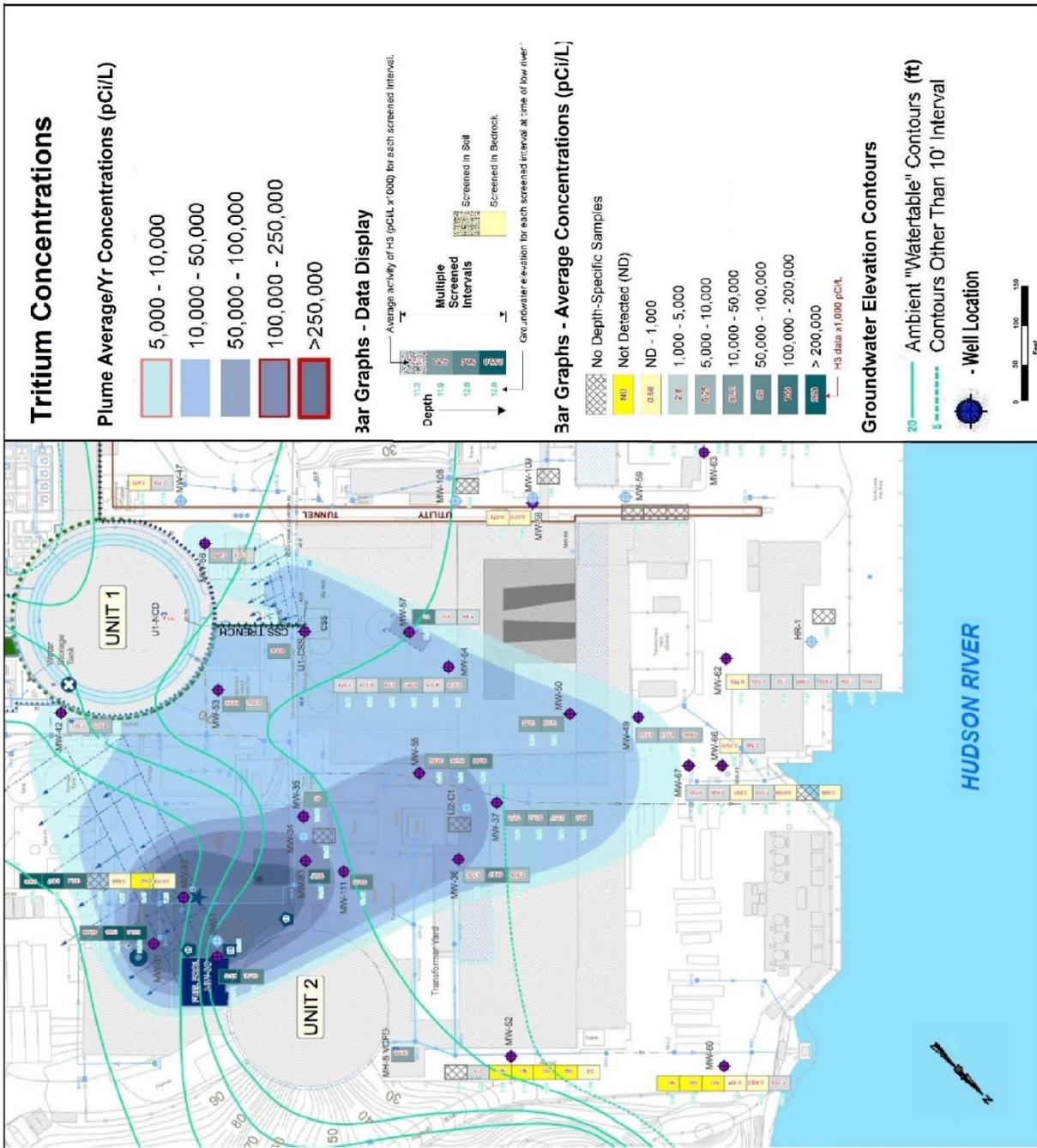
Source: Modified from Entergy 2016d

Figure 5-7. IP1 and IP2 Tritium Plumes in the 1st Quarter of 2016



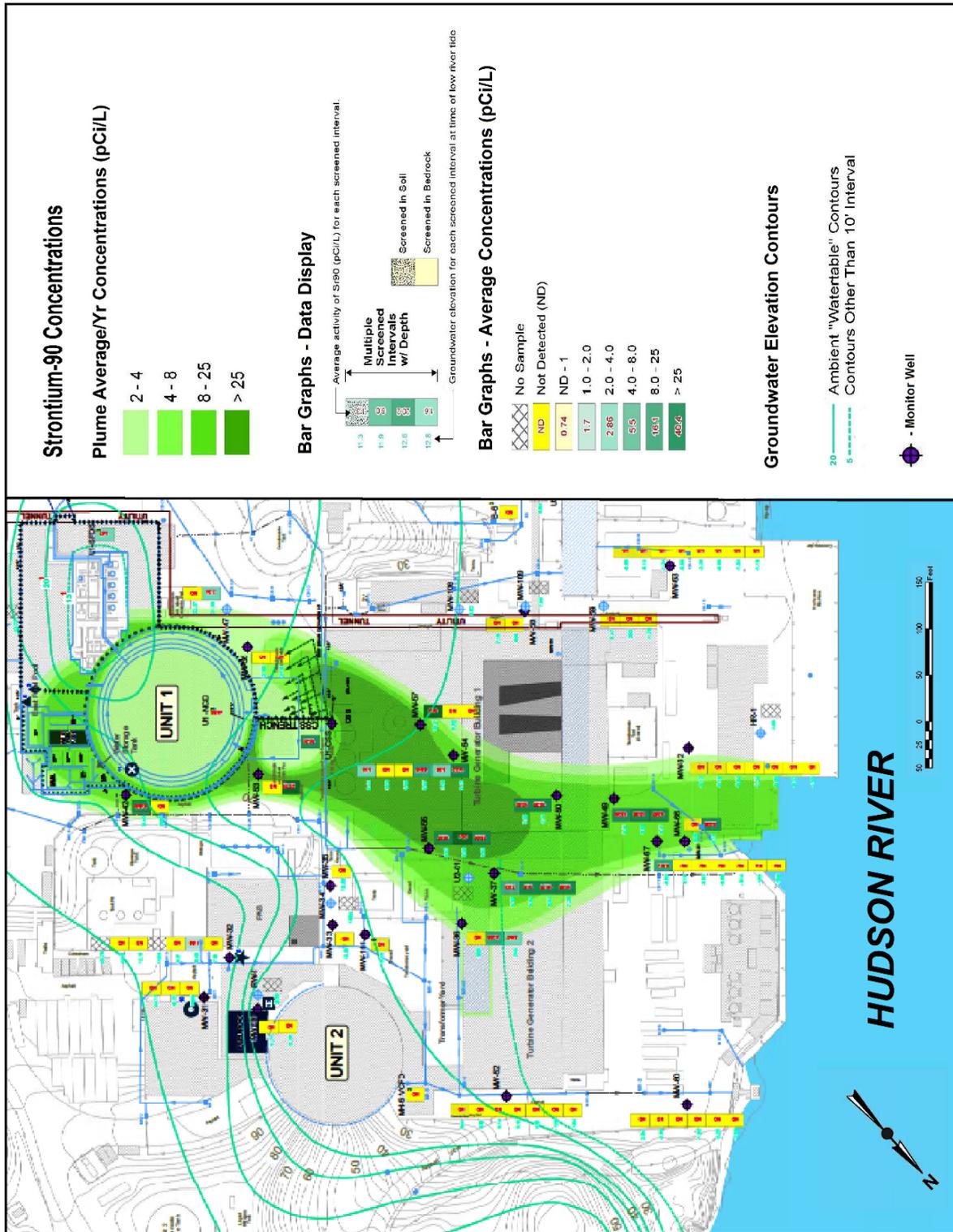
Source: Modified from Entergy 2016d

Figure 5–8. IP1 and IP2 Tritium Plumes in the 3rd Quarter of 2016



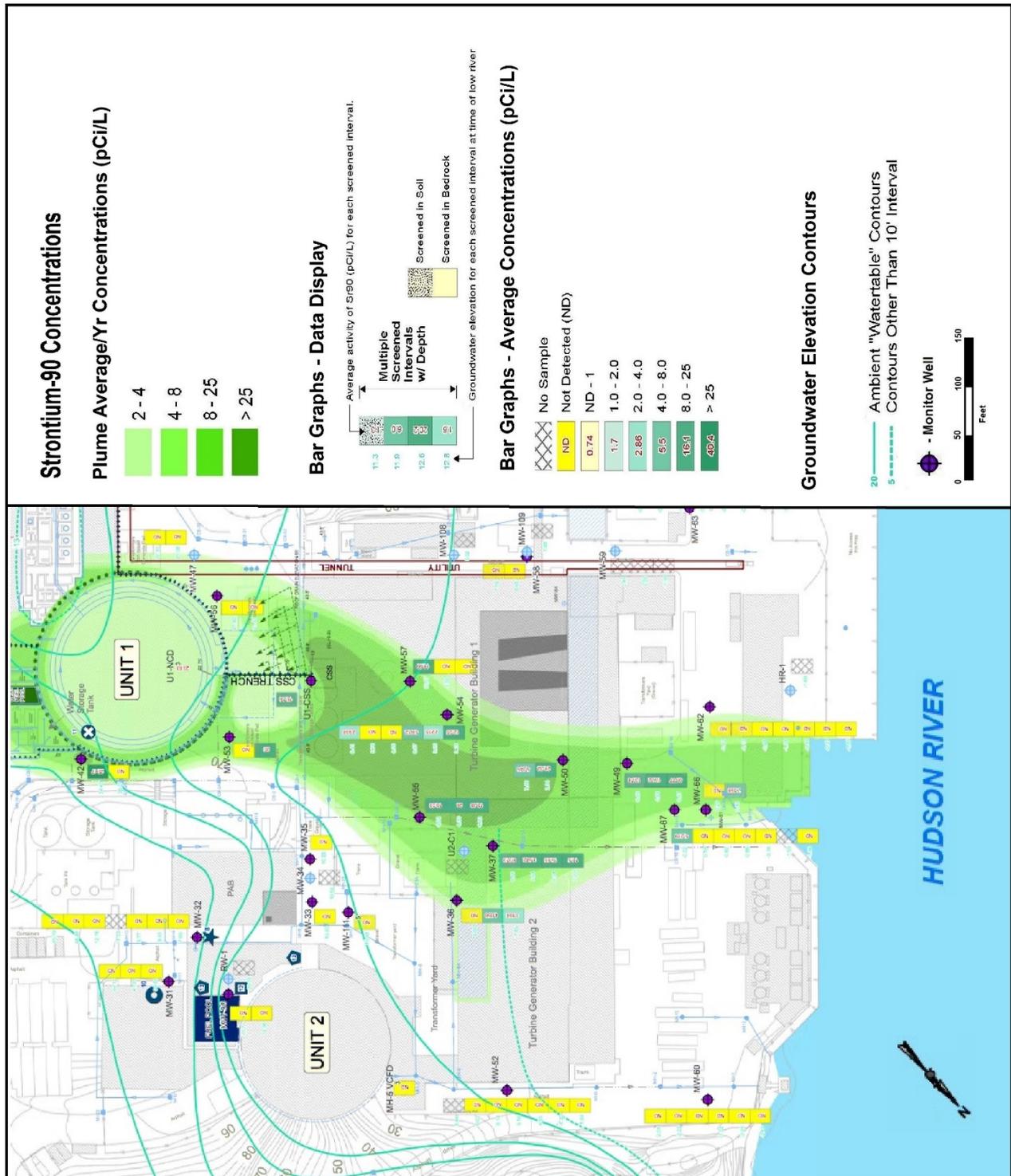
Source: Modified from Entergy 2017b

Figure 5–9. Strontium-90 Plume in the 4th Quarter of 2014



Source: Modified from Entergy 2015f

Figure 5–10. Strontium-90 Plume in the 3rd Quarter of 2016



Source: Modified from Entergy 2017b

For short periods of time, from 2007 through June 2015, cesium-137, nickel-63, and cobalt-60 were sporadically detected in some wells located near plant structures. How these

radionuclides got into the groundwater has not been determined. However, cesium-137 and nickel-63 have been consistently detected at sample location MW-42-49. Sample location MW-42-49 is located close to the IP1 spent fuel pool (Figure 5–5) (Entergy 2008c, 2009a, 2010a, 2011a, 2012b, 2013a, 2014f, 2014h, 2015b, 2015f, 2016b, 2016d, 2016e, 2017b). Antimony-125, cobalt-58, and chromium-51, which were recently detected in the groundwater in two wells near IP2, are believed to be the result of the 2016 spill described in Section 5.4.2.1 (Entergy 2016d). No plumes of contamination have been found for antimony-125, cesium-137, chromium-51, cobalt-58, cobalt-60, or nickel-63 indicating that they have contaminated only small areas of the groundwater.

To better characterize the impacts on groundwater quality (i.e., the groundwater as a resource), it is helpful to compare the concentrations of the radionuclides in the groundwater to EPA maximum contaminant levels (MCL). For radionuclides in drinking water, EPA has established an MCL of 4 millirem (mrem) per year for various radionuclides. This MCL includes antimony-125, cesium-137, cobalt-58, cobalt-60, nickel-63, strontium-90, and tritium. The MCL represents the sum of all radionuclides in drinking water, so that, taken together, the annual dose from all the applicable radionuclides will not exceed 4 mrem per year. However, for ease of comparison, Table 5–2 presents a concentration that would be required from an individual radionuclide in drinking water to yield a dose of 4 mrem per year (i.e., without the added contribution of any other radionuclides). Looking at the concentrations in Table 5–2, strontium-90 concentrations have the biggest influence on dose, and tritium has the least influence on the dose calculation.

Table 5–2. Radionuclide Concentration Limits

Radionuclide	Concentration Limit (pCi/L) ^(a)
Antimony-125	300
Cesium-137	200
Cobalt-60	100
Cobalt-58	300
Chromium-51	6,000
Nickel-63	50
Strontium-90	8
Tritium	20,000

^(a) Concentration in drinking water for this radionuclide to produce a dose of 4 mrem per year.

Sources: EPA 2002b, 2002c, 2002d, 2002e, 2002f, 2015f

In the 3rd quarter of 2014, tritium concentrations in the plume associated with IP2 were below the concentration in Table 5–2 over much of the area of the plume, but they exceeded the concentration limit in Table 5–2 in a small area near the IP2 spent fuel pool. Tritium concentrations in the plume from the IP1 spent fuel pool were all below the concentration in Table 5–2 over the entire plume length. However, as a result of the 2014 and 2016 spills into the groundwater near IP2, tritium concentrations in the groundwater significantly increased, with the result that in much of the area between IP2 and the Hudson River, tritium levels exceed the concentration limit in Table 5–2. As of the 3rd quarter of 2016, concentrations of strontium-90 usually exceed the Table 5–2 limit over much of the plume area.

For the radionuclides antimony-125, cesium-137, chromium-51, cobalt-60, cobalt-58, and nickel-63, no plumes of contamination have been identified. In the 1st quarter of 2016,

cobalt-60 was detected in monitoring well MW-32 (located near IP2) at a concentration of 20.5 pCi/L. The measured concentration is below the limit in Table 5-2. In the 2nd and 3rd quarters of 2016, cobalt-60 was not detected in any of the monitoring wells. In the 3rd quarter of 2016, a low concentration of cesium-137 (13.4 pCi/L) was detected in well MW-32. This is significantly below the limit in Table 5-2 (Entergy 2016d, 2016e, 2017b).

Since 2007, cesium-137 and nickel-63 have been detected in well MW-42. This well is located near the IP1 fuel pool. In the 1st quarter of 2016, the concentration of cesium-137 in well MW-42 was 46,000 pCi/L and nickel-63 was 498 pCi/L. In the 2nd quarter of 2016, nickel-63 was not detected in any of the monitoring wells. However, cesium-137 had increased in well MW-42 to 68,600 pCi/L. In the 3rd quarter of 2016, cesium-137 concentrations had decreased to 8,340 pCi/L and nickel concentrations were measured at 1,070 pCi/L. These concentrations are well above the limits in Table 5-2. Since 2007, while concentrations of cesium-137 and nickel-63 in well MW-42 have varied over time, they do not seem to have moved from the area monitored by this well (Entergy 2016d, 2016e, 2017b).

As previously described, in the 1st quarter of 2016, antimony-125, cobalt-58, and chromium-51 were detected in two monitoring wells (MW-31 and MW-32) located adjacent to IP2. Antimony concentrations in MW-31 were less than the limit in Table 5-2, while the maximum concentration (4,750 pCi/L) in well MW-32 exceeded the limits in Table 5-2. In the 2nd quarter of 2016, antimony concentrations in MW-31 continued to be less than the limit in Table 5-2, although concentrations in well MW-32 were just above the limit with a maximum concentration of 516 pCi/L. This is a significant decrease from the antimony-125 concentrations reported in the 1st quarter of 2016 (Entergy 2016d, 2016e, 2017b).

As previously described, cobalt-58 and chromium-51 were detected in the 1st quarter of 2016, but values were not reported. No mention is made in the 2nd quarter report (Entergy 2016e) as to whether cobalt-58 and chromium-51 were detected in the groundwater. However, in the 3rd quarter of 2016, a maximum concentration of 76.7 pCi/L was reported for well MW-32 (Entergy 2017b). This is significantly below the limit in Table 5-2. Values have not been reported for chromium-51, so no comparison to the values in Table 5-2 can be made at this time (Entergy 2016d).

From 1995 through 2015, routine monitoring of tritium in Hudson River water has been conducted. Concentrations in the river water did not exceed 800 pCi/L. This is a very low-level concentration relative to the concentration limits in Table 5-2 (Entergy 2006, 2014g, 2017b).

5.4.2.3 *Monitoring Contamination*

Entergy began a Long-Term Monitoring Program in 2005 (NRC 2010). This expanded monitoring program is designed to provide groundwater information to address the following four main objectives (Entergy 2014h, 2014k, 2015b, 2015f):

- (1) characterize the current and potential future offsite groundwater contaminant migration to the Hudson River,
- (2) confirm that contaminated groundwater is not migrating off the property to locations other than the Hudson River,
- (3) monitor groundwater proximate to critical structures, systems, and components that might have releases that cannot be visually detected and might carry an activity level of significance, and
- (4) monitor changes in plume concentrations.

As previously described, the monitoring network contains over 150 depth-specific sampling locations at 65 monitoring installations.

In accordance with NRC regulatory requirements, Entergy also conducts a Radiological Environmental Monitoring Program (REMP) that provides for the monitoring and reporting of radiological impacts resulting from plant operations. Entergy has institutionalized the Long-Term Monitoring Program in the Offsite Dose Calculation Manual and its implementing procedures (Entergy 2008f; NRC 2012e). This means that in addition to the REMP, the Long-Term Monitoring Program is subject to NRC inspection activities. The NRC staff currently inspects Entergy's Long-Term Monitoring Program and will continue to do so in the future.

The Long-Term Monitoring Program is also part of the nuclear industry's "Industry Ground Water Protection Initiative." Entergy implemented the "Industry Ground Water Protection Initiative" (NEI-07-07) (NEI 2007) at the Indian Point site in 2007. Since 2008, NRC staff has been monitoring implementation of this initiative at licensed nuclear reactor sites. The initiative identifies actions to improve management and responses to instances in which the inadvertent release of radioactive substances may result in low, but detectable, levels of nuclear power plant-related radioactive materials in subsurface soils and water. The initiative identifies those actions necessary for implementation of a timely and effective groundwater protection program. In addition, objectives are specified to accomplish each action and the acceptance criteria to demonstrate that the objectives have been met.

The objectives include:

- Ensure that the site characterization of geology and hydrology provides an understanding of predominant groundwater gradients based upon current site conditions.
- Identify site risks based on plant design and work practices.
- Evaluate all systems, structures, or components that contain or could contain licensed material and for which there is a credible mechanism for the licensed material to reach groundwater.
- Evaluate work practices that involve licensed material and for which there is a credible mechanism for the licensed material to reach groundwater.
- Establish an onsite groundwater monitoring program to ensure timely detection of inadvertent radiological releases to groundwater.
- Establish a remediation protocol to prevent migration of licensed material off site and to minimize decommissioning impacts.
- Ensure that records of leaks, spills, and remediation efforts are retained and retrievable.
- Conduct initial and periodic briefings on the site-specific Groundwater Protection Initiative program with the designated State and local officials.
- Make informal communications as soon as practicable to appropriate State and local officials, with follow up notifications to the NRC, as appropriate, regarding significant onsite leaks or spills into groundwater.
- Document all onsite groundwater sample results and a description of any significant onsite leaks/spills into groundwater for each calendar year in the Annual Radiological Environmental Operating Report (AREOR) or the Annual Radioactive Effluent Release Report.

New Environmental Issues

- Perform a self-assessment of the Groundwater Protection Initiative program.
- Conduct a review of the Groundwater Protection Initiative program, including at a minimum, the licensee's self-assessments, under the auspices of the Nuclear Energy Institute.

As previously discussed, a porous media groundwater flow model is used by Entergy to compute radionuclide release rates to the discharge canal and directly to the Hudson River (Entergy 2014h, 2014k, 2015a). The model calculates groundwater flow rates across the site. Yearly rolling average radionuclide levels within each zone are then used to calculate the release rate. The results of this monitoring program are reported annually in an Annual Radioactive Effluent Release Report and an AREOR. These reports are publicly available on the NRC Web site (NRC 2016f).

Entergy committed to the following conditions as part of a settlement with Riverkeeper, Inc., Hudson and River Sloop Clearwater, Inc. (Riverkeeper et al. 2012):

- Publish on a publicly available Web site each new quarterly Indian Point radionuclide groundwater monitoring report within 6 months of the end of each quarter. In the event that any such report is unavailable within 6 months of the end of the quarter, publish the final quality assurance-reviewed groundwater monitoring data for that quarter instead.
- Conduct additional downstream fish sampling at a location in Haverstraw Bay or in the vicinity in accordance with Entergy's REMP for IP2 and IP3 and report the results of such monitoring in the AREOR.

The radionuclide groundwater monitoring reports are available to the public at Entergy 2016d.

5.4.2.4 *Independent Evaluations Conducted Prior to 2015*

In 2005, the NRC staff established an independent inspection team in response to the discovery of groundwater contamination at the IP2 and IP3 site. The NRC inspection team included NRC staff experts, as well as experts from the USGS and NYSDEC. The NRC inspection team reviewed Entergy's progress, questioned the adequacy of the conceptual site model, and examined Entergy's conclusions. From 2005 through 2009, the NRC staff completed eight inspections associated with the groundwater contamination issue. The NRC staff concluded that Entergy's investigation of groundwater contamination at the IP2 and IP3 site provided a sound understanding of the extent of radiological groundwater contamination, including the spatial location and vertical depth of the radionuclide plumes. The NRC staff found that Entergy's investigation had established site groundwater flow parameters and had developed an acceptable precipitation mass/flow methodology to calculate the groundwater flux. This methodology provided a reasonable basis to quantify offsite radiological releases from groundwater. The NRC staff also concluded that continued implementation of Entergy's current groundwater monitoring program should provide reasonable assurance that if any future leaks occur they will be detected (NRC 2012e).

The NRC staff conducted its own independent groundwater sample testing to confirm the types and concentrations of radioactive contaminants that were present. The details of this analysis are discussed in NRC 2012e. In addition to tritium, the sampling program also included strontium-90, cobalt-60, nickel-63, and cesium-137. The inspection team determined that the consumption of fish and invertebrates in the Hudson River was the only viable exposure pathway to humans from the discharge of contaminated groundwater from the site (NRC 2012e).

In conjunction with the State of New York, the NRC staff performed an independent fish sampling study to investigate the strontium-90 background levels present in Hudson River fish. Fish samples obtained far upstream from the IP2 and IP3 site were compared with strontium-90 levels in fish samples taken near the site. This comparative analysis showed no contamination in any fish samples near the site greater than background levels (NRC 2012e).

In September 2009, the NRC staff issued a groundwater-related special inspection report in which it concluded that Entergy's Long-Term Monitoring Program was effectively implemented and maintained to monitor groundwater conditions. The report confirmed that Entergy was conforming to NRC regulatory requirements that protect public health and safety and the environment (NRC 2012e).

As discussed in Sections 2.1.4.1 and 2.2.7 of the 2010 FSEIS (NRC 2010), radiological environmental monitoring and surveillance has been conducted at the site and reported to the NRC, beginning 4 years before the startup of IP1 in 1958. The objectives of the program are to enable the identification and quantification of changes in the radioactivity of the area and to measure radionuclide concentrations in the environment attributable to site operations. The preoperational program was designed and implemented to determine the background radioactivity and to measure variations in activity levels from natural and other sources in the vicinity, as well as fallout from nuclear weapons tests. In addition to monitoring direct radiation and the radiation from the site via the airborne pathway, monitoring includes waterborne pathways. The waterborne pathway is monitored by collecting and analyzing samples of Hudson River water, fish and invertebrates, aquatic vegetation, bottom sediment, and shoreline sediment. Measurements of the media comprising the waterborne pathway have indicated that there is no radiological impact to the surrounding environment from the IP2 and IP3 site (NRC 2010). Additional information on the radiological impact of normal operations can be found in Section 4.3 of the 2010 FSEIS (NRC 2010).

The NYSDOH performs independent sampling and analysis of radionuclide concentrations around the site. It typically collects samples of air, water, milk, sediment, vegetation, animals, and fish (NRC 2010). NYSDEC and NYSDOH oversaw Entergy's investigation into the source and fate of the radionuclide contamination in the groundwater at the IP2 and IP3 site. The State's goals were to ensure that Entergy performed a comprehensive characterization of site groundwater contamination, took appropriate actions to identify and stop the sources of the leaks, carried out any necessary remedial actions, and developed a comprehensive monitoring program to detect any future leaks (NYSDEC 2008a).

Sampling by the State showed no significant difference between strontium-90 in the flesh of fish caught near the site and fish caught as far as 70 mi (113 km) upstream (NYSDEC 2008; NRC 2012e; Skinner and Sinnott 2009). In September 2007, the NYSDEC published some of the findings from the State's ongoing monitoring activities. The findings confirmed Entergy's calculated dose to humans from fish and concluded that (1) there are no residential or municipal drinking water wells or surface reservoirs near the plant, (2) there are no known impacts to any drinking water source, (3) no contaminated groundwater is moving toward surrounding properties, (4) contaminated groundwater is moving into the Hudson River, and (5) public exposure can only occur from the groundwater entering the Hudson River through the consumption of fish. The State also stated that it would continue to provide an independent source of information for the counties and other interested parties on topics related to the IP2 and IP3 groundwater investigation and that it would evaluate long-term monitoring plans (NYSDEC 2007).

In May 2008, the State reported that it had (NYSDEC 2008a) conducted the following activities:

- Collected split samples of groundwater from onsite and offsite monitoring wells.
- Reviewed and made recommendations on the work of Entergy's hydrology contractor.
- Performed an independent assessment of potential public health impacts.
- Recommended that Entergy expand its Hudson River fish sampling program in 2007 to address questions regarding potential impacts from strontium-90.
- Collected split samples of fish flesh from this enhanced effort and unilaterally collected bone samples for strontium-90 analysis.
- Participated in periodic stakeholder calls and meetings.

The State reported the following key findings (NYSDEC 2008a):

- Groundwater from the site flows east to west directly toward and into the Hudson River and does not flow to surrounding properties.
- Concentrations of strontium-90 have been detected on site at up to 14 times the drinking water standard.
- Contaminated groundwater is moving into the Hudson River, but the levels of radionuclides in the river are below State surface water standards for tritium (20,000 pCi/L) and strontium-90 (8 pCi/L).
- No drinking water sources are affected because the Hudson River in this area is brackish and, therefore, is not used as a drinking water source.
- Because the Hudson River is not used as a drinking water source in this area, the only pathway for a dose to the public from groundwater entering the River is through consumption of fish.

The State reported the following investigation outcomes (NYSDEC 2008a):

- NYSDEC and NYSDOH have accepted Entergy's characterization of the extent and levels of contamination reported in its report entitled, "Hydrogeologic Site Investigation Report for the Indian Point Energy Center," dated January 7, 2008 (GZA 2008).
- The planned remedy for the strontium-90 contamination (i.e., removal of the spent fuel and water from the IP1 spent fuel pool) will remove the active source of contamination for that plume, but residual contamination will continue for many years.
- The tritium contamination primarily came from the IP2 spent fuel pool.
- Although the known leaks have been stopped in the IP2 spent fuel pool, the full extent of the leaks is not known because of an inability to inspect the liner in the IP2 spent fuel pool while the unit is operating.
- With the removal of the active contamination source, Entergy's planned use of monitored natural attenuation is an acceptable approach to managing the remaining strontium-90 and tritium plumes.

- Because tritium becomes part of the water molecule, it cannot be removed from site groundwater by current treatment methods.
- Entergy's 2007 calculated doses to the public through fish consumption (0.00027-mrem whole body and 0.00099-mrem organ dose) are less than 1 percent of the NRC dose limits.

The State also reported the following (NYSDEC 2008a):

- The NYSDOH has confirmed Entergy's calculated dose to humans from fish.
- The enhanced 2007 fish sampling effort showed no significant difference between strontium-90 in the flesh of fish caught near the site and fish caught as far as 70 mi (113 km) upstream.

In 2015, the State reported the following (NYSDEC 2015c):

- The results of the 2006 REMP found no differences in strontium-90 concentrations in fish caught near the plant and those caught upriver at a control location near Newburgh, New York, and no public health threat from consumption of fish caught in the Hudson as a result of the strontium-90 groundwater flow into the river.
- The results of the 2007 enhanced REMP analyses again showed no differences in strontium-90 concentration in fish flesh between fish caught near the Indian Point Energy Center (IPEC) and those caught near Newburgh, New York. There was also no difference between flesh concentrations in fish caught at either of these locations and the fish caught near Catskill, New York. Additionally, there was no difference in the more sensitive indicator of strontium-90 concentrations in fish bones caught in these three locations.

5.4.2.5 *Corrective Actions*

To eliminate the source of radionuclide groundwater contamination, Entergy completed the following corrective measures:

- The IP2 transfer canal liner weld imperfection was repaired in December 2007.
- The fuel rods in the IP1 spent fuel pool were removed and the fuel pool was drained of water in late 2008.

Removing the fuel rods and draining the water from the IP1 spent fuel pool stopped it from adding more radionuclides to the groundwater. Repairing the weld imperfection in the IP2 transfer canal liner eliminated a source that was adding tritium to the groundwater (GZA 2008; Entergy 2015b).

A Long-Term Monitoring Program with multi-level groundwater monitoring installations was established throughout the site. Some monitoring installations are located near existing releases, and some are positioned to detect any future inadvertent releases that might occur in other areas of the site (GZA 2008).

Different options were considered to address the existing radiological groundwater contamination. Entergy concluded that pumping the groundwater had the risk of expanding the strontium-90 plume over a larger area. Therefore, Entergy decided to continue with the existing active groundwater restoration activities via drains near the IP1 spent fuel pool and to use monitored natural attenuation as a remediation approach (NRC 2012e). Monitored natural attenuation is a methodology endorsed by EPA and NYSDEC that, depending on site-specific circumstances, is used to reduce or attenuate the concentration of contaminants in the groundwater (EPA 1999a, 2012; NYSDEC 2010). Natural attenuation relies on natural

processes, such as dilution, sorption, evaporation, radioactive decay, and chemical reactions with natural substances.

At the IP2 and IP3 site, depending on the radionuclide, the primary natural processes attenuating radionuclide contamination in the groundwater are radioactive decay, dilution, and sorption. Radioactive decay results in a reduction in the quantity of a radionuclide that is present over time. Dilution decreases the concentrations of contaminants as they move through and mix with clean groundwater. Sorption causes contaminants to bind to soil or rock. As part of a monitored natural attenuation program to remediate groundwater contamination, the site is monitored to ensure that natural attenuation is working (EPA 2012).

Based on radionuclide half-lives over a 20-year license renewal period, the NRC staff estimates that radioactive decay would reduce the mass of cobalt-60 by approximately 93 percent, antimony-125 by 41 percent, cesium-137 by 32 percent, and nickel-63 by 13 percent. Cobalt-58 and chromium-51 have very short half-lives and would likely have decayed away within 4 years of entering the groundwater.

Because tritium has a half-life of 12.3 years and strontium-90 has a half-life of 29 years, the tritium plumes will be more attenuated by radioactive decay than the strontium-90 plume. Over a 20-year license renewal period, radioactive decay would reduce the mass of the tritium plumes by approximately 68 percent and the mass of the strontium-90 plume by approximately 38 percent. As the mass of radiological contaminants decreases, the concentration of radiological contaminants would see a corresponding decrease.

When the radiological contaminants move into the Hudson River, they are greatly diluted by the high volume of water in the Hudson River because the flow rate of contaminated groundwater into the river is very low with respect to the volume of water flowing in the river. Entergy will continue to use groundwater and surface water quality monitoring during the license renewal term to confirm that radionuclide attenuation is occurring as expected and that Hudson River water quality is not being significantly affected.

Tritium is a hydrogen atom with an atomic mass of 3. It behaves chemically like any ordinary hydrogen atom. As hydrogen readily binds with oxygen to form water; tritium also reacts with oxygen to form water. This means that a tritium atom usually moves through the environment as part of a water molecule. A water molecule that contains tritium will behave in the environment just like a water molecule that does not contain tritium would behave.

When the source of water containing tritium is stopped, the contaminated water reaching the water table should eventually stop. The plume of contamination in the water table should begin to attenuate by the natural flow of groundwater toward the Hudson River. However, some of the fractures above the water table in the Inwood Marble may have trapped some of the water containing tritium. Local rainfall should eventually flush this water out and move it down to the water table. The addition of this formerly trapped tritium into the water table would lengthen the time for natural flushing to fully attenuate the groundwater in the Inwood Marble.

Releases of water containing strontium-90 also flow through the fractures in the Inwood Marble above the water table. Some of this water may also be temporarily trapped in fractures above the water table. Like the tritium plumes, the trapping of this water would lengthen the time for strontium-90 to reach the water table. However, unlike tritium, strontium-90 atoms do not move at the same rate as the water because strontium-90 can be adsorbed onto rock and minerals within the fractures. As strontium-90 concentrations increase in the water, some of the strontium-90 moves out of the water and is adsorbed. Later, as strontium-90 concentrations in the water decrease, some of the strontium-90 desorbs from the rock and moves back into the water. This same process of adsorption and desorption, referred to as retardation, occurs

above the water table and in the water table along the entire groundwater flow path to the river. This process of retardation not only will lengthen the period of plume attenuation, but it will also reduce the rate that strontium-90 enters the river. In effect, less strontium-90 will be released per year over a longer period of time than if the strontium-90 did not adsorb onto the rock and minerals of the Inwood Marble fractures.

As tritium flows into the Hudson River, it will readily move with the water in the river. However, as groundwater containing strontium-90 flows into the river, some will mix with the water in the river, and some may temporarily adsorb to the sediments in the river before it mixes with the river water.

Groundwater chemistry data collected since 2007 record the rate of groundwater restoration. The data show that tritium concentrations in the groundwater have decreased substantially between 2007 and 2014 (Entergy 2008c, 2009a, 2010a, 2011a, 2012b, 2013a, 2014e, 2014f, 2014h, 2014k, 2015b, 2015f). The concentrations in the tritium plume from the IP1 spent fuel pools have been reduced to the point that they are all well below the concentration in Table 5–2 of 20,000 pCi/L. From the 2nd quarter of 2007 through the 1st quarter of 2014, the radioactivity in the tritium plume associated with IP2 decreased by 80 percent (Entergy 2014h). However, the April 2014 and the January 2016 releases near IP2 (described above) increased the radioactivity in the tritium plume to close to 2007 levels (Entergy 2015f, 2016d). If no more releases occur, the tritium released into the groundwater in 2015 and 2016 should show a similar decrease in concentrations as occurred between 2007 and 2014.

As discussed in Section 5.4.2.1, operations to remove the spent fuel from the IP1 spent fuel pools temporarily increased the leakage rate to groundwater. This increased leakage rate resulted in increased strontium-90 radioactivity levels in the IP1 strontium-90 plume, relative to average pre-defueling radioactivity levels. However, strontium-90 radioactivity levels in the IP1 strontium-90 plume have exhibited an overall decrease since the spent fuel in the IP1 spent fuel pools was removed and the pools were dewatered (Entergy 2014f, 2014h, 2015a). From the 4th quarter of 2008—when the IP1 spent fuel pools were defueled and strontium-90 radioactivity values were at their highest reported levels in the groundwater—until the 3rd quarter of 2014, strontium radioactivity levels have decreased by 77 percent. Overall, this is a 40 percent decrease from average pre-defueling radioactivity when strontium-90 radioactivity was at lower levels (Entergy 2015f). As of the 3rd quarter of 2016, strontium-90 concentrations have shown little change from the 3rd quarter of 2014 (Entergy 2016d, 2017b).

To illustrate the rate of attenuation, Figure 5–11 shows the extent of the tritium plume from the IP2 spent fuel pool in 2007, and Figure 5–5 shows the extent of the plume in the 4th quarter of 2014. Figure 5–12 shows the extent of the strontium-90 plume in 2007, and Figure 5–9 shows the extent of the plume in the 4th quarter of 2014. Over this time period, the tritium plume shows a marked reduction in concentrations over most of the plume, with much of the reduction occurring within 2 to 3 years (Entergy 2016d). The strontium-90 plume shows decreased concentrations in the upper one-half of the plume (away from the river and near IP1), but it generally covers the same area.

As previously mentioned, the fracture network appears to have some preferred directions of groundwater flow. This might explain why existing groundwater contamination plumes have originated at different areas of the site, but discharge into the Hudson River at about the same location (Entergy 2015b). Table 5–3 displays changes with time in the concentration (maximum yearly average) of tritium and strontium-90 in groundwater near the Hudson River. The table reports concentrations from sampling stations within monitor wells MW-66 and MW-67. These wells and the sampling stations within them are located near the river and within the plumes (Entergy 2008c, 2009a, 2010a, 2011a, 2012b, 2013a, 2014f, 2015d, 2016c, 2017b).

Well locations MW-66 and MW-67 are shown on Figure 5–5 through Figure 5–12. From 2007 through 2014, tritium concentrations generally decreased, whereas strontium concentrations stayed the same or decreased. The implication is that the two plumes are being diluted by clean groundwater as the radionuclides move toward the river and as river water moves into and out of the aquifer near the river. Because of this process, the concentrations of tritium and strontium-90 in groundwater entering the river have generally remained low. Therefore, even with the previously discussed 2016 tritium leaks, which are now approaching the river; over the period of license renewal, the Hudson River is unlikely to see high concentrations of radionuclides flowing into the Hudson River.

Table 5–3. Yearly Averages of Radionuclide Concentrations in Onsite Groundwater Sampling Stations Located Near the Hudson River

Year	Groundwater Sampling Stations Near the Hudson River			
	MW-66-36 Tritium (pCi/L)	MW-67-39 Tritium (pCi/L)	MW-66-36 Strontium-90 (pCi/L)	MW-67-39 Strontium-90 (pCi/L)
2007	9,030	4,970	9	23
2008	5,950	3,730	14	18
2009	3,850	3,260	9	11
2010	2,700	3,200	5	9
2011	3,440	3,680	11	12
2012	3,475	2,765	8	10
2013	1,858	1,171	9	9
2014	1,116	1,500	8	7
2015	1,008	1,183	8	6
2016 Qtr 3	3,660	5,800	8	5

Sources: Entergy 2008c, 2009a, 2010a, 2011a, 2012b, 2014f, 2015d, 2016c, 2106e, 2017b

In addition, from 2007 through the 3rd quarter of 2016, tritium concentrations as shown in Table 5–3 were at low levels relative to the concentration limit in Table 5–2 of 20,000 pCi/L, whereas strontium-90 concentrations in the same two wells were above the concentration limit in Table 5–2 of 8 pCi/L (Entergy 2017b). However, as previously discussed, the September 2014 groundwater flow model calculated that over a 12-month period of time, the groundwater discharge rate to the Hudson River was 17 gpm (65 L/min). Using the tidal flow of 80 million gpm (302 million L/min) in the Hudson River, this rate of groundwater discharge is approximately 0.00002 percent of the water flowing in the river. This would dilute strontium and tritium values to concentrations well below the concentrations in Table 5–2. As previously stated, no plumes of contamination have been identified for the radionuclides antimony-125, cesium-137, cobalt-60, cobalt-58, chromium-51, or nickel-63. Antimony-125, like tritium, should readily move with the groundwater (PNNL 2002). It has been identified in two wells near IP2, MW-31 and MW-32. In the 3rd quarter of 2016, the maximum concentration of antimony-125 in monitoring well MW-31 was 136 pCi/L while monitoring well MW-32 had a maximum concentration of 516 pCi/L (Entergy 2017b). Cleanup of this radionuclide using monitored natural attenuation should follow the same process as tritium (i.e., movement with the general groundwater flow, dilution along the groundwater flow path and then substantial dilution within the Hudson River) (Bekins, Rittmann, MacDonald 2001; NRC 2009a; PNNL 2002).

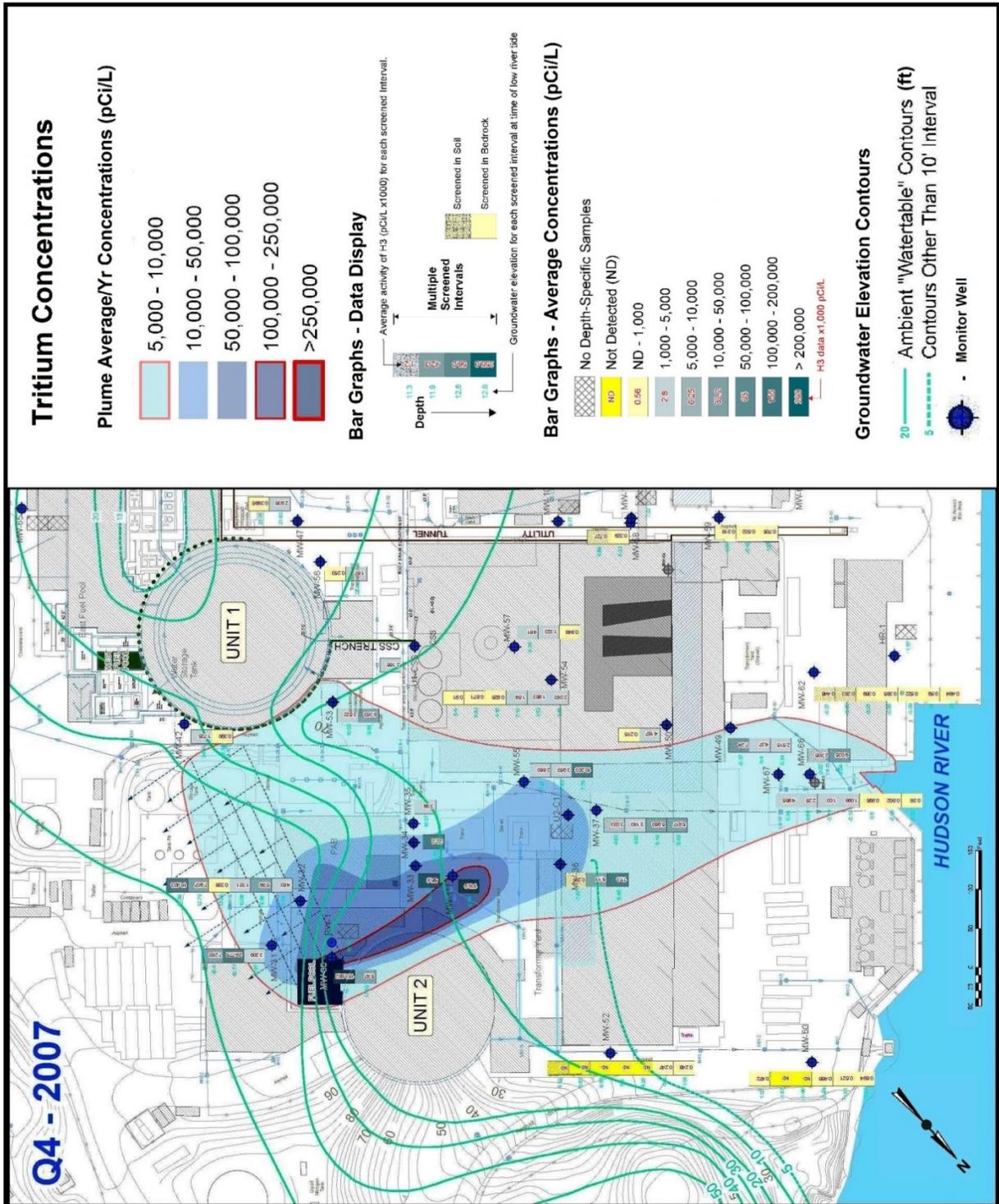
Like strontium-90, the radionuclides cesium-137, cobalt-60, cobalt-58, and nickel-63 also are likely to be attenuated (Bekins, Rittmann, MacDonald 2001; NRC 2009a) although they should move at a slower rate than the rate of groundwater flowing through the Inwood Marble. Nickel-63 and cesium-137 have historically been detected in groundwater samples from well MW-42. In the 2nd quarter of 2016, cesium-137 (340 pCi/L) and nickel-63 (1,070 pCi/L) were detected in this monitoring well (Entergy 2017b). This well is near the IP1 fuel pool. Since 2007, cesium-137 and nickel-63 do not seem to have moved far from the area monitored by this well. Therefore, over the period of license renewal, cesium-137 and nickel-63 contamination is likely to remain near this well and should not reach the Hudson River.

Cobalt-60 has been sporadically detected in the groundwater. In the 3rd quarter of 2016, cobalt-60 was detected in only one monitoring well, MW-32, at a concentration of 20.5 pCi/L. Adsorption onto the rock and minerals within Inwood Marble fractures should cause cobalt-60 and cobalt-58 movement in the groundwater to be relatively slow.

The 2nd and 3rd quarter reports (Entergy 2016e, 2017b) do not mention whether chromium-51 was detected in the groundwater. However, in the 1st quarter of 2016, chromium-51 was detected in two wells (MW-31 and MW-32) near IP2 (Entergy 2016d). The retardation rate of chromium-51 will largely depend on the chemistry of the chromium atom, which at the Indian Point site is unknown. Within the environment, chromium is found primarily in two oxidation states: chromium (III) and chromium (VI). Chromium (VI) is relatively mobile, whereas chromium (III) is less mobile and is immobile under moderately alkaline to slightly acidic conditions (EPA 1994). Because the chemical state of the chromium is unknown, the movement of chromium-51 in the groundwater could range from relatively mobile to immobile. Concentrations of chromium-51 in the groundwater at the site are currently unavailable. However, as previously mentioned, even if the concentration of chromium-51 is high and it is immobile, any chromium-51 should decay away within 4 years. If it is mobile and reaches the river in less than 4 years, it will be significantly diluted at the river.

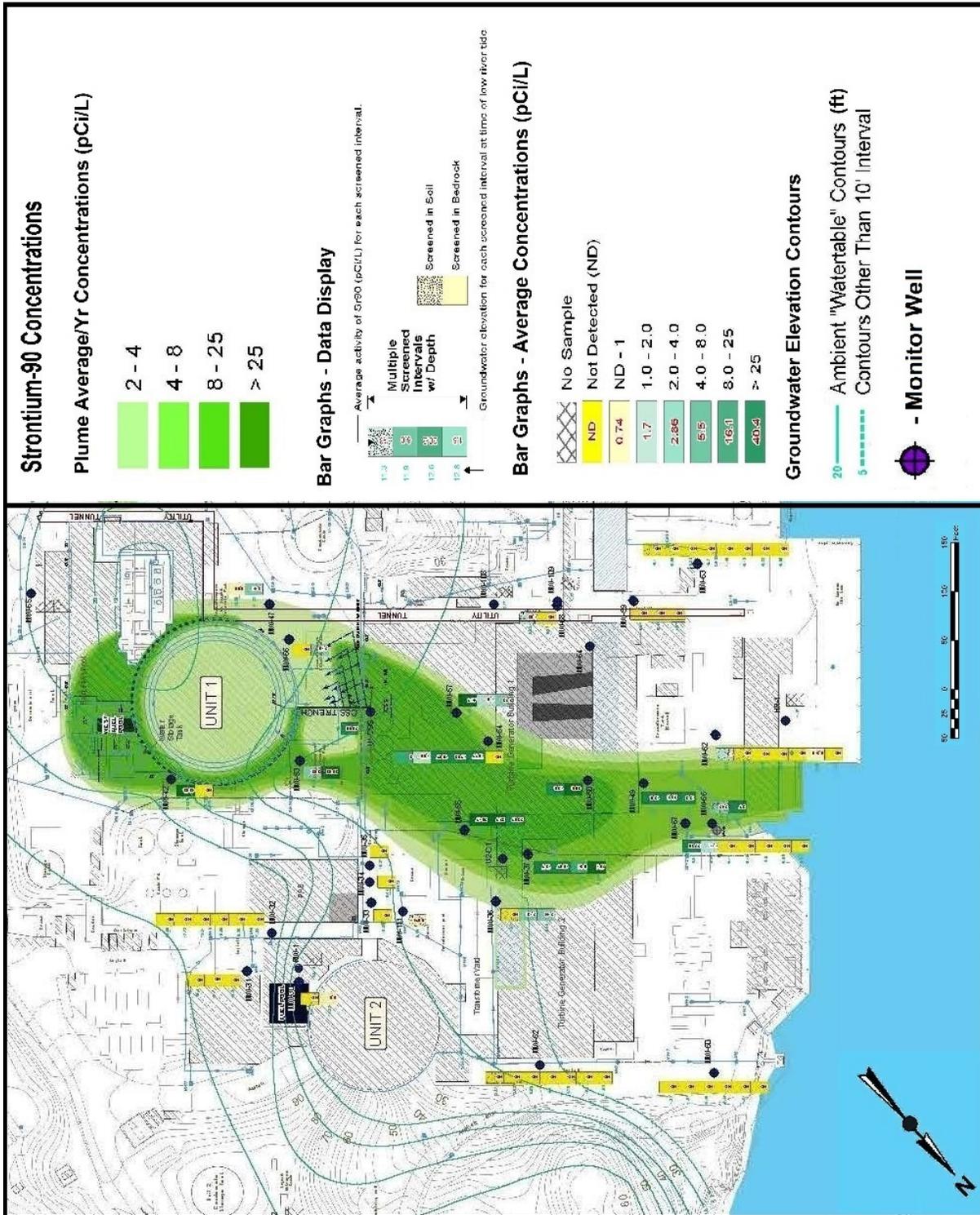
Should onsite groundwater contamination remain after the period of license renewal, Entergy would be required to address any residual contamination of the facility, as necessary.

Figure 5–11. IP2 Tritium Plume in 2007



Source: Modified from Entergy 2015b

Figure 5-12. Strontium-90 Plume in 2007



Source: Modified from Entergy 2008d

5.4.3 Environmental Consequences

This section evaluates the impact of inadvertent releases of radionuclides on groundwater and associated impacts on ambient surface water quality projected over the period of license renewal from the continued operation of IP2 and IP3. The combined impacts from IP1, IP2, and IP3 are evaluated in Section 5.14.4.

As discussed above in Section 5.4.2, the groundwater monitoring program has detected radionuclide leaks into the groundwater. The Long-Term Monitoring Program is subject to NRC oversight. If any inadvertent releases of radionuclides to the groundwater occur over the period of license renewal, it is likely that they will be readily detected by the Long-Term Monitoring Program, allowing corrective actions to be quickly taken.

The NRC staff has concluded that groundwater contamination will either remain on site or be discharged into the Hudson River. Offsite groundwater supplies should continue to be unaffected by ongoing operations. Onsite and offsite groundwater within the Inwood Marble are situated within the same continuous (i.e., interconnected) resource. Inadvertent releases (leaks and spills) of tritium into the groundwater, while not continuous, have occurred near IP2 since approximately 1990 (26 years). The impacts on groundwater quality at the Indian Point site, including impacts caused by leaks during the extended period of operation, are detectable and sufficient to alter noticeably, but not to destabilize, important attributes of the resource. Therefore, the staff concludes that the current impact to onsite groundwater quality is MODERATE. However, with the elimination of radionuclide leaks to the groundwater and with the use of monitored natural attenuation, the impact to onsite groundwater quality could move to SMALL.

The closure agreement calls for early shut down of the units. A shorter license renewal period leaves less time for the processes of natural attenuation to remove onsite radionuclide contamination from the groundwater while the plant is operating. Therefore, this issue will likely have an impact rating of MODERATE throughout the extended period of plant operations. Any remaining groundwater restoration will be addressed after plant operations have ceased.

The only surface water body that could be affected is the Hudson River. At this location, the Hudson River is brackish or saline and, therefore, is not currently used as a source of drinking water. The concentration of tritium in groundwater discharging to the Hudson River is below the concentration in Table 5–2. Furthermore, over the period of license renewal, the concentrations of radionuclides in groundwater discharging to the Hudson River should be rapidly diluted to such low levels they may not be noticeable. Therefore, the NRC staff concludes that the impact on surface water quality is SMALL.

5.5 Effects on Terrestrial Resources (Non-Cooling System Impacts)

In the 2013 GEIS (NRC 2013a), the NRC staff determined that non-cooling system effects on terrestrial resources is a Category 2 issue that requires site-specific evaluation during each license renewal review. According to the 2013 GEIS, non-cooling system impacts can include those impacts that result from landscape maintenance activities, stormwater management, elevated noise levels, and other ongoing operations and maintenance activities that would occur during the renewal period and that could affect terrestrial resources on and near a plant site.

Landscape Maintenance Activities

As indicated in Section 2.2.6.1 of the FSEIS regarding IP2 and IP3 license renewal (NRC 2010), the IP2 and IP3 site includes small tracts of forest that total approximately 25 acres (ac) (10 hectares (ha)) interspersed among the site's facilities and paved areas, maintained areas of

grass that cover about 7 ac (2.8 ha) of the site, and a forest area that covers approximately 70 ac (28 ha) of the northern portion of the site. The majority of site landscape maintenance is performed within the protected area and not within natural areas on the site. Entergy (2015a) has no plans to disturb any previously undisturbed natural habitats on the site as part of or following the proposed IP2 and IP3 license renewal. Therefore, landscape and maintenance activities are unlikely to result in noticeable effects on terrestrial resources during the proposed license renewal term.

Stormwater Management

Entergy maintains a BMP plan in accordance with Special Condition 1 of the site's SPDES permit (Permit No. NY-0004472) (NYSDEC 2000). The BMP plan identifies practices to prevent or minimize the potential for release of significant amounts of toxic or hazardous pollutants to the waters of the State through plant site runoff, spillage and leakage, sludge or waste disposal, and stormwater discharges. Entergy further monitors areas at IP2 and IP3 with the potential for spills of oil or other regulated substances under each unit's Spill Prevention, Control, and Countermeasure Plan, which is required by the EPA's Oil Pollution Prevention Rule under the authority of Section 311(j)(1)(C) of the CWA (40 CFR Part 112; Entergy 2007a). Collectively, these measures ensure that the pollutants carried by stormwater are unlikely to have adverse effects on terrestrial resources during the proposed license renewal term.

Noise

The 2013 GEIS (NRC 2013a) indicates that elevated noise levels could be a noncooling system impact to terrestrial resources. However, the 2013 GEIS also concludes that generic noise impacts would be SMALL because noise levels would remain well below regulatory guidelines for offsite receptors during continued operations and refurbishment associated with license renewal. The NRC staff did not identify any information during its review that would indicate that noise impacts to terrestrial resources at IP2 and IP3 would be unique or require separate analysis.

Other Operations and Maintenance Activities

Other operations and maintenance activities that could occur as a result of license renewal include potential replacement of the IP2 and IP3 reactor vessel heads and control rod drive mechanisms. Section 3.2.1 of the FSEIS (NRC 2010) addresses impacts to terrestrial resources that could result from these refurbishment activities. In the FSEIS, the NRC staff concluded that impacts of refurbishment on terrestrial resources would be SMALL, and the NRC staff has not identified any new and significant information that would change this conclusion.

Entergy (2015a) anticipates that all maintenance and repair of plant infrastructure (including roadways, piping installations, fencing, and other security-related infrastructure) that may be undertaken during the license renewal term would be confined to previously disturbed areas of the site. Entergy (2007a) maintains fleet procedural controls to ensure that environmentally sensitive areas, if present, are appropriately considered during site operations and project planning. These controls require Entergy personnel to review potential impacts to the environment when projects will require additional construction, require a change in the conditions of existing permits, or otherwise result in an environmental impact. Additionally, the IP2 and IP3 licenses (NRC 1973, 1975) contain Environmental Protection Plans that require Entergy to report to the NRC any occurrence of an unusual or important environmental event that could result in significant impacts causally related to plant operation. Such events include, but are not limited to, bird impaction events, fish kills, and the mortality of any species protected under the Endangered Species Act of 1973, as amended (ESA) (16 U.S.C. 1531 et seq.).

Entergy must report such events to the NRC within 24 hours and must submit a written report of events within 30 days.

Conclusion

Based on its independent review, the NRC staff concludes that the landscape maintenance activities, stormwater management, elevated noise levels, and other ongoing operations and maintenance activities that Entergy might undertake during the renewal term would primarily be confined to disturbed areas of the IP2 and IP3 site. These activities would not have noticeable effects on terrestrial resources, nor would they destabilize any important attribute of the terrestrial resources on or in the vicinity of the IP2 and IP3 site. Therefore, the NRC staff expects noncooling system impacts on terrestrial resources during the license renewal term to be SMALL.

5.6 Exposure of Terrestrial Organisms to Radionuclides

This section addresses the issue of potential impacts of radionuclides on terrestrial organisms resulting from normal operations of a nuclear power plant during the license renewal term. This issue is a new Category 1 issue that the NRC staff evaluated in the 2013 GEIS (NRC 2013a) due to public concerns about the impacts of radionuclides on terrestrial organisms at some power plants.

Section 4.6.1.1 of the 2013 GEIS considers the effects of direct and indirect exposure of terrestrial organisms to radionuclides through various pathways, including air and liquid effluent releases. The 2013 GEIS considers a number of radionuclides, including the noble gases krypton, xenon, and argon; tritium; isotopes of iodine and cesium; strontium; cobalt; and chromium. These radionuclides may be deposited directly on terrestrial plants, animals, or soils if released from power plant vents during normal operation, or terrestrial organisms may take up radionuclides if the radionuclides enter shallow groundwater. Accordingly, terrestrial organisms may be exposed to ionizing radiation from radionuclides through direct contact with air, water, or other media; inhalation; or ingestion of food, water, or soil.

In 2002, the U.S. Department of Energy (DOE) created a general screening methodology that provides limiting radionuclide concentration values (called Biota Concentration Guides (BCGs)) for aquatic and terrestrial biota. The DOE's BCGs were developed on the basis of experimental evidence that negative effects would not occur at the guideline doses. If site-specific data indicate that the BCGs are exceeded, the DOE's screening methodology leads the user to conduct a more detailed analysis. The BCGs for terrestrial organisms are as follows:

- riparian animal (0.1 radiation-absorbed dose per day (rad/d)) (0.001 gray per day (Gy/d)),
- terrestrial animal (0.1 rad/d) (0.00 Gy/d), and
- terrestrial plant (1 rad/d) (0.01 Gy/d).

In the 2013 GEIS, the NRC estimates the total dose expected to be received by the three terrestrial receptors (riparian animal, terrestrial animal, and terrestrial plant) based on site-specific radionuclide concentrations in water, sediment, and soils at 15 nuclear plants using the RESRAD-BIOTA dose evaluation model (DOE 2004). The IP2 and IP3 site (which includes IP1) is one of the sites evaluated. The estimated radiation doses listed in the 2013 GEIS for the IP2 and IP3 site, which are based on the site's 2006 REMP results as reported in the AREOR (Entergy 2007b), are as follows:

- riparian animal (2.30×10^{-3} rad/d) (2.3×10^{-5} Gy/d),
- terrestrial animal (2.22×10^{-3} rad/d) (2.22×10^{-5} Gy/d), and
- terrestrial plant (2.44×10^{-4} rad/d) (2.44×10^{-6} Gy/d).

The maximum estimated dose rate calculated for the IP2 and IP3 site and the other 14 plants evaluated in the 2013 GEIS is well below the DOE's guideline values. Based on these calculations and on a review of the available literature, the NRC staff concludes in the 2013 GEIS that the impact of routine radionuclide releases from past and current operations and refurbishment activities on terrestrial biota would be SMALL for all nuclear plants and would not be expected to appreciably change during the license renewal period.

The NRC staff has not identified any new and significant information related to the exposure of terrestrial organisms to radionuclides during its independent review of Entergy's ER; the last 5 years of IP2 and IP3 AREOR reports (Entergy 2010b, 2011b, 2012c, 2013c, 2014g); the last 5 years of IP2 and IP3 radioactive effluent release reports (Entergy 2010a, 2011a, 2012b, 2013a, 2014f); the supplemental information submitted by Entergy in March 2015 (2015a); or other available information. Section 2.1.4 of the FSEIS regarding IP2 and IP3 license renewal (NRC 2010) describes Entergy's radioactive waste management program to control radioactive effluent discharges to ensure that discharges comply with NRC regulations in 10 CFR Part 20. Section 4.3 of the FSEIS contains the NRC staff's evaluation of IP2's and IP3's radiological impacts during normal operations, which provide further support for the conclusion that the impacts to terrestrial organisms from radioactive effluents are SMALL. The NRC staff concludes that there are no impacts beyond those described in the 2013 GEIS, which concludes that the impacts from license renewal on terrestrial organisms from radionuclides would be SMALL.

5.7 Cooling System Impacts on Terrestrial Resources (Plants with Once-Through Cooling Systems or Cooling Ponds)

This section addresses the effects that continued operation of the IP2 and IP3 cooling system during the proposed license renewal term might have on terrestrial vegetation and wildlife. In the 1996 GEIS (NRC 1996), this issue only applied to nuclear power plants with cooling ponds. Accordingly, this issue was not addressed in the 2010 FSEIS (NRC 2010) because it did not apply to IP2 and IP3 when the FSEIS was published. This Category 1 issue was expanded in the 2013 GEIS (NRC 2013a) to include plants (like IP2 and IP3) with once-through cooling systems.

Section 4.6.1.1 of the 2013 GEIS considers the effects that cooling systems might have on terrestrial resources, including the following:

- increased water temperatures,
- humidity and fogging,
- disturbance of wetlands or riparian habitat during maintenance dredging,
- erosion of shoreline wetlands, and
- contaminants in surface water or groundwater.

Elevated water temperatures associated with cooling systems may affect the distribution of some terrestrial plant and animal species associated with riparian or wetland communities. For example, the growth of plants along the cooling pond shoreline is restricted by the thermal effluent at the H.B. Robinson Steam Electric Plant, Unit 2, in South Carolina (NRC 2003).

Increased humidity and fogging around the cooling system discharge resulting from elevated water temperatures may alter the distributions of some vegetation communities. Maintenance dredging near cooling system intakes or discharges may disturb wetland habitats along with accumulated sediments, and sedimentation from dredging disposal may indirectly affect wetlands. Shoreline wetlands or riparian habitats may be affected by erosion resulting from high-velocity effluent discharges or altered current patterns. The cooling system may also transport contaminants generated during normal power plant operations to animal and plant receptors. Terrestrial biota may be exposed to contaminants released from the power plant's cooling system through direct contact with cooling system effluent or through uptake from aquatic or riparian food sources near the cooling system. Contaminants of potential concern in the cooling system effluent include chlorine and other biocides, heavy metals, VOCs, oil products, tritium, and strontium. The concentrations of these contaminants have been found to be low within the liquid effluent discharged from the nuclear power plants, and compliance with applicable NPDES permits should ensure that nonradioactive contaminant concentrations discharged in cooling system effluents are low enough to have only small impacts on terrestrial biota. Regarding tritium and strontium, the NRC (2013a) found that the maximum estimated dose rate to terrestrial organisms at nuclear power plants is well below the DOE's guidelines for terrestrial biota. Exposure of terrestrial organisms to these and other radionuclides is discussed in more detail in Section 5.6 of this supplement.

To evaluate the impacts of these potential effects in the 2013 GEIS, the NRC staff reviewed site-specific radiological effluent release reports, site environmental reports, and supplemental environmental impact statements (SEISs) for license renewal at eight nuclear power plants with different types of cooling systems. Impacts on terrestrial biota associated with the operation of the cooling systems were not found to be an issue at any of the nuclear power plants evaluated, and the NRC concludes in the 2013 GEIS that cooling system impacts on terrestrial resources are SMALL for all nuclear power plants during the license renewal term.

The NRC staff has not identified any new and significant information related to cooling system impacts on terrestrial resources during its independent review of Entergy's ER; the last 5 years of IP2 and IP3 radioactive effluent release reports (Entergy 2010a, 2011a, 2012b, 2013a, 2014f); the supplemental information submitted by Entergy in March 2015 (Entergy 2015a); or other available information. The NRC staff concludes that there are no impacts beyond those impacts described in the 2013 GEIS, which concludes that the impacts from license renewal on terrestrial organisms from continued operation of the cooling system would be SMALL.

5.8 Exposure of Aquatic Organisms to Radionuclides

The issue of potential impacts of radionuclides on aquatic organisms resulting from normal operations of a nuclear power plant during the license renewal term is a new generic (Category 1) issue in the 2013 GEIS (NRC 2013a). The 2013 GEIS includes this issue due to public concern about the impacts of radionuclides on aquatic organisms at some power plants. Section 4.6.1.2 of the 2013 GEIS considers the effects of direct and indirect exposure of aquatic organisms to radionuclides, and greater detail on this subject can be found there.

Aquatic organisms can be exposed externally to ionizing radiation from radionuclides in water, sediment, and other biota and can be exposed internally through ingested food, water, and sediment and absorption through the integument and respiratory organs. The 2013 GEIS notes that some radionuclides tend to follow pathways similar to their nutrient analogs and can therefore be transferred rapidly through the food chain. These include (1) radionuclides, such as strontium-90, barium-140, radon-226, and calcium-46, that behave like calcium and that are therefore accumulated in bony tissues, (2) radionuclides, such as iodine-129 and iodine-131,

that act like stable iodine and accumulate in thyroid tissue, (3) radionuclides, such as potassium-40, cesium-137, and rubidium-86, that follow the general movement of potassium and that can be distributed throughout the body, and (4) radionuclides, such as tritium, which resembles stable hydrogen, that are distributed throughout the body of an organism.

The DOE (DOE 2002, 2004) developed and published a screening methodology that provides limiting radionuclide concentration values (called BCGs) for aquatic and terrestrial biota. The DOE's BCGs were developed on the basis of experimental evidence that negative effects would not occur at or below the guideline doses.

Of the aquatic test subjects considered, the early life stages (especially developing eggs and the young) of some fish species appear to be the most sensitive to the effects of ionizing radiation. Significant histological effects on the gonads of small tropical fish were detected at a dose rate of 1 rad/d (0.01 Gy/d), although the majority of tests for chronic effects of ionizing radiation on aquatic organisms did not find significant effects unless the dose was much greater. The DOE's guideline for radiation dose rates from environmental sources recommends limiting the radiation dose to aquatic biota to no more than 1 rad/d (0.01 Gy/d) (i.e., the level below which the DOE expects no negative population-level effects). Because fish at early life stages were the most sensitive subjects reviewed, this dose rate should be protective of aquatic biota in general.

In the 2013 GEIS, the NRC staff reported dose rates for aquatic biota calculated with the RESRAD-BIOTA dose evaluation model using site-specific radionuclide concentrations in water and sediments from REMP reports for 15 NRC-licensed power plants, including IP2 and IP3. The estimated radiation doses listed in the 2013 GEIS for the IP2 and IP3 site (which includes IP1) are based on the site's 2006 REMP results reported in Entergy's AREOR (Entergy 2007b) as follows:

- water (5.01×10^{-2} rad/d) (5.01×10^{-4} Gy/d),
- sediment (2.03×10^{-5} rad/d) (2.03×10^{-7} Gy/d), and
- total (5.01×10^{-2} rad/d) (5.01×10^{-4} Gy/d).

The total calculated dose to aquatic biota at the IP2 and IP3 site of 5.01×10^{-2} rad/d (5.01×10^{-4} Gy/d) is one-twentieth of the DOE's guideline value of 1 rad/d (0.01 Gy/d), which indicates that no adverse effects would occur.

The total calculated dose rates for aquatic biota for all 15 plants were all less than 0.2 rad/d (0.002 Gy/d), which is less than the guideline value of 1 rad/d (0.01 Gy/d), and the 2013 GEIS anticipates that normal operations of these facilities would not result in negative effects on aquatic biota. Based on literature reviewed and on the dose rates that have been estimated for aquatic biota from site-specific data, the 2013 GEIS concludes that the impact of radionuclides on aquatic biota from past operations would be SMALL for all nuclear plants and would not be expected to change appreciably during the license renewal period. The 2013 GEIS also concludes that the impact of radionuclides on aquatic biota resulting from continued operations is a generic (Category 1) issue for license renewal.

The NRC staff did not identify any new and significant information related to the exposure of aquatic organisms to radionuclides from IP2 and IP3 during its independent review of Entergy's ER; the last 5 years of IP2 and IP3 AREOR reports (Entergy 2010b, 2011b, 2012c, 2013c, 2014g); the last 5 years of IP2 and IP3 radioactive effluent release reports (Entergy 2010a, 2011a, 2012b, 2013a, 2014f); the supplemental information submitted by Entergy in March 2015 (2015a); or other available information. Section 2.1.4 of the FSEIS regarding IP2 and IP3 license renewal (NRC 2010) describes Entergy's radioactive waste management

program to control radioactive effluent discharges to ensure that discharges comply with NRC regulations at 10 CFR Part 20. Section 4.3 of the FSEIS contains the NRC staff's evaluation of IP2's and IP3's radiological impacts during normal operations, which indicates that the impacts from radioactive effluents are SMALL. The NRC staff identified no impact to aquatic organisms from operation of IP2 and IP3 due to radionuclides beyond those impacts described in the 2013 GEIS, which concludes that the impacts to aquatic organisms during the license renewal term from radionuclides due to normal plant operation would be SMALL.

5.9 Effects of Dredging on Aquatic Organisms

The issue of effects of dredging on aquatic organisms associated with normal operations of a nuclear power plant during the license renewal term is a new generic (Category 1) issue in the 2013 GEIS (NRC 2013a). The affected environment for aquatic resources is described in Section 2.2.5 of the December 2010 FSEIS (NRC 2010). Section 2.2.5.2 describes dredging, channelization, and dam construction in the Hudson River. This section describes historic and ongoing dredge and fill activities that have altered the aquatic environment and affected flow patterns in the Hudson River, which in turn affects the river's ecosystem. Section 2.2.5 does not discuss any dredging associated with the IP2 and IP3 intake structures. In response to the NRC staff's RAI, Entergy (2015a) reported no dredging activities associated with the IP2 and IP3 intake structures over the last 5 years and reported infrequent dredging before that, with the last dredging occurring in 1994. Regarding future dredging, Entergy (2015a) states that "it may well be that no dredging occurs during the license renewal period." If dredging were to occur, such dredging must comply with USACE and NYSDEC permit requirements, including mitigation measures.

The 2013 GEIS (NRC 2013a) reviews the effects of dredging at nuclear power plants on aquatic organisms and finds that dredging would generally occur infrequently, would be relatively short in duration, and would only affect relatively small areas. On this basis, the 2013 GEIS concludes that the impact of dredging on aquatic organisms would be SMALL and would be a generic (Category 1) issue. The conditions described by the 2013 GEIS apply to dredging that might occur at IP2 and IP3 intake structures over the license renewal period if any dredging were to occur. As discussed above, Entergy (2015a) reported no dredging activities associated with the IP2 and IP3 intake structures over the last 5 years and reported infrequent dredging before that, with the last dredging occurring in 1994. Further, Entergy does not anticipate dredging during the license renewal period at this time. Accordingly, the NRC staff finds no impacts beyond those described in the 2013 GEIS, which concludes effects of dredging on the aquatic organisms during the license renewal term would be SMALL.

5.10 Impacts of Transmission Line Right-of-Way Management on Aquatic Resources

The 2013 GEIS (2013a) redefined the effects of transmission line right-of-way (ROW) management on aquatic resources in two ways. First, it separated this issue from other aquatic resource issues. Second, the NRC (2013a) redefined the action area in Section 3.1.6.5 to exclude transmission lines that may have been constructed and operated to connect the power plant to the regional electrical distribution grid but that are no longer owned or managed by the licensees and would remain energized regardless of a license renewal decision. The new issue, impacts of transmission line ROW management on aquatic resources, is a generic (Category 1) issue in the 2013 GEIS (NRC 2013a).

Sections 2.1.7 and 4.2.1 of the 2010 FSEIS (NRC 2010) describe the two 345-kilovolt (kV) transmission lines that distribute power to the electric grid and the two 138-kV lines that use the

same transmission towers to supply offsite (standby) power. These lines are within the IP2 and IP3 property boundary except for where they cross a public road to connect to the Buchanan substation owned by Consolidated Edison. Under the 2013 GEIS definition, this is the only ROW transmission line segment in scope for license renewal. In response to the NRC staff's RAI, Entergy (2015a) reports that this ROW does not cross any aquatic habitat.

Based on the absence of potentially affected aquatic habitat, no impacts are associated with the impacts of transmission line ROW management on aquatic resources beyond those considered in the 2013 GEIS, which concludes that the impact level for this issue is SMALL.

5.11 Human Health Impacts from Chemicals and Physical Occupational Hazards

Two new Category 1 (generic) issues related to Human Health were added in the NRC's 2013 revision to 10 CFR Part 51: "Human health impact from chemicals" and "Physical occupational hazards." The first issue considers the impacts from chemicals to plant workers and members of the public. The second issue considers the nonradiological occupational hazards of working at a nuclear power plant. An understanding of these nonradiological hazards to nuclear power plant workers and members of the public has been well established at nuclear power plants during those plants' current licensing terms. The impacts from chemical hazards are expected to be minimized through the applicant's use of good industrial hygiene practices as required by permits and Federal and State regulations (e.g., in compliance with the Occupational Safety and Health Administration's regulation on chemical hazards and the use of the Material Safety Data Sheet for the respective facilities). In addition, the impacts from physical hazards to plant workers will be of small significance if workers adhere to safety standards and use protective equipment as required by Federal and State regulations (e.g., Occupational Safety and Health Administration rules for industrial safety, such as mitigation measures for asphyxiation concerns and working in an enclosed space or with overhead loads). The impacts to human health for each of these new issues from continued plant operations are SMALL.

In response to the NRC staff's RAI, Entergy indicated that the use and storage of chemicals at IP2 and IP3 are controlled in accordance with Entergy's chemical control program procedure and appropriate industrial safety procedures to ensure that necessary practices are taken to protect the plant workers from exposure to hazardous chemicals. These practices can entail the use of personal protection equipment; industrial hygiene monitoring; or respiratory protection, as appropriate, based on the specific chemical hazards. In addition to the chemical storage requirements specified in Entergy's chemical control program procedure, IP2 and IP3 also have site-specific spill prevention plans and waste management procedures to minimize the potential for a chemical or hazardous waste release into the environment (Entergy 2015a).

Wastewater discharges from IP2 and IP3, including wastewater that may contain minimal amounts of chemicals or metals, are controlled in accordance with water discharge permits issued by the State of New York. Sanitary wastewater from the facility is sent to the Village of Buchanan's publically owned treatment works system. However, there are a few isolated plant areas that have their own septic tanks, which are pumped out by a septic company and taken to an offsite facility for disposal (Entergy 2015a).

Workers at or around the IP2 and IP3 site would be involved in non-nuclear work, such as electrical work, electric power line maintenance, repair work, and maintenance activities and, therefore, would be exposed to some potentially hazardous physical conditions (e.g., falls, excessive heat, cold, noise, electric shock, and pressure). Entergy maintains an occupational health and safety program consistent with Occupation Safety and Health Administration standards to address occupational hazards at IP2 and IP3 (Entergy 2015a).

The NRC staff has not identified any new and significant information related to these nonradiological issues during its independent review of Entergy's ER and responses to the NRC staff's RAIs. The NRC staff concludes that there are no impacts beyond those described in the 2013 GEIS, which concludes that the impacts to human health from chemicals or physical hazards during the license renewal term are SMALL.

5.12 Minority and Low-Income Populations

With respect to environmental justice concerns, the NRC's 2013 revision to 10 CFR Part 51 added a new Category 2 issue ("Minority and low-income populations") to evaluate the impacts of continued operations and any refurbishment activities during the license renewal term on minority populations and low-income populations living in the vicinity of the plant. The environmental justice issue was not evaluated in the 1996 GEIS because guidance for implementing Executive Order (EO) 12898 (59 FR 7629) was not available before its completion but was listed in Table B-1 of 10 CFR Part 51 as an uncategorized issue. As such, the previous finding in Table B-1 stated that "[t]he need for and the content of an analysis of environmental justice will be addressed in plant-specific reviews." Therefore, environmental justice was, and continues to be, addressed as a plant-specific issue in each SEIS, including the 2010 FSEIS (NRC 2010), along with other Category 2 license renewal NEPA issues.

Under EO 2898, Federal agencies are responsible for identifying and addressing, as appropriate, disproportionately high and adverse human health and environmental impacts on minority and low-income populations. Independent agencies, such as the NRC, are not bound by the terms of EO 12898 but are, as stated in paragraph 6-604 of the EO, "requested to comply with the provisions of [the] order." In 2004, the Commission issued a *Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions* (69 FR 52040), which states, "The Commission is committed to the general goals set forth in EO 12898, and strives to meet those goals as part of its NEPA review process."

Section 4.4.6 of the 2010 FSEIS (NRC 2010) describes minority and low-income populations within 50 mi (80 km) of IP2 and IP3 using information from the 2000 decennial Census. Updated 2010 decennial Census information on minority and low-income populations residing within 50 mi (80 km) of IP2 and IP3 is provided below.

Minority Population

According to 2010 Census data, 53 percent of the U.S. population residing within a 50-mi (80-km) radius of IP2 and IP3 (approximately 17,231,000 individuals) identified themselves as minority. The largest minority group was Hispanic or Latino (of any race) (24 percent) followed by Black or African American (17 percent) (EPA 2015c).

According to the U.S. Census Bureau's (USCB's) 2010 Census data, minority populations in Westchester County increased by approximately 63,000 persons and now comprise approximately 43 percent of the total population. The largest increase occurred in the Hispanic or Latino population (an increase of 44 percent), to 22 percent of the total population, followed by the Asian population (an increase of 25 percent), to 5 percent of the total population (USCB 2015).

Low-Income Population

According to the USCB's 2012 American Community Survey 5-Year Estimates, approximately 15 percent of individuals residing within a 50-mi (80-km) radius of IP2 and IP3 were identified as living below the Federal poverty threshold in 2010 (CAPS 2012). The 2012 Federal poverty threshold was \$23,492 for a family of four (USCB 2015).

According to the USCB's 2013 American Community Survey 1-Year Estimates, 7.2 percent of families and 9.7 percent of individuals in Westchester County were living below the 2012 Federal poverty threshold. People living in Westchester County had a median household income average of \$84,220 and a per capita income of \$47,305 (USCB 2015).

Analysis of Impacts

Section 4.4.6 of the 2010 FSEIS (NRC 2010) describes potential human health and environmental effects of license renewal on minority and low-income populations living near IP2 and IP3. The analysis uses the current human health and environmental effects of IP2 and IP3 as a "baseline" for assessing potential impacts to minority and low-income populations during the period of extended operation. Because current human health and environmental effects to minority and low-income populations are SMALL and because those effects are expected to remain unchanged during the period of extended operation, minority and low-income populations are not expected to experience disproportionately high and adverse impacts during the period of extended operation.

During the adjudicatory proceeding on the IP2 and IP3 license renewal application, an intervenor filed a contention challenging the adequacy of the NRC staff's analysis of the environmental impacts to minority and low-income populations in the 2010 FSEIS, largely focusing on the consequences of a radiological emergency requiring sheltering-in-place or an evacuation. The Commission upheld the NRC staff's analysis, finding, in pertinent part, that the FSEIS appropriately considered the reasonably foreseeable impacts of license renewal to minority and low-income populations and that supplementation of the FSEIS was not required (NRC 2015c).

Although minority and low-income populations have increased within a 50-mi (80-km) radius of IP2 and IP3 since publication of the FSEIS in 2010, supplementation of the environmental justice analysis in the FSEIS is not required because there were neither substantial changes made to the proposed action, nor did the other environmental analyses conducted for this supplement identify any new and significant human health and environmental effects.

The supplemental site-specific analysis for the license renewal of IP2 and IP3 included a review of the Entergy ER, the response to the RAI, public comments, and other information and data gathered during the site visit to IP2 and IP3. The review revealed no new and significant information about possible human health and environmental effects that would exceed those previously discussed in the 2010 FSEIS.

5.13 Greenhouse Gas Emissions and Climate Change

The following sections discuss greenhouse gas (GHG) emissions released from operation of IP2 and IP3 and the environmental impacts that could occur from changes in climate conditions. The cumulative impacts of GHG emissions on climate are discussed in Section 5.14.12.

5.13.1 Revisions to Section 6.2, "Greenhouse Gas Emissions"

The lifecycle GHG emission studies and analysis presented in Section 6.2 of the 2010 IP2 and IP3 FSEIS (NRC 2010) have been updated and included in the 2013 GEIS (Section 4.12.3.1, "Greenhouse Gas Emissions"). Therefore, the NRC staff is removing the discussion of GHG emissions presented in Section 6.2 of the 2010 FSEIS in its entirety and is replacing it with an evaluation of GHG emissions and climate change impacts at IP2 and IP3, which are presented in Section 5.13.2 of this supplement.

Lines 33-38 on page 6-8, lines 1-39 on page 6-9, lines 1-37 on page 6-10, lines 1-43 on page 6-11, lines 1-22 on page 6-12, lines 1-5 on page 6-13, lines 1-13 on page 6-14, lines 1-4 on page 6-15, lines 1-44 on page 6-16, and lines 1-3 on page 6-17 in Section 6.2 of the FSEIS are deleted.

5.13.2 GHG Emissions and Climate Change

5.13.2.1 GHG Emissions from License Renewal

Gases found in the Earth's atmosphere that trap heat and play a role in the Earth's climate are collectively termed GHGs. GHGs include carbon dioxide (CO₂); methane (CH₄); nitrous oxide (N₂O); water vapor (H₂O); and fluorinated gases, such as hydrofluorocarbons (HFC), perfluorocarbons (PFC), and sulfur hexafluoride (SF₆). The Earth's climate responds to changes in concentration of GHGs in the atmosphere as GHGs affect the amount of energy absorbed and heat trapped by the atmosphere. Increasing GHG concentration in the atmosphere generally increases the Earth's surface temperature. Atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have significantly increased since 1750 (IPCC 2007a, 2013). Carbon dioxide, methane, nitrous oxide, water vapor, and fluorinated gases (termed long-lived GHGs) are well-mixed throughout the Earth's atmosphere and their impact on climate is long-lasting as a result of their long atmospheric lifetime⁴ (EPA 2009b). Carbon dioxide is of primary concern for global climate change due to its long atmospheric lifetime, and it is the primary gas emitted as a result of human activities. Climate change research indicates that the cause of the Earth's warming over the last 50 years (see Section 5.13.2.2) is the buildup of GHGs in the atmosphere resulting from human activities (USGCRP 2014; IPCC 2013). The EPA has determined that GHGs "may reasonably be anticipated both to endanger public health and to endanger public welfare" (74 FR 66496).

Plant operations at IP2 and IP3 release GHGs directly and indirectly. Direct GHG emissions are from sources owned or controlled by the entity, which include emissions from fossil fuels burned on site, emissions from entity-owned or entity-leased vehicles, and other direct sources. Indirect GHG emissions are from sources that are not owned or directly controlled by the reporting entity but that are related to the entity's activities, such as vendor supply chains, delivery services, outsourced activities, and employee travel and commuting. Annual total (direct and indirect) GHG emissions at IP2 and IP3 for the 2009 to 2013 period are presented in Table 5-4. The GHG emission sources include permitted combustion equipment (diesel generators, boiler, and gas turbines); electrical equipment; and worker vehicles. Combustion-related sources and vehicles release primarily carbon dioxide; however, electrical equipment results in fugitive release of sulfur hexafluoride. Fluorinated gases are typically emitted in small quantities but their impacts could be substantial because of their high global warming potential (GWP).

Additional GHG emission sources present at IP2 and IP3 include refrigerant equipment and delivery vehicles. However, these are not presented in Table 5-4 because data were not readily available to quantify emissions. Entergy does not compile data on delivery vehicles (Entergy 2015a). Refrigerant equipment contains ozone-depleting substances, such as chlorofluorocarbons and hydrochlorofluorocarbons (HCFC), but these substances are typically

⁴ Atmospheric lifetime is the average time that a molecule resides in the atmosphere before it is removed by chemical reaction or deposition. This can also be thought of as the time that it takes after the human-caused emission of a gas for the concentrations of that gas in the atmosphere to return to natural levels. Greenhouse gas lifetimes can range from a few years to a few thousand years.

excluded from GHG emission inventories (EPA 2014a); estimating GHG emissions from these substances is complicated because of their ability to deplete ozone (which is also a GHG), thus making their GWPs difficult to quantify. Table 5–4 shows that GHG emissions resulting from operations at IP2 and IP3 are below the EPA’s reporting threshold of 25,000 MT (27,558 tons) of carbon dioxide equivalent (CO_{2eq}),⁵ above which facilities are required to report GHG emissions to EPA annually in accordance with 40 CFR Part 98.

Table 5–4. Estimated Greenhouse Gas Emissions from Operations at IP2 and IP3

Year	Combustion Related Sources	Worker Vehicles	Electrical Equipment Related Sources	Total
	(CO _{2eq} (MT/year)) ^(a)		(CO _{2eq} (MT/year)) ^(b)	
2009	330	4,470	1,250	6,050
2010	750	4,470	3,740	8,960
2011	360	4,470	1,250	6,080
2012	290	4,470	6,230	10,990
2013	490	4,470	N/A	4,960

^(a) Sources include diesel generators, pumps, boilers, and gas turbines. Emissions estimated based on annual fuel usage.

^(b) Represents emissions of sulfur hexafluoride used in electrical equipment. Entergy does not track pounds of sulfur hexafluoride added to electrical equipment. Emission values were estimated based on the number of sulfur hexafluoride canisters (115 pounds per canister) utilized, assuming the entire canister represents GHG emissions. No data are available for 2013.

^(c) Total emissions from combustion sources, worker vehicles, and electrical equipment.

Source: Entergy 2015a

5.13.2.2 Climate Change Impacts to Resource Areas

Climate change is the decades or longer change in climate measurements (e.g., temperature and precipitation) that has been observed on a global, national, and regional level (IPCC 2007a; EPA 2014b; USGCRP 2014). Climate change can vary regionally, spatially, and seasonally depending on local, regional, and global factors. Just as regional climate differs throughout the world, the impacts of climate change can vary between locations.

On a global level, from 1901 to 2013, average surface temperatures have risen at a rate of 0.15 °F (0.08 °C) per decade, and total annual precipitation has increased at an average rate of 0.2 percent per decade (EPA 2014b). The observed global change in average surface temperature and precipitation has been accompanied by an increase in sea surface temperatures, a decrease in global glacier ice, an increase in sea level, and changes in extreme weather events. Such extreme events include an increase in the frequency of heat waves, heavy precipitation, and minimum and maximum temperatures (IPCC 2007a; USGCRP 2009, 2014; EPA 2014b).

⁵ Carbon dioxide equivalent (CO_{2eq}) is a metric used to compare the emissions of GHG based on their GWP. The GWP is a measure used to compare how much heat a GHG traps in the atmosphere. The GWP is the total energy that a gas absorbs over a period of time compared to carbon dioxide. CO_{2eq} is obtained by multiplying the amount of the GHG by the associated GWP. For example, the GWP of methane is estimated to be 21; therefore, 1 ton of methane emission is equivalent to 21 tons of carbon dioxide emissions.

In the United States, the U.S. Global Change Research Program (USGCRP) reports that from 1895 to 2012, average surface temperature has increased by 1.3 °F to 1.9 °F (0.72 to 1.06 °C), and since 1900, average annual precipitation has increased by 5 percent (USGCRP 2014). On a seasonal basis, warming has been the greatest in the winter and spring. Since the 1980s, an increase in the length of the frost-free season, the period between the last occurrence of 32 °F (0 °C) in the spring and first occurrence of 32 °F (0 °C) in the fall, has been observed for the contiguous United States; between 1991 and 2011, the average frost-free season was 10 days longer than that between 1901 and 1960 (USGCRP 2014). Since the 1970s, the United States has warmed at a faster rate as the average surface temperature rose at an average rate of 0.31 to 0.45 °F (0.17 to 0.25 °C) per decade, and the year 2012 was the warmest on record (USGCRP 2014; EPA 2014b). Observed climate-related changes in the United States include increases in the frequency and intensity of heavy precipitation, earlier onset of spring snowmelt and runoff, rise of sea level in coastal areas, increase in occurrence of heat waves, and a decrease in occurrence of cold waves (USGCRP 2014).

Average air temperatures for the U.S. Northeast region, where IP2 and IP3 are located, increased by 2 °F (1.1 °C) between 1895 and 2011, and precipitation increased by more than 10 percent (USGCRP 2014). Additionally, the temperature of Northeast coastal waters has warmed by roughly 1.1 °F (0.6 °C) or by about 0.1 °F (0.05 °C) per decade. Between 1958 and 2010, the Northeast experienced a 71-percent increase in heavy precipitation events, the largest increase of any region in the United States. Other climate-related changes in the Northeast include a sea level rise by 1 ft (0.3 m) since 1900, a rate that exceeds the global average of 8 in. (20 cm) (USGCRP 2014). The frost-free period has increased by 10 to 14 days during the 1991 to 2012 timeframe. River flooding in the Northeast region from the 1920s through 2008 indicate an increasing trend in flooding magnitude. Since the 1980s, the intensity, frequency, and duration of North Atlantic hurricanes have increased (USGCRP 2014). Increase in the frequency of hurricanes has been linked to higher sea surface temperatures; however, numerous interacting factors contribute to hurricane activity, and these complex interactions are currently being analyzed (USGCRP 2014). Although an increase in the frequency of hurricanes has been observed, a similar trend in landfall frequency is lacking.

The NRC staff analyzed temperature and precipitation trends for the period of 1865 to 2014 in the Hudson Valley region. Average annual temperatures during this time period show large year-to-year variations, but a clear upward trend in temperature is observed. Since 1865, temperatures have increased by 0.2 °F (0.1 °C) per decade (NCDC 2015). Average annual precipitation also displays year-to-year variations; however, precipitation has increased at a rate of 0.47 in. (1.2 cm) per decade (NCDC 2015). Average sea level rise along the New York State coastline is 1.2 in. (3 cm) per decade since 1900 (Horton et al. 2014). Seekell and Pace (2011) document a long-term warming trend in the Hudson River Estuary of 0.015 °C (0.027 °F) per year over the course 63 years (1946 to 2008). Seekell and Pace (2011) have found that warming of the Hudson is driven by increases in air temperature along with a seasonal relationship between air temperatures and water temperatures. Changes in air temperatures had the greatest effect on water temperatures during the spring and summer.

Future GHG emission concentrations (emission scenarios) and climate models are commonly used to project possible climate change. Climate models indicate that over the next few decades, temperature increases will continue due to current GHG emission concentrations in the atmosphere (USGCRP 2014). Over the longer term, the magnitude of temperature increases and climate change effects will depend on both past and future GHG emissions (IPCC 2007a; USGCRP 2009, 2014).

The Northeast is projected to face continued warming and more extensive climate-related changes. For the proposed license renewal period for IP2 and IP3 (2013 through 2033 and

2015 through 2035, respectively), climate models (between 2021 and 2050 relative to the reference period (1971 to 1999)) indicate an increase in annual mean temperature for the Northeast region of 1.5 to 3.5 °F (0.8 to 1.9 °C) under a low-emission modeled scenario and 2.5 to 3.5 °F (1.4 to 1.9 °C) under a high-emission modeled scenario (NOAA 2013; USGCRP 2014). The predicted increase in temperature during this time period occurs for all seasons, with the largest increase occurring in the summertime (June, July, and August). Climate model simulations (for the time period 2021 to 2050) suggest spatial differences in annual mean precipitation changes for the Northeast. A 0- to 6-percent increase in annual mean precipitation is projected for both a low- and high-emission modeled scenario, with the northern areas of the Northeast experiencing the larger increases (NOAA 2013). Although there is great uncertainty, mean global sea levels are expected to rise 0.5 to 1.5 ft (0.15 to 0.46 m) by 2050 and 1 to 4 ft (0.3 to 1.2 m) by the end of this century (USGCRP 2014). Sea level along the Northeast coast is projected to rise 0.7 to 1.7 ft (0.2 to 0.5 m) by 2050, depending on the extent of glacier and ice sheet melt (USGCRP 2014). Future sea level rise has been difficult to predict and is dependent on the amount of warming; ice melt from glaciers and ice sheets; and local processes, such as land subsidence or uplift. Projected hurricane activity from models is uncertain: some models project increases in hurricanes and intensity, whereas others project a decrease in hurricanes and intensity (USGCRP 2014). However, models are in agreement that hurricane-associated precipitation will increase.

The New York State Energy Research and Development Authority sponsored a technical report to assess climate change impacts for the State (Horton et al. 2014; Rosenzweig et al. 2011). The report projects that air temperatures may increase 2.0 to 3.4 °F (1.1 to 1.9 °C) by 2020 and 4.1 to 6.8 °F (2.3 to 3.8 °C) by 2050 for the State of New York. Precipitation is projected to increase by approximately 1 to 8 percent by the 2020s and 3 to 12 percent by the 2050s, with much of the additional precipitation occurring during the winter months. Furthermore, sea level rise along the New York State coastline and in the tidal Hudson River is projected to rise by 3 to 8 in. (7.6 to 20 cm) by 2020 and 9 to 21 in. (23 to 53 cm) by 2050. Regional average sea surface temperatures surrounding New York are projected (between 2040 to 2069) to increase by 1.8 to 2.5 °F (1.0 to 4 °C) for near-shore waters (Rosenzweig et al. 2011). The frequency and duration of heat waves and intense precipitation events are projected to increase across the State of New York by 2020 (Horton et al. 2014).

Changes in climate have broader implications for public health, water resources, land use and development, and ecosystems. For instance, changes in precipitation patterns and increase in air temperature can affect water availability and quality, distribution of plant and animal species, land use patterns, and land cover; these changes can in turn affect terrestrial and aquatic habitats. The sections below discuss how future climate change may affect air quality, water resources, land use, terrestrial resources, aquatic resources, and human health in the region of interest for IP2 and IP3. Although the exact future climate change is uncertain, the discussions provided below demonstrate the potential implications of climate change on resources.

Air Quality

Air pollutant concentrations result from complex interactions between physical and dynamic properties of the atmosphere, land, and ocean. The formation, transport, dispersion, and deposition of air pollutants depend in part on weather conditions (IPCC 2007b). Air pollutant concentrations are sensitive to winds, temperature, humidity, and precipitation (EPA 2009a). Hence, climate change can impact air quality as a result of the changes in meteorological conditions.

Ozone has been found to be particularly sensitive to climate change (IPCC 2007b; EPA 2009b). Ozone is formed, in part, by the chemical reaction between nitrogen oxides (NO_x) and VOCs in

the presence of heat and sunlight. Nitrogen oxides and VOC sources include both natural emissions (e.g., biogenic emissions from vegetation or soils) and human activity-related emissions (e.g., motor vehicles and power plants). Sunshine, high temperatures, and air stagnation are favorable meteorological conditions to higher levels of ozone (IPCC 2007b; EPA 2009a). The emission of ozone precursors also depends on temperature, wind, and solar radiation (IPCC 2007b); both nitrogen oxides and biogenic VOC emissions are expected to be higher in a warmer climate (EPA 2009b). Although surface temperatures are expected to increase in the Northeast, this may not necessarily result in an increase in ozone concentrations. The observed correlation between increased ozone concentrations and temperature has been found to occur in polluted and urban regions (i.e., those areas where ozone concentration is greater than 60 parts per billion). Additionally, increases in ozone concentrations correlated with temperature increases occur in combination with cloud-free regions and air stagnation episodes (Jacob and Winner 2009; IPCC 2013). Climate models indicate increases in summertime daily ozone concentrations with climate change for the Northeast (e.g., Wu et al. 2008) but decreases in annual average ozone concentrations (e.g., Tagaris et al. 2007). However, increases in summertime daily ozone concentrations due to climate change have been found to be small (Tagaris et al. 2007).

Water Resources

Predicted changes in the timing, intensity, and distribution of precipitation would likely result in changes in surface water runoff affecting water availability and quality across the Northeast. As discussed above, precipitation is projected to increase across the Northeast. Additionally, increases in the frequency and intensity of extreme (heavy) precipitation events are projected across the State of New York. However, changes in precipitation alone do not equate necessarily to changes in water resources since hydrology is dependent on a number of interacting factors (Horton et al. 2014). As cited by the USGCRP, in spite of increased annual average precipitation, the loss of moisture from soils because of higher temperatures along with increased evapotranspiration from vegetation and increased average number of days without precipitation is likely to intensify short-term (seasonal or shorter) droughts across the region into the future (USGCRP 2009, 2014). Such conditions can potentially reduce the amount of water available for surface runoff and streamflow on a seasonal timeframe. However, increases in runoff and streamflow have been observed in the Northeast. In addition, the Hudson River has been identified as a water source with low sensitivity to drought (Rosenzweig et al. 2011).

The effects of climate change are projected to significantly increase water demand across most of the United States. When accounting for projected changes in population along with climate change, the eastern portion of New York may experience an increase of up to 10 percent in water demand (Figure USGCRP 2014; Figure 3.11). Furthermore, sea level rise can lead to increased saltwater advance, altering the location of the salt line (front) of the Hudson River, and to a decline in freshwater dilution downstream (Rosenzweig et al. 2011). As for water quality implications, increases in the frequency of very heavy precipitation events can result in increases in the runoff of nutrients, sediment, and other contaminants into surface water, which can lower the overall water quality (USGCRP 2014).

Climate change impacts on groundwater availability depends on basin geology, frequency and intensity of high rainfall periods, recharge, soil moisture, and interaction between groundwater and surface water (USGCRP 2014). Precipitation and evapotranspiration are key drivers in aquifer recharge. Although exact responses in groundwater storage and flow to climate change are not well understood, recent studies have started to consider the effects that climate change has on groundwater resources (USGCRP 2014). Average annual recharge is expected to remain the same with climate change, although there may be changes in the yearly timing of recharge (Horton et al. 2014). With much of the additional precipitation forecast to occur during

the winter months across New York State, at least a portion of this precipitation would fall as snow. As a result, much of the snow is likely to slowly melt in place and would not otherwise suffer significant loss through evapotranspiration during the winter months, contributing positively to groundwater recharge.

Sea level rise can also result in saltwater intrusion to coastal aquifers. Flooding and sea water intrusion from sea level rise and increasing storm surge threaten New York City and many other cities along the Atlantic Coast (USGCRP 2014).

Land Use

Anthropogenic land use is both a contributor to climate change, as well as a receptor of climate change impacts (Dale 1997). As described previously, the Northeast will likely experience rising temperatures and heavier precipitation events. Growing urban areas will further exacerbate these changes by continuing to inhibit natural ecosystem functions that could moderate climate change effects. The USGCRP (2014) indicates that land use changes, such as the continued expansion of urban areas, paired with climate change effects, such as heavier precipitation events, can exacerbate climate change effects, including reduced water filtration into the soil and increased surface runoff due to increases in impervious surface area.

Although anthropogenic land uses will contribute to climate change in these and other ways, land uses will also be affected by climate change in several ways. For instance, plant winter hardiness zones⁶ are likely to shift one-half to one full zone by the end of the proposed license renewal period (USGCRP 2014). This shift could affect the ability of native plant species to grow and could result in the introduction of new, non-native species (USGCRP 2014). Such changes in land cover and expansion of exurban and suburban areas could reduce the quality and availability of land resources and agricultural productivity. Changes or fluctuations in river water and sea levels could cause land use changes along affected water bodies and impacts to infrastructure. Such changes could necessitate infrastructure redesign and replacement. However, the limited extent of climate change that could occur during the 20-year license renewal term would not cause any significant land use changes in the vicinity of the IP2 and IP3 site.

Aquatic Resources

This discussion supplements subsection, "Climate Change," of Section 4.8.1, "Cumulative Impacts on Aquatic Resources," and Appendix H.2 of the 2010 FSEIS (NRC 2010).

The future impacts of climate change on the aquatic resources of the Hudson River will be complex due to the number of environmental factors that could change and the diversity of aquatic life in the river that will be affected. Because the understanding of how all the environmental drivers affect the interconnected web of aquatic life is incomplete, much cannot be predicted, but some effects of climate change have already been observed, and these provide some basis for predicting future impacts.

The introduction to this section discusses some specific stressors to Hudson River aquatic resources associated with climate change that have already been observed and are predicted to continue. Primarily, these stressors are increase in earth surface temperature, sea level rise in the Northeast region of the United State, an increase in heavy precipitation events, an increase in the length of the frost-free season, and long-term warming of the waters of the Hudson River estuary. For example, Seekell and Pace (2011) documented a long-term warming trend in the

⁶ Plant hardiness zones represent the geographic area in which certain categories of plant life are likely to grow based on the climate of the area.

Hudson River Estuary of 0.015 °C (0.027 °F) per year over the course of 63 years (1946 to 2008). Sea level rise along the New York State coastline and in the tidal Hudson River, regional sea surface temperature rise surrounding New York, and climatic changes are summarized above. Another observed aspect of climate change that affects aquatic resources is acidification of water resulting from dissolution of atmospheric carbon dioxide.

The IP2 and IP3 site lies in the transition zone of the Hudson River estuary where freshwater meets saltwater; therefore, the aquatic ecology can be complicated. For example, Waldman et al. (2006) found that, as of 2005, 212 fish species had been reported from the Hudson River drainage, and they classified those species into 12 groups based on zoogeographic origins. Some are resident in the river and estuary, some are migrants, and some are strays. In regard to salinity preference and residence, fish may be grouped as freshwater species, marine species, estuarine species (some of which migrate within the estuary), and diadromous species (those that spawn in freshwater but migrate to the sea and those that do the opposite). The invertebrate fauna is more complex. As examples, Strayer (2006) reports approximately 300 species of macrobenthic invertebrates alone from the tidal freshwater portion of the Hudson River estuary, and Cerrato (2006) reports 328 marine benthic species from the Lower Hudson River Bay Complex. These groups of bottom-living animals exhibit a wide array of body sizes and shapes, life histories, ecologies, and taxonomy.

Rose (2005) examined data for 141 fish species of the temperate to subarctic North Atlantic Ocean. He found evidence of distributional changes of some species due to climate change and identified groups of species that might be expected to react differently due to climate change. He notes that climate variability and change and their effects may not be uniform over the North Atlantic and that changes in the distribution of forage fish species may have major influences on ecosystem structure and the productivity of species that feed on them.

The National Marine Fisheries Service (NMFS) (2009) found sustained perturbations in the Northeast U.S. Continental Shelf Large Marine Ecosystem (NES LME) due to environmental and anthropogenic impacts over the last 4 decades. The NMFS found that thermal conditions in the NES LME are changing due to warming of coastal and shelf waters and cooling in the northern end of the range that have resulted in a constriction of thermal habitats in the ecosystem, a northward shift in the distributions of some fish species, and a shift to a warmer water fish community. In concert with the climate and physical process acting over the North Atlantic basin, zooplankton community structures and some components of benthic communities have changed. The NMFS reports a pronounced shift from a demersal fish-dominated community to one dominated by elasmobranchs (sharks and rays) and pelagic fish and from a fish community that has also been affected by a persistent change in conditions from one that favors temperate-cold water fish species to one favoring warmer water species. In addition to climate change, the NMFS cites overfishing of marine stocks as a driver of these changes. Such changes affect the Hudson River aquatic resources not only through the intrusion of sea water and marine species into the lower estuary but also through the migration of diadromous species between fresh water and the sea. Several diadromous species occur seasonally in the river near IP2 and IP3.

Nye et al. (2009) reported specifically on the results of the NMFS's investigations on spatial distribution of fish stocks on the Northeast U.S. continental shelf in relation to climate and population size from 1968 through 2007. Of 36 fish stocks examined, 24 display statistically significant changes consistent with warming as indicated by a poleward shift in the center of biomass and an increase in mean depth of occurrence, and two more show weak indications of distributional changes consistent with warming. Some of these species occur in the lower Hudson River estuary, and two, American shad (*Alosa sapidissima*) and alewife (*Alosa pseudoharengus*), are regular seasonal migrants that occur in the river near IP2 and IP3.

Overholtz et al. (2011) have found changes in the distribution of the Northwest Atlantic stock of Atlantic mackerel (*Scomber scombrus*), which occurs from Cape Hatteras to Newfoundland and migrates great distances on a seasonal basis. During a period of over 40 years (1968 through 2008), the distribution of the stock has shifted about 250 km (155 mi) to the north and east. The depth distribution of the stock has also changed from deeper off-shelf locations to shallower on-shelf ones. These areal and bathymetric changes in distribution correlate with interannual temperature variability and gradual warming. Waldman et al. (2006) report the occurrence of Atlantic mackerel in the Hudson River estuary as “temperate marine strays.”

O’Connor et al. (2012) examined the effects of climate change on the Hudson River estuary fish community over 32 years from 1974 through 2005 using data from the sampling surveys done by the Hudson River electric utilities; these surveys are the same ones that the NRC staff examined in other sections of this supplement. O’Connor et al. chose a variety of resident marine, freshwater, and anadromous fish species and life stage combinations to represent the fish community. They found that the Hudson River estuary fish community has changed significantly over the 32-year time period and that similar changes have been reported in other estuaries. They examined 20 species life stage combinations and found that changes correlate with local hydrology (freshwater flow and water temperature) and regional climate.

Invertebrates and fish are affected by climate change. The distribution of blue crabs (*Callinectes sapidus*) is also moving north. Blue crab is a commercially and recreationally important invertebrate species that occurs in the Hudson River and is sometimes impinged at IP2 and IP3. Johnson (2015) has documented that the northern range of the blue crab has moved northward from its historic limit, although it is too early to determine whether this change is permanent or ephemeral. The effects of global warming on invertebrates are not limited to blue crabs. Byrne (2011) finds that marine and estuarine invertebrates in general are adversely affected by climate change. Global warming and increased atmospheric carbon dioxide levels have deleterious effects through the direct effect of water temperature on metabolism and the narcotic effect of increased levels of dissolved carbon dioxide. Increased levels of dissolved carbon dioxide react with water and cause ocean acidification and decreases in the availability of carbonate ions that larvae require to build skeletons. Increased acidification also affects metabolism directly. These processes can affect persistence and stability of aquatic ecosystems, species invasions, and community function.

In summary, the effects of climate change and increased levels of carbon dioxide on the aquatic resources of the Hudson River are already observable. The NRC staff expects that effects will continue through the proposed license renewal period. The aquatic resources of the Hudson River estuary are diverse. The responses to environmental stressors and the interactions within and among the populations are complex. Because of these complexities, the NRC staff cannot predict the future responses of aquatic resources to climate change and increased levels of carbon dioxide.

Terrestrial Resources

As described above, the Eastern United States will likely experience rising temperatures, rising sea levels, more precipitation, and heavier precipitation events during the proposed license renewal period. As the climate changes, terrestrial resources either will need to be able to tolerate the new physical conditions or shift their population range to new areas with a more suitable climate. Scientists currently estimate that species are shifting their ranges at a rate of between 6.1 to 11 m (20 to 36 ft) in elevation per decade and 6.1 to 16.9 km (3.8 to 10.5 mi) in latitude per decade (Chen et al. 2011; Thuiller 2007). A study by Woodall et al. (2009) suggests that northward tree migration is currently underway at a rate of 100 km (62-mi) per century for many species. Although some species may readily adapt to a changing climate, others may be

more prone to experience adverse effects. For example, species whose ranges are already limited by habitat loss or fragmentation or that require very specific environmental conditions may not be able to successfully shift their ranges over time. Migratory birds that travel long distances may also be disproportionately affected because they may not be able to pick up on environmental clues that a warmer, earlier spring is occurring in the United States while overwintering in tropical areas. Fraser et al. (2013) found that songbirds overwintering in the Amazon did not leave their winter sites earlier, even when spring sites in the Eastern United States experienced a warmer spring. As a result, the song birds missed periods of peak food availability. Special status species and habitats, such as those that are Federally protected by the ESA, would likely be more sensitive to climate changes because these species' populations are already experiencing threats that are endangering their continued existence throughout all or a significant portion of their ranges. For instance, in its final rule to list the red knot (*Calidris canutus rufa*), a shorebird that migrates through the Eastern United States during fall and spring, the U.S. Fish and Wildlife Service cites several effects resulting from climate change as factors contributing to the species' decline (79 FR 73706). These effects include habitat loss from sea level rise, asynchronies in the timing of annual cycles, and increased frequency of severe storm events. Climate changes could favor non-native, invasive species and promote population increases of insect pests and plant pathogens, which may be more tolerant to a wider range of climate conditions. For instance, Albani et al. (2010) anticipate that climate change will enable the hemlock wooly adelgid (*Adelges tsugae*), an insect that has killed many eastern hemlocks (*Tsuga canadensis*) in recent years, to expand its range. Sea level rise could reduce or threaten wetland, floodplain, and riparian habitats in the Eastern United States. Reductions in these habitats, which serve as natural buffers against storm surges, could exacerbate effects to inland habitats, especially given that the intensity of storm events in the Eastern United States is likely to increase.

Historic and Cultural Resources

Increases in sea and river water levels because of changes in meteorological conditions due to climate change could result in the loss of historic and cultural resources from flooding, erosion, or inundation. Some resources could be lost due to erosion and inundation from sea and river water level changes before they could be documented or otherwise studied. However, as discussed above, future sea level changes are uncertain. The limited extent of climate change that could occur during the license renewal term would not have a significant effect on historic and cultural resources at the IP2 and IP3 site.

Socioeconomics

Rapid changes in climate conditions could have an impact on the availability of jobs in certain industries. For example, tourism and recreation are major job creators in some regions, bringing billions of dollars to regional economies. Climate change, including changes in sea temperature and water levels, could affect the unique economic characteristics of coastal areas. Across the Nation, fishing, hunting, and other outdoor activities make important economic contributions to rural economies and are also a part of the cultural tradition. A changing climate would mean reduced opportunities for some activities in some locations and expanded opportunities for others. Hunting and fishing opportunities could also change as animals' habitats shift and as relationships among species are disrupted by their different responses to climate change (USGCRP 2014). For instance, surface water thermal changes might cause a northward shift of fish; changes in the abundance and distribution of fish can potentially affect commercial and recreational fishing (USGCRP 2014). Water-dependent recreation could also be affected (USGCRP 2009). Coastal area economies are also sustained by the income from tourism, recreation, and seaport commerce. Sea level rise, which increases coastal erosion, along the Northeast region is projected to rise 0.7 to 1.7 ft (0.2 to 0.5 m) by 2050; and hurricane

rainfall and intensity is also projected to increase (USGCRP 2014). A changing climate resulting in stronger storms, coastal erosion, inundation, and flooding could damage seaports and reduce beach attractiveness. However, the limited extent of climate change that could occur during the proposed license renewal term would not cause any significant changes in socioeconomic conditions in the vicinity of the IP2 and IP3 site.

Human Health

Increasing temperatures due to changes in climate conditions could have an impact on human health. However, changes in climate conditions that may occur during the proposed license renewal term will not result in any change to the impacts from IP2 and IP3 radioactive and nonradioactive effluents.

Environmental Justice

Rapid changes in climate conditions could disproportionately affect minority and low-income populations. Sea level rise has the potential to place communities in coastal areas at risk from storms, coastal erosion, inundation, and flooding. Specifically, minority and low-income communities in coastal areas may be more vulnerable to the impacts of climate change because of their inability to afford property insurance and other protective measures. Sea level rise and inundation of coastal lands could also cause the displacement of minority and low-income communities, resulting in reduced contact and declining community cohesiveness (USGCRP 2014).

The USGCRP (2014) indicates that “infants and children, pregnant women, the elderly, people with chronic medical conditions, outdoor workers, and people living in poverty are especially at risk from a variety of climate related health effects.” Examples of these effects include increased heat stress, air pollution, extreme weather events, and diseases carried by food, water, and insects. The greatest health burdens related to climate change are likely to fall on the poor, especially those lacking adequate shelter and access to other resources, such as air conditioning. Elderly people living on fixed income, who are more likely to be poor, are more likely to have debilitating chronic diseases or limited mobility. In addition, elderly people can have a reduced ability to regulate their own body temperature or sense when they are too hot. According to the USGCRP (2009), they “are at greater risk of heart failure, which is further exacerbated when cardiac demand increases in order to cool the body during a heat wave.” The USGCRP (2009) study also found that people taking medications, such as diuretics for high blood pressure, have a higher risk of dehydration.

The USGCRP (2014) study reconfirmed the previous report findings regarding the risks of climate change on low-income populations and also warns that climate change could affect the availability and access to local plant and animal species, thus affecting the people who have historically depended on them for food or medicine. However, because of the limited extent of climate change that could occur during the proposed license renewal term, minority and low-income populations living near the IP2 and IP3 site are not expected to experience disproportionately high and adverse impacts.

5.14 Cumulative Impacts

Cumulative impacts are those that result from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions. As discussed in Section 5.0 of this supplement, the revised GEIS (NRC 2013a) and final rule (78 FR 37282) amended Table B–1 in Appendix B to Subpart A of 10 CFR Part 51 by adding cumulative impacts as a new Category 2 issue subject to site-specific review during license renewal.

Section 4.8 of the 2010 FSEIS (NRC 2010) addresses potential cumulative impacts that could occur in conjunction with IP2 and IP3 license renewal, including the contributory effects of several Federal projects and activities described in Section 2.2.10 of the FSEIS. The following sections of this supplement update the cumulative impacts analysis presented in the 2010 FSEIS.

The table below identifies new actions and projects considered in the NRC staff’s analysis of cumulative impacts in this supplement related to the environmental analysis of the continued operation of IP2 and IP3. These new actions and projects are in addition to those previously considered in Sections 2.2.10 and 4.8 of the 2010 FSEIS.

Table 5–5. Actions and Projects Considered in the Cumulative Impacts Analysis Subsequent to the Issuance of the 2010 FSEIS

Project Name^(a)	Summary of Project	Approximate Location (Relative to IP2 and IP3)	Status
Electrical Distribution Projects			
Champlain Hudson Power Express Project	1,000-MW high-voltage transmission system extending 335 mi (539 km), primarily underground, from the Canadian border to the New York City Metropolitan area. Cables would be buried along existing ROWs and within several waterbodies, including the Hudson River.	0.7 mi (1.1 km) northwest of the IP2 and IP3 site at the nearest location	Proposed construction from 2015 to 2017 (FERC 2015; TDI 2015)
West Point Transmission Project	1,000-MW high-voltage transmission system from Athens to Cortlandt, New York. The line would be buried in the Hudson River for 74 mi (119 km).	0.5 mi (0.8 km) southwest of the IP2 and IP3 site at the nearest location	Proposed construction in 2016 (FERC 2015; Times-Herald Record 2013)
Natural Gas Energy Projects			
Algonquin Incremental Market (AIM) Project	Construction and operation of 37.4 mi (60.2 km) of a natural gas pipeline and associated equipment and facilities in New York, Connecticut, and Massachusetts.	Proposed to cross southern portion of the IP2 and IP3 site	Proposed construction from 2015 to 2016 (FERC 2015)

Project Name^(a)	Summary of Project	Approximate Location (Relative to IP2 and IP3)	Status
NRG Bowline Repowering Project	Modernization of the existing 580-MW peaking plant to produce two 500-MW natural gas combined-cycle plants.	4.5 mi (7 km) south-southwest of the IP2 and IP3 site on the Hudson River	Proposed but no established construction/operating schedule (FERC 2015; Reuters 2013)
Manufacturing Facilities			
U.S. Gypsum Company dredging activities	Maintenance dredging of an access channel (approximately once every 5 years).	3 mi (4.8 km) south-southwest of the IP2 and IP3 site	Ongoing (FERC 2015)
IP2 and IP3 Projects			
Expansion of the existing independent spent fuel storage installation at IP2 and IP3	Expansion of the dry spent fuel storage facility to handle additional spent nuclear fuel generated during the license renewal term.	On the IP2 and IP3 site	Undetermined (Entergy 2015a)
Other Projects			
Future Urbanization	Construction of planned residential, commercial, and industrial developments and the associated transportation and utility infrastructure and the water and wastewater treatment and distribution facilities.	Throughout the region	Future construction as described in State and local land use planning documents

^(a) The draft version of this supplement included a separate category for water supply and treatment facilities, and referenced a desalination facility that was proposed to be constructed and operated in the town of Haverstraw, referred to as the Haverstraw Water Supply Project. On December 21, 2015, SUEZ Water announced that it had abandoned the project; therefore, all references to that project have been removed from the FSEIS supplement. For additional information, please see: <http://documents.dps.ny.gov/public/mattermanagement/casemaster.aspx?mattercaseno=13-w-0303>.

Potential cumulative impacts associated with these new actions and projects are discussed in the following subsections. Not all actions or projects listed in this table are considered in each resource area because of the uniqueness of the resource and its geographic area of consideration.

5.14.1 Air Quality and Noise

5.14.1.1 Air Quality

This section addresses the direct and indirect effects of license renewal on air quality when added to the aggregate effects of other past, present, and reasonably foreseeable

future actions. Air quality designations for criteria air pollutants are generally made at the county level. Therefore, the geographic area considered in the cumulative air quality analysis is the County where IP2 and IP3 are located, Westchester County, New York. With regard to NAAQS, Westchester County is designated a nonattainment area for ozone and a maintenance area for carbon monoxide and PM_{2.5} (EPA 2015a). Furthermore, New York is part of the OTR. The OTR is established in Section 184 of the CAA and requires those States in the OTR to take steps to control interstate transport of air pollutants that form ozone.

As noted in Section 5.1.3 of this supplement, the incremental impacts from the proposed license renewal would be SMALL. Entergy does not anticipate increases of air emissions associated with continued operation with IP2 and IP3 during the license renewal period (Entergy 2015a). Any unforeseen increases from future activities at IP2 and IP3 that may increase air emissions would require an air permit from NYSDEC, and additional emissions will be limited and in accordance with the requirements set forth in the air emissions permit.

Table 5–5 above and Section 2.2.10 of the 2010 FSEIS identify present and reasonably foreseeable projects that could contribute to cumulative impacts to air quality. Although project timing and location are difficult to predict, some of the activities in Table 5–5 can have cumulative impacts to air quality. Construction of the projects identified in Table 5–5 will emit air pollutants as a result of diesel or gasoline exhaust from construction equipment, land clearing and excavation, and worker vehicle emissions. However, air emissions will be temporary (through the duration of construction), intermittent, and localized. Therefore, potential emissions resulting from construction-related activities associated with these projects/activities are not anticipated to significantly affect air quality.

Operation of the natural gas combined-cycle plants identified in Table 5–5 will emit criteria pollutants (nitrogen oxides, sulfur dioxide, carbon monoxide, and PM) and could qualify as a major emitting industrial facility that would be subject to a New Source Review under requirements of the CAA. Air emissions from these facilities will need to be permitted in accordance with State and Federal regulatory requirements, and compliance with such requirements and permits will minimize impacts to air quality.

Operation of the Algonquin Incremental (AIM) project will result in additional air emissions both within and outside of the geographic area considered in this air quality cumulative analysis (Westchester County). Emissions would result from the operation of new and current compressor units, meter and regulating stations, and fugitive releases from the pipeline and components. Although the operation of the AIM project will require major or minor New Source Review permits, the Federal Energy Regulatory Commission concluded that operational emissions for the project would not contribute to a violation of NAAQS (FERC 2015). Furthermore, as a result of modifications of existing equipment, removal of existing compressors at compressor stations near IP2 and IP3, or both, emissions will be reduced from their current levels for those specific project locations (FERC 2015). With respect to the New York/New Jersey/Philadelphia Metropolitan Area Airspace Redesign project, the U.S. Department of Transportation (DOT)/Federal Aviation Administration (FAA) determined that the project would not result in emissions that would exceed applicable de minimis emission levels and, therefore, will not cause a new violation, worsen an existing violation, or delay meeting the NAAQS (DOT/FAA 2007a). Development and construction activities associated with regional growth of housing, business, and industry, as well as associated vehicular traffic, will also result in additional air emissions.

As discussed in Section 5.13 of this supplement, climate change can impact air quality as a result of the changes in meteorological conditions. Specifically, ozone has been found to be particularly sensitive to climate change. Increases in ground-level ozone depend on a number

of factors, including background ozone concentrations, temperature, air stagnation events, and solar insolation. Computer models project decreases in annual average concentrations for the Northeast region (e.g., Tagaris et al. 2009) but increases in summertime ozone concentrations (e.g., Wu et al. 2008; Sheffield et al. 2011). In other words, seasonal (summertime) or short-term increases in ozone concentrations may occur. Westchester County, as discussed above, is designated a nonattainment area for ozone. Projections specific to Westchester County, under a high-emissions modeled scenario, project a 7-percent increase in summertime (June, July, and August) ozone concentrations by the 2020s (Sheffield et al. 2011).

The NRC staff concludes that the incremental impacts to air quality from the proposed license renewal of IP2 and IP3 would be SMALL. However, the NRC staff concludes that the cumulative impacts from past, present, and reasonably foreseeable future actions on air quality during the license renewal term would be SMALL to MODERATE. A SMALL impact would be expected under the condition of minimal climate change impacts on air pollutants with the lowest emissions scenario and compliance of major emitting industrial facilities with air permits to minimize impacts to air quality. Given Westchester County's designated nonattainment area for ozone, a MODERATE impact would be expected under the condition that climate change increases concentrations of ozone, thus worsening current ozone air quality conditions in Westchester County.

5.14.1.2 Noise

This section addresses the direct and indirect effects of license renewal on noise when they are added to the aggregate effects of other past, present, and reasonably foreseeable future actions. The geographic area considered in the cumulative noise analysis is a 1-mi (1.6-lm) radius from IP2 and IP3.

Principal noise sources from nuclear power plant operation include transformers, loudspeakers, and auxiliary equipment (e.g., pumps). At IP2 and IP3, noise sources are intermittent and typically not audible, with the exception of emergency sirens, beyond the site boundary (Entergy 2015a). The nearest resident is approximately 715 m (0.44 mi) from IP2 and IP3 (Entergy 2014g). Ambient sound levels (L_{90}) measured at sensitive noise receptors in the vicinity of IP2 and IP3 ranged between 36 to 61 A-weighted decibels (dBA) (Enercon 2003). Sound levels below 60 dBA are typically considered comfortable.

Noise levels may increase as a result of refurbishment activities, such as reactor vessel head, control rod drive mechanism replacement, and construction of a storage building, due to additional worker vehicles and motorized and construction equipment needed for these activities. Increased traffic volumes due to the additional 250 workers needed during refurbishment activities can increase noise levels on U.S. Highway 9 and roads near IP2 and IP3. Noise emissions from common construction equipment could be in the 85- to 100-dBA range (FHWA 2006); however, noise levels attenuate rapidly with distance. For instance, a noise level of 80 dBA at a distance of 50 ft (15 m) from construction equipment drops to 65.5 dBA at a distance of 200 ft (60 m) from the same construction equipment (FHWA 2006). Noise impacts from refurbishment are anticipated to be minimal because they would be intermittent (during use of equipment and workers commuting time) and temporary because they would only last through the duration of refurbishment (60 days). Additionally, the activities associated with refurbishment will occur inside buildings and, therefore, are not anticipated to be audible beyond the site boundary (Entergy 2015a). Furthermore, any additional noise due to refurbishment activities would need to be in accordance with the Buchanan sound ordinance (Chapter 211-23 of the Village Zoning Code). Given the distance of the nearest resident, attenuations of noise with distance, short-term duration of refurbishment activities, and location of activities, noise from refurbishment activities are not anticipated to cause noise issues.

The cumulative impacts on noise depend on the nuclear plant's proximity to other noise sources. Ongoing or foreseeable future projects in and around IP2 and IP3 identified in Table 5-5 will increase noise levels in the vicinity of their noise sources. However, the majority of these projects or activities are beyond the region of influence; therefore, combined noise levels are not expected to be high enough to cause noise issues. For those projects that are within the region of influence (the Champlain Hudson Power Express Project, West Point Transmission Project, AIM Project, and independent spent fuel storage installation (ISFSI) expansion), noise levels can increase as a result of motorized equipment required during construction of these activities and additional vehicles from the workforce. However, any additional noise will be temporary, occurring during the period of construction. The DOT/FAA determined that the New York/New Jersey/Philadelphia Metropolitan Area Airspace Redesign project would result in significant noise and noise-related impacts (DOT/FAA 2007a). However, mitigation measures were developed to reduce noise impacts (DOT/FAA 2007b).

Noise levels from present and future actions are not anticipated to contribute to noise impacts in the vicinity of IP2 and IP3. Therefore, cumulative impacts on the noise environment are expected to be SMALL.

5.14.2 Geology and Soils

This section addresses the direct and indirect effects of license renewal on geology and soils when they are added to the aggregate effects of other past, present, and reasonably foreseeable future actions. As described in Section 5.2, the incremental impacts on geology and soils from the continued operations of IP2 and IP3 during the license renewal term would be SMALL. Ongoing operation and maintenance activities at the IP2 and IP3 site are expected to be confined to previously disturbed areas (Entergy 2015a). Any soil-disturbing activities will be localized to the site and will be minimized by adherence to regulations and permits and the use of BMPs.

Any use of geologic materials, such as aggregates, to support operation and maintenance activities would be procured from local and regional sources. These materials are abundant in the region. The continued operations of IP2 and IP3 would not prevent access to economically valuable mineral resources.

Future changes in climate are unlikely to change the soils or result in changes to site operations that could affect local soils. Geologic conditions are not expected to change during the license renewal term. Thus, activities associated with continued operations are not expected to affect the geologic environment. Considering ongoing activities and reasonably foreseeable actions, the NRC staff concludes the cumulative impacts on geology and soils during the IP2 and IP3 license renewal term would be SMALL.

5.14.3 Surface Water

This section addresses the direct and indirect effects of the proposed action (license renewal) on surface water resources when they are added to the aggregate effects of other past, present, and reasonably foreseeable future actions.

As described in Section 4.1 of the 2010 FSEIS (NRC 2010), the incremental impacts on surface water resources from continued operations of IP2 and IP3 during the license renewal term were projected to be SMALL for all Category 1 (generic) issues, with the impacts on those issues determined to be bounded by those discussed in the 2013 GEIS. No Category 2 (site-specific) issues were deemed applicable to IP2 and IP3 operations.

As discussed in Section 5.14 of this supplement, the NRC staff has updated its review and evaluation of additional projects and actions in determining their contribution to cumulative impacts on surface water resources (see Table 5–5). The NRC staff's assessment included consideration of Entergy's responses to the NRC staff's RAIs (Entergy 2015a) and a review for new and significant information.

The descriptions of the affected environment in Sections 2.2.2, 2.2.3, 2.2.5.1, and 2.2.5.2 of the 2010 FSEIS together serve as the baseline for the cumulative impacts assessment for surface water resources. A summary of affected environment conditions relevant to this cumulative impacts analysis is presented below and has been updated as necessary with respect to the physical descriptions and trends in water resource conditions in proximity to, and affected by, operation of IP2 and IP3.

The geographic area of analysis considered for the surface water resources component of the cumulative impacts analysis spans the lower Hudson River Basin or watershed but focuses on a 5-mi (8-km) radius surrounding the intake and discharge structures for IP2 and IP3. As such, this review focused on those projects and activities that would withdraw water from, or discharge effluent to, the lower Hudson River and to its connecting waterways and on the potential for impacts to ambient surface water quality and water availability for downstream users. Following a summary of relevant affected environment conditions, the cumulative impacts on surface water use and quality, along with associated climate change considerations, are presented below.

Affected Environment Considerations

As discussed in Section 2.2.5.1 of the 2010 FSEIS (NRC 2010), the Hudson River originates in the Adirondack Mountains of northern New York State and flows south for 315 mi (507 km) to its mouth at the Battery, at the south end of the Island of Manhattan. The Hudson River Basin extends 128 mi (206 km) from east to west and 238 mi (383 km) from north to south and drains an area of 13,336 square miles (34,540 square kilometers), with most of this area located in the eastern-central part of New York State and small portions in Vermont, Massachusetts, Connecticut, and New Jersey.

IP2 and IP3 are located within the lower Hudson River Basin, which encompasses the Hudson River estuary. This tidally influenced portion of the river begins at the Troy Dam near Albany, New York, at RM 152 (RKm 245) and extends south. IP2 and IP3 are located on the east bank of the Hudson River at RM 43 (RKm 69) and about 24 mi (39 km) north of New York City (see Figure 2–10 in the 2010 FSEIS). In the vicinity of the IP2 and IP3 site, the Hudson River estuary is approximately 4,500 ft (1,370 m) wide and averages 40 ft (12 m) deep. This stretch of the river is characterized as oligohaline (i.e., low salinity). The salt front (or wedge) is the location where freshwater flowing toward the mouth of the river intersects the denser seawater pushing up the Hudson River estuary, creating a distinct boundary. Its edge is defined at the point where the measured salt concentration is 100 milligrams per liter. With high runoff in the spring, the salt front is typically found between RM 17 and RM 27 (RKm 27 and RKm 43) and migrates north during the summer past the IP2 and IP3 site to just south of Poughkeepsie near RM 75 (RKm 121). Drought conditions may enable the front to move further north past Poughkeepsie (Entergy 2007a; NRC 2010; NYSDEC 2015d, 2015e).

The flow and salinity in the lower Hudson are influenced by tidal flux and excursion that typically can result in water movement of 3 to 6 mi (5 to 10 km) or more upstream during the tidal cycle. This tidal flux prevents an accurate measurement of freshwater flow in the lower estuary and in the vicinity of IP2 and IP3. However, freshwater flow is measured upstream of the IP2 and IP3 site by the USGS at Green Island, New York, and just upstream from the Troy Lock and Dam. It is the farthest downstream USGS gage on the Hudson above tidewater (NRC 2010). The mean

annual river discharge measured at Green Island, New York, for water years 1946 through 2015 is 14,370 cubic feet per second (cfs) (405.9 cubic meters per second (m³/s)). The lowest average annual mean flow recorded over the period of record is 6,386 cfs (180 m³/s). The mean 90-percent exceedance flow is 4,420 cfs (125 m³/s). The 90-percent exceedance flow is an indicator value of hydrologic drought in a watershed and is the flow rate that is exceeded 90 percent of the time (USGS 2017).

Flow in the downriver stretch extending past the IP2 and IP3 site is tidally dominated and influenced by river channel morphology, a relatively flat water surface elevation, and other factors. Still, freshwater flow contributions exceed the cited values at the USGS Green Island gage by virtue of the larger drainage area, minus intervening losses and other diversions. In total, the tidally driven flow volume of the Hudson River near the IP2 and IP3 site is approximately 80 million gpm (303,000 cubic meters per minute (m³/min)), which is equivalent to a flow of about 178,000 cfs (5,030 m³/s). This flow is estimated to occur about 80 percent of the time. In the nearshore waters immediately adjacent to the IP2 and IP3 site corridor, the 80-percent frequency flow volume is estimated to be 9 million gpm (34,000 m³/min), which is equivalent to 20,000 cfs (560 m³/s). This point estimate is for a location that is approximately 500 ft (150 m) from the shoreline and that encompasses the area from which cooling water is withdrawn and to which return cooling water flows are returned (Entergy 2007a; NRC 2010).

With respect to water quality and beneficial use, the segment of the lower Hudson adjacent to the IP2 and IP3 site is classified by the NYSDEC as Class SB saline waters. The best usages of Class SB waters are for primary and secondary contact recreation and fishing. New York State further stipulates that such waters must be suitable for fish, shellfish, and wildlife propagation and survival (6 NYCRR 701; NYSDEC 2008b, 2014).

Nonetheless, and as described in Section 2.2.5.2 of the 2010 FSEIS, water and sediment quality in the lower Hudson River have been affected by historic and ongoing activities throughout the watershed and in the main stem of the river. These activities include dredging, channelization, and dam construction; industrial water use; municipal wastewater treatment discharges; chemical contaminants; nonpoint pollution; and invasive or exotic species (Entergy 2007a; NRC 2010). The river segment encompassing the IP2 and IP3 site and extending from Riverdale, New York, to Bear Mt. Bridge is listed as “impaired” by NYSDEC and unable to meet certain water quality standards pursuant to Section 303(d) of the CWA. Contaminants include PCBs in contaminated sediment, which result in fish consumption advisories, dioxins/furans, polycyclic aromatic hydrocarbons, pesticides, mercury, and other heavy metals (NYSDEC 2014).

Water Use Considerations

The Hudson River is an important regional resource and is extensively used for navigation, transportation, and recreation and as a water supply source. Water is withdrawn from the lower Hudson River for municipal potable water supply, for industrial makeup and cooling water, and for permitted or other authorized municipal and industrial wastewater discharges. As stated in Section 2.2.5.2 of the 2010 FSEIS, the chemical industry has the greatest number of industrial users followed by oil, paper, and textile manufacturers; sand, gravel, and rock processors; power plants; and cement companies (Entergy 2015a; NRC 2010).

Power plants are the primary users of water along the Peekskill–Haverstraw portion of the lower Hudson River. More specifically, the approximately 5-mi (8-km) segment of the Hudson River along which IP2 and IP3 are located supports several major facilities dominated by thermoelectric power-generating plants. These include the Wheelabrator Westchester waste-to-energy facility located approximately 1 mi (1.6 km) north and upstream of the IP2 and IP3 site. The facility has a generation capacity of about 60 megawatt electric (MWE) and

withdraws about 45 mgd (70 cfs; 2 m³/s) of water, with peak daily withdrawals of 54 mgd (84 cfs; 2.4 m³/s) (Wheelabrator Technologies 2015; NYSDEC 2017b). Approximately 4 mi (6 km) downstream of IP2 and IP3 is the Bowline Generating Station. It is a 758-MWe natural-gas fired plant (NRG 2015). Like IP2 and IP3, Bowline has a once-through cooling system and withdraws an average of 230 mgd (356 cfs; 10.1 m³/s) of water, with a peak daily withdrawal of about 910 mgd (1,410 cfs; 39.8 m³/s) (NYSDEC 2017b).

IP2 and IP3 each employ once-through cooling systems that withdraw water from the Hudson River, as further described in Section 2.1.3 of the 2010 FSEIS. The combined, maximum (nominal) surface water withdrawal rate for IP2 and IP3 is 1,731,000 gpm (3,855 cfs; 108.9 m³/s), or a total volume of about 2,490 mgd (3,850 cfs; 109 m³/s). Virtually the same amount of water that is withdrawn for condenser cooling and service water is discharged. Some water is lost due to increased evaporation in the heated cooling water effluent. The NRC previously estimated this loss at less than about 60 cfs (1.7 m³/s), or about 39 mgd (60 cfs; 1.7 m³/s) (NRC 2010). This estimate reflects a consumptive water use of less than 2 percent. In 2015, reported withdrawals for IP2 and IP3 averaged 2,064 mgd (3,193 cfs (90.2 m³/s), with a maximum daily withdrawal of 2,514 mgd (3,889 cfs; 109.9 m³/s) (NYSDEC 2017b; State of New York 2017).

The NRC staff stated in Section 4.8.1 of the 2010 FSEIS (NRC 2010) that water withdrawals for power generation and other uses in the freshwater portions of the Hudson River will continue to occur and will increase in the future due to urbanization and industrial expansion. Based on the above information, average surface water withdrawals at IP2 and IP3, combined with those from other large surface water users along the Peekskill–Haverstraw portion of the lower Hudson River, total about 2,339 mgd (3,618 cfs; 102.2 m³/s). This is approximately 2 percent of the normal tidal flow of the river (i.e., 178,000 cfs; 5,030 m³/s). The vast majority of this water is not consumptively used, but is returned to the river.

Under the State of New York's Water Resources Law, which was updated in 2011, a permit is required for any type of water withdrawal system having the capacity to withdraw 0.1 mgd (378 m³) or more of surface water or groundwater. Previously, this law applied only to public water supplies (NYSDEC 2015f; 6 NYCRR 601). This regulatory oversight would be expected to improve the management of the water resources of the basin, especially new allocations or diversions of surface water, such as for the NRG Bowline repowering project (see Table 5–5), into the future. In summary, regulated water withdrawals and the current low rate of consumptive use, including by IP2 and IP3, is not likely to have a substantial cumulative impact on the downstream availability of surface water during the license renewal term.

Water Quality Considerations

Section 4.8.1 of the 2010 FSEIS evaluated a number of contributors to cumulative impacts on aquatic resources and, by extension, to surface water resources, including surface water quality. These contributors include continued operation of IP2 and IP3 and other water withdrawals (considered above), habitat loss, changes to water and sediment quality, and climate change (discussed below). The State of New York cites the following as major water quality concerns for the lower Hudson River Basin: (1) municipal wastewater and combined sewer overflows from urban areas, (2) urban stormwater runoff and industrial impacts, (3) agricultural and other nonpoint sources of nutrients, (4) impacts from legacy PCB discharges in the upper Hudson River Basin, and (5) declining fishery stocks from habitat loss, power generation withdrawals, and other causes (NYSDEC 2015e).

An increase in heavy precipitation events, which is forecast to continue across the Northeast portion of the United States associated with climate change, would be additive to the manmade contributors to water quality decline from increased surface runoff laden with nutrients,

sediment, and other contaminants. Degraded surface water quality also increases the costs of water treatment for both industrial cooling water and potable water supply because of the need for increased filtration and higher additions of chemical treatments, such as for corrosion control and for disinfection.

As discussed in Sections 4.8.1 and 2.2.5.2 of the 2010 FSEIS, there are indications that the overall water quality of the lower Hudson River is improving. In summary, efforts to address PCB contamination in the sediments above the Troy Dam continue, and upgrades to the region's wastewater treatment plants have improved the quality of sanitary effluents. Additionally, on an individual facility and project basis (see Table 5–5), NYSDEC-administered SPDES permits issued under Section 402 of the CWA would set limits on wastewater, stormwater, and other point source discharges to surface waters, as applicable.

Likewise, chemical and thermal characteristics of the IP2 and IP3 effluent discharges are limited by SPDES Permit No. NY-0004472. The permit has been administratively continued by NYSDEC since it expired in 1992. Entergy continues to operate IP2 and IP3 in accordance with the permit and mitigation measures prescribed by the Hudson River Settlement Agreement (as detailed in Section 2.2.5.3 of the 2010 FSEIS) while adjudicatory proceedings associated with the SPDES permit renewal continue.

SPDES permitting requirements apply to existing industrial facilities and to large land-disturbing activities and projects, and such requirements would also apply to future activities in the basin. Regardless, non-point sources of chemicals and nutrients from agriculture and urban areas; climate change; and the presence of persistent chemicals, such as PCBs and metals in riverine sediments, with associated implications for aquatic life, will continue to be a major challenge for water quality in the lower Hudson River Basin and contributors to cumulative water quality impacts.

Climate Change Considerations

The NRC staff considered USGCRP's most recent compilations of the state of knowledge relative to global climate change effects (USGCRP 2009, 2014). In Section 4.8.1 of the 2010 FSEIS, the NRC staff indicated that the cumulative effects of climate change could have substantial impacts on the aquatic and water resources of the Hudson River Basin (NRC 2010).

As detailed in Section 5.13.2.2, ambient air temperatures in the Northeast region and sea surface temperatures in the North Atlantic have increased since about 1900. This trend in air and ocean surface temperatures is projected to persist into the future. In a tidal regime such as that at the IP2 and IP3 site, the immediate implication of warmer source water is an increased water demand for plant cooling systems and decreased plant capacity, with a corresponding rise in the temperature of cooling water effluents (USGCRP 2014). Power plants and other industrial facilities using the Hudson River as a water source would have to account for such changes in operational practices and procedures, perhaps requiring investment in additional infrastructure and capacity.

A rise in global and North Atlantic sea levels has also been observed and increases are forecast to continue (see Section 5.13.2.2). Changes in sea level at any one coastal location depend not only on the increase in the global average sea level but also on various regional geomorphic, meteorological, and hydrological factors (USGCRP 2009). Specific to the Northeast U.S. coast, sea level rise is projected to exceed the global rate due to local land subsidence and will rise 0.7 to 1.7 ft (0.2 to 0.5 m) by 2050, depending on the extent of glacier and ice sheet melt (USGCRP 2014).

The intensity, frequency, and duration of North Atlantic hurricanes have increased since the 1980s, and the Northeast region has experienced the largest increase in heavy precipitation

events over the last 50 years. Hurricane-associated storm intensity and rainfall are projected to increase, as well as heavy precipitation events. Sea level rise, increased coastal storm intensity with associated surge, and heavy precipitation events can result in an increase in the incidence of coastal flooding (USGCRP 2014).

The IP2 and IP3 site has not experienced tidal flooding. The tidal range averages 4 ft (1.2 m) (Entergy 2007a). Water levels, such as those from a storm surge, would have to exceed 15 ft (4.6 m) to challenge the critical elevation of IP2 and IP3 facilities on the site (Entergy 2013d). Thus, projected increases in sea level alone would not be expected to threaten the site during the license renewal term.

Separate from this environmental review, the NRC staff reviewed Entergy's flooding hazard re-evaluations for IP2 and IP3 (Entergy 2013d, 2014l) and the supplemental responses it submitted in response to the NRC staff's RAI under Recommendation 2.1 of the Japan Lessons Learned Near-Term Task Force (NRC 2012a). Concurrently with the re-evaluation of flooding hazards, licensees were required to develop and implement mitigating strategies in accordance with NRC Order EA-12-049, "Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (NRC 2012b). Meanwhile, Entergy undertook interim actions to protect structures, systems, and components up to flood levels of more than 17 ft (5.2 m) (Entergy 2013d).

Subsequently, Entergy prepared and submitted to the NRC its Final Integrated Plan for IP2 and IP3, in August 2016, to address flood mitigation strategies to comply with NRC Order EA-12-049 (Entergy 2016f). As part of the NRC staff's review of Entergy's plan, the staff prepared a safety evaluation and concluded that Entergy had developed guidance and a proposed design that, if implemented appropriately, will adequately address the requirements of Order EA-12-049 (NRC 2017b).

In October 2016, Entergy submitted for NRC review its re-evaluated flood mitigating strategies assessment (MSA) (Entergy 2016g). The re-evaluated flood MSA is intended to confirm that licensees have adequately addressed the re-evaluated flooding hazards within their mitigation strategies for beyond-design-basis external events. The NRC staff completed its evaluation of the MSA in April 2017. The NRC staff concluded that Entergy had demonstrated that the facility, with appropriate implementation of Entergy's mitigation strategies, is reasonably protected from re-evaluated flood hazard conditions for beyond-design-basis external events (NRC 2017c).

By letter dated July 24, 2017, Entergy requested deferral of actions related to beyond-design-basis external event flooding actions for IP2 and IP3, including completion of the flooding integrated assessment scheduled for December 2018 (Entergy 2017i). Entergy requested deferral of this assessment until August 31, 2021, for both IP2 and IP3. The NRC staff approved Entergy's request on October 4, 2017. The staff concluded that public health and safety will continue to be adequately protected through the requested deferral period based on (1) the ability of IP2 and IP3 to cope with the re-evaluated flood hazard; (2) the safety margin provided as a result of Entergy's compliance with NRC Order EA-12-049, and 10 CFR 50.54(hh)(2); (3) changes to the FLEX strategies that are being implemented to address the re-evaluated flood hazard; and (4) the limited period of operation remaining for IP2 and IP3 based on the closure agreement (NRC 2017d).

Sea level rise associated with climate change could cause an increase in the upstream migration of the salt line, which could potentially affect fresh water availability. However, increases in precipitation over the Hudson River Basin and increased runoff and freshwater inflow to the main stem of the Hudson River from heavy precipitation events could have the effect of dampening any increased tidal influence from rising sea levels. The overall likelihood

of substantial changes in salinity levels in the waters near the IP2 and IP3 site during the license renewal term is deemed to be low.

Conclusions

Water withdrawals from continued operation of IP2 and IP3, combined with other users, are not expected to substantially affect downstream surface water availability during the license renewal term. Such uses will remain a relatively small percentage of the normal tidal flow of the river, and a regulatory framework is in place to manage surface water withdrawals from the Hudson River Basin.

Legacy contamination, hydrologic alteration, and ongoing pollutant loading continue to affect sediment and ambient water quality for beneficial uses in the lower Hudson River. Development trends, coupled with ongoing climate change, could exacerbate some of these water quality and hydrologic stressors despite ongoing efforts to address water quality impacts through cleanup activities and improvements in wastewater treatment and effluent regulation. The effects from climate change could have negative implications for industrial cooling and potable water uses, requiring additional water treatment, operational changes, and a potential need for added infrastructure investment.

In addition, the chemical and thermal characteristics of cooling water and other wastewater and stormwater discharges from IP2 and IP3 would continue to be regulated during the period of continued operations in accordance with SPDES permit provisions. These permit requirements will apply to other industrial users and major development projects as well.

Overall, the NRC staff finds that the incremental impacts on water use and quality from the continued operation of IP2 and IP3 during the license renewal term will continue to be SMALL. However, although uncertainly exists with respect to the magnitude of future climate change impacts, the hydrology and water quality of the lower Hudson River Basin will be increasingly and incrementally affected by other contributors within the license renewal timeframe and beyond. As a result, the NRC staff concludes that the cumulative impacts from past, present, and reasonably foreseeable future actions and trends on surface water resources during the license renewal term would be SMALL to MODERATE.

5.14.4 Groundwater

This section addresses the direct and indirect effects of license renewal on groundwater use and quality in the region (i.e., over a 50-mi (80-km) radius) when they are added to the aggregate effects of other past, present, and reasonably foreseeable future actions. The IP2 and IP3 reactors do not and would not use onsite groundwater. Onsite groundwater is not likely to be used as a source of public water or to affect any offsite groundwater resources. The impact to offsite water resources would be through discharge of radiologically contaminated groundwater into the Hudson River.

In Section 4.8.3 of the 2010 FSEIS, the NRC staff reported that within the 50-mi (80-km) radius of IP2 and IP3, there are no other nuclear power reactors or uranium fuel cycle facilities (NRC 2010). Therefore, within that radius, most radiological releases to the Hudson River are likely to be from operations at IP2 and IP3 and the migration of contaminated groundwater to the river. Tritium releases to the Hudson River are expected to occur from contaminated groundwater and from routine permitted releases directly to the river or the air. Depending on the atmospheric conditions, some of the tritium released to the air may condense and find its way into the river. From 2003 through 2013, routine monitoring of Hudson River water for tritium has shown that near the IP2 and IP3 site, tritium concentrations in the river are at very low levels relative to the 20,000 pCi/L drinking water standard (Entergy 2014g). These very

low-level concentrations of tritium in the river are expected to continue over the proposed license renewal period.

Strontium-90 resulting from the now drained IP1 spent fuel pool would enter the river via the discharge of contaminated onsite groundwater. As discussed in Section 5.4, any strontium-90 entering the river from groundwater discharge would be diluted to very low concentrations. Because there are no other new sources of strontium-90, the level of strontium-90 in the river should continue to be very low.

The amount of river water flowing past the IP2 and IP3 site is not likely to be adversely affected by climate change because the amount of water in the river and the rate of river flow throughout most of the year are dominated by the tides. Therefore, a large volume of river water is available to dilute any radiological discharges. Future climatic changes should not result in changes to site operations that would result in increased impacts to the radiological quality of the surface water resources.

Considering ongoing activities and reasonably foreseeable actions, the NRC staff concludes that the cumulative impacts on groundwater quality and, indirectly, on surface water quality in the region via the discharge of radionuclides from contaminated groundwater beneath the IP2 and IP3 site during the license renewal term would be SMALL.

5.14.5 Terrestrial Resources

In Section 4.8.2 of the 2010 FSEIS, the NRC staff described the cumulative impacts on terrestrial resources from past, present, and reasonably foreseeable future actions (NRC 2010). The NRC staff concluded that the cumulative impacts on terrestrial resources were LARGE relative to predevelopment conditions and that much of this impact occurred before the construction of IP2 and IP3. As discussed in Section 5.5 of this supplement, the incremental contribution of the proposed IP2 and IP3 license renewal would result in SMALL impacts on terrestrial resources. The NRC staff considered whether the actions and projects in Table 5-5 or the information provided by Entergy (2015a) constitute new information that could change the staff's conclusion in the 2010 FSEIS. Although the proposed AIM Project includes construction of a gas pipeline that would cross a portion of the IP2 and IP3 property, the implementation of the AIM project would not change the staff's previous conclusion of LARGE for cumulative impacts on terrestrial resources. Accordingly, the staff concludes that no new and significant information exists regarding cumulative impacts on terrestrial resources and that impacts to this resource are bounded by the staff's previous assessment in the 2010 FSEIS.

5.14.6 Aquatic Resources

Cumulative impact for aquatic resources addresses the direct and indirect effects of license renewal on aquatic resources when added to the aggregate effects of other past, present, and reasonably foreseeable future actions. The cumulative impact is the total effect on the aquatic resources of all actions taken, no matter who has taken the actions (CEQ 1997). Two related concepts bound the analysis of cumulative impacts: the timeframe and geographic extent. The timeframe for cumulative analyses for ecological resources extends far enough into the past to understand the processes that affect the present resource conditions and to examine whether and why aquatic resources are stable or unstable, which the NRC definitions of impact levels require. The timeframe for cumulative impact analysis is more extensive than that for the direct and indirect impact analysis.

The geographic area of interest considered in the cumulative aquatic resource analysis depends on the particular cumulative impacts being discussed. The geographic area considered for

cumulative impacts to aquatic resources is the lower Hudson River Estuary. The level of cumulative impacts is measured against a baseline. Consistent with other agencies' and CEQ's (1997) NEPA guidance, the term "baseline" pertains to the condition of the resource without the action, i.e., under the no-action alternative. Under the no-action alternative, the plant would remain but be shut down and the resource would conceptually return to its condition without the plant, which is not the same as the condition before the plant was constructed because of changes that have occurred to the potentially affected resources. The baseline, or benchmark, for assessing cumulative impacts on aquatic resources takes into account the pre-operational environment as recommended by EPA (1999b) for its review of NEPA documents.

This section updates the previous cumulative impacts sections from the 2010 FSEIS with information that became available subsequent to publication pertaining to two projects that could potentially affect aquatic resources. The assessment of new information in Chapter 4 of this supplement on the direct and indirect impacts of impingement and entrainment to aquatic resources does not revise the 2010 FSEIS conclusion of MODERATE. The FSEIS (NRC 2010) presents cumulative impacts to aquatic resources in Section 4.8.1, Appendix H.2, and Appendix I.3, and finds that the level of cumulative impact is LARGE. Section 5.13.2.2 of this supplement assesses the effects of climate change and supplements discussion on the effects of climate change on aquatic resources in FSEIS (NRC 2010) Section 4.8.1 and Appendix H.2.

The Tappan Zee Hudson River Crossing Project is replacing the current Tappan Zee Bridge across the Hudson River south of the IP2 and IP3 site. The final EIS (NYSDOT and NYSTA 2012) finds that about 13 ac (5.25 ha) of oyster habitat would be adversely impacted by construction operations (discussed in NYSDOT and NYSTA 2012, Chapter 18, "Construction Impacts"), some or all of which may be permanently lost. Compensatory mitigation for the project includes the restoration of 13 ac (5.25 ha) of hard bottom/shell oyster habitat and the reintroduction of oysters to the habitat. The final EIS for the Tappan Zee Hudson River Crossing Project (NYSDOT and NYSTA 2012, Chapter 16) finds that the project would not have the potential to result in adverse impacts on aquatic biota.

The updated information does not substantially alter the NRC staff's previous analysis of cumulative impacts. The level of impact to aquatic resources considering the updated information in this supplement is bounded by the level of impact determined in the NRC staff's previous assessment, which concluded that the cumulative impacts to aquatic resources are LARGE.

5.14.7 Radiological Impacts

In Section 4.8.3 of the 2010 FSEIS, the NRC staff described the cumulative radiological impacts on human health from past, present, and reasonably foreseeable future actions. The radiological dose limits for protection of the public and workers have been developed by the NRC and EPA to address the cumulative impact of acute and long-term exposure to radiation and radioactive material. These dose limits are codified in 10 CFR Part 20 and 40 CFR Part 190. Based on its review of radiological effluent and environmental monitoring data, the NRC staff concluded that the cumulative impacts on human health were SMALL. The NRC staff also considered whether the actions and projects in Table 5-5 or the information provided by Entergy (Entergy 2015a) constitute new information that could change the staff's conclusion in the 2010 FSEIS (NRC 2010). The NRC staff identified one project that may affect the radiological impacts from the IP2 and IP3 site—the expansion of the ISFSI to store additional spent nuclear fuel. However, as discussed in Section 4.8.3 of the 2010 FSEIS, the installation and monitoring of the ISFSI is governed by NRC requirements in 10 CFR Part 72. Radiation from this facility and from the operation of IP2 and IP3 must not exceed the radiation dose limits

in 10 CFR Part 20, 40 CFR Part 190, and 10 CFR Part 72. Accordingly, expansion of the ISFSI is not expected to change Entergy's ability to maintain radiological doses to members of the public well within regulatory limits.

5.14.8 Waste Management and Pollution Prevention

This section describes waste management impacts from IP2 and IP3 during the license renewal term when they are added to the cumulative impacts of other past, present, and reasonably foreseeable future actions. For the purpose of this cumulative impacts analysis, the area within a 50-mi (80-km) radius of IP2 and IP3 was considered. The NRC staff concluded in Sections 4.3 and 6.1 of the 2010 FSEIS that the potential human health impacts from IP2's and IP3's radioactive and nonradioactive waste during the license renewal term would be SMALL.

As discussed in Sections 2.1.4 and 2.1.5 of the 2010 FSEIS, Entergy maintains waste management programs for radioactive and nonradioactive waste generated at IP2 and IP3 and is required to comply with Federal and State permits and other regulatory requirements for the management of waste material. Other facilities and projects listed in Table 5–5 within a 50-m (80-km) radius of IP2 and IP3 are also required to comply with appropriate NRC, EPA, and New York State requirements for the management of radioactive and nonradioactive waste. Waste management activities at IP2 and IP3 are expected to be stable during the license renewal term and to comply with Federal and State requirements for radioactive and nonradioactive waste. Adequate disposal options at licensed disposal facilities are expected to handle the cumulative volume of radioactive and nonradioactive waste generated by IP2, IP3, and other facilities. If access to a disposal facility is temporarily unavailable, the waste will be safely stored in accordance with NRC, EPA, and State requirements.

Based on the above information, the NRC staff concludes that the potential cumulative impact from radioactive and nonradioactive waste would be SMALL.

5.14.9 Socioeconomic Impacts

The NRC staff described the cumulative socioeconomic impacts from past, present, and reasonably foreseeable future actions in Section 4.8.4 of the 2010 FSEIS. Based on its review, the NRC staff concluded that the contributory effects of IP2 and IP3 to socioeconomic conditions in the region has been SMALL. In this supplement, the NRC staff considers whether the actions and projects listed in Table 5–5 or the information provided by Entergy (Entergy 2015a) constitute new information that could change the cumulative impacts conclusion in the 2010 FSEIS.

Based on the information presented in Chapter 4 of the 2010 FSEIS, there would be no new or increased contributory effect on socioeconomic conditions in the region during the license renewal term from the continued operation of IP2 and IP3 beyond what is currently being experienced. Therefore, the only contributory effects would come from reasonably foreseeable future planned activities at IP2 and IP3, unrelated to the proposed action (license renewal), and from other reasonably foreseeable planned offsite activities. For example, offsite residential development is planned throughout the region. Therefore, the availability of new housing could attract individuals and families from outside the region, thus increasing the local population and causing, in turn, increased traffic on local roads and increased demand for public services.

In general, the population in the region surrounding IP2 and IP3 continues to experience growth, increasing economic activity and tax revenue and changing demographics. Installation of the AIM pipeline and ISFSI expansion, if these activities occur simultaneously, would increase the total number of workers at the IP2 and IP3 site. This situation could increase the demand for

rental housing and public services, as well as traffic volumes near IP2 and IP3. However, given the relatively short amount of time needed to complete these actions, socioeconomic conditions in the vicinity of IP2 and IP3 would not be permanently affected. Again, when combined with other past, present, and reasonably foreseeable future activities (e.g., AIM pipeline installation and ISFSI expansion), the contributory effects of continued reactor operations at IP2 and IP3 would have no new or increased impact on socioeconomic conditions in the region beyond what is currently being experienced. Therefore, the actions and projects listed in Table 5–5 and the information provided by Entergy would not change the cumulative impacts conclusion in the 2010 FSEIS for socioeconomics. Accordingly, the cumulative effects of these additional activities remain bounded by the previous assessment in the 2010 FSEIS.

5.14.10 Historic and Cultural Resources

This section addresses the direct and indirect effects of license renewal (the proposed action) on historic and cultural resources in and around IP2 and IP3 when added to the aggregate effects of other past, present, and reasonably foreseeable future actions. Section 2.2.9 of the 2010 FSEIS discusses the cultural background and known historic and cultural resources in and around IP2 and IP3.

As described in Section 4.4.5 of the 2010 FSEIS, the NRC concluded that license renewal would have a SMALL impact on historic and cultural resources at IP2 and IP3. However, ground-disturbing maintenance and operations activities during the license renewal term could affect undiscovered historic and archaeological resources. Additionally, the construction of the proposed AIM pipeline through the IP2 and IP3 site could also affect historic and cultural resources.

Entergy has established procedures for the protection of cultural resources at IP2 and IP3 (Entergy 2007a). These procedures are designed to ensure that site investigations and appropriate consultations are conducted and that cultural resources are adequately protected. Any ground-disturbing maintenance and operations activities during the license renewal term at IP2 and IP3 would be evaluated in accordance with these procedures.

According to Entergy's procedures, should historic or archaeological resources be encountered during excavations, work would cease until Entergy environmental personnel can assess the situation and consider possible mitigation measures and, if necessary, consult with the New York State Historic Preservation Officer, as appropriate.

Based on this information, there would be no contributory effect on historic and cultural resources in the region during the license renewal term from the continued operation of IP2 and IP3 beyond what has already occurred. Therefore, the only contributory effects would come from reasonably foreseeable future planned activities at IP2 and IP3 unrelated to the proposed action (license renewal) and from other reasonably foreseeable planned offsite activities. When combined with other past, present, and reasonably foreseeable future activities, the contributory effects of continued reactor operations at IP2 and IP3 would not contribute to the overall cumulative impact on historic and cultural resources.

5.14.11 Environmental Justice

The NRC staff described the cumulative environmental justice impacts from past, present, and reasonably foreseeable future actions in Section 4.8.4 of the 2010 FSEIS. Based on the review, it was concluded that there would be no disproportionately high and adverse human health and environmental effects on minority and low-income populations in the region. In this supplement, the NRC staff considers whether the actions and projects listed in Table 5–5 or the information

provided by Entergy (2015a) constitutes new information that could change the cumulative impacts conclusion in the 2010 FSEIS.

The environmental justice cumulative impact analysis evaluates the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from past, present, and reasonably foreseeable future actions, including the continued operational effects of IP2 and IP3 during the renewal term. Everyone living near Indian Point experiences the operational effects of IP2 and IP3, including minority and low-income populations. As explained in the 2010 FSEIS, the NRC addresses environmental justice matters for license renewal by identifying the location of minority and low-income populations, determining whether there would be any potential human health or environmental effects to these populations, and determining if any of the effects may be disproportionately high and adverse.

Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant and exceeds the risk or exposure rate for the general population or for another appropriate comparison group. Disproportionately high environmental effects refer to impacts or risks of impacts on the natural or physical environment in a minority or low-income community that are significant and that appreciably exceed the environmental impact on the larger community. Such effects may include biological, cultural, economic, or social impacts. Some of these potential effects have been identified in resource areas presented in Chapter 4 of the 2010 FSEIS and this supplement.

As explained in Section 4.4.6 of the 2010 FSEIS, there would be no disproportionately high and adverse impacts on minority and low-income populations from the continued operation of IP2 and IP3 during the license renewal term. Because Entergy has no plans to hire additional workers during the license renewal term, employment levels at IP2 and IP3 would remain relatively constant, and there would be no additional demand for housing or increased traffic. Based on this information and the analysis of human health and environmental impacts presented in the 2010 FSEIS, it is not likely that there would be any disproportionately high and adverse contributory effect on minority and low-income populations from the continued operation of IP2 and IP3 during the license renewal term. Therefore, the only contributory effects would come from the other reasonably foreseeable future planned activities at the IP2 and IP3 site unrelated to the proposed action (license renewal) and from other reasonably foreseeable planned offsite activities.

Potential impacts to minority and low-income populations during the installation of the AIM pipeline and ISFSI expansion would mostly consist of environmental effects (e.g., noise, dust, traffic, and housing impacts). However, given the relatively short amount of time needed to complete these actions, environmental conditions in the vicinity of IP2 and IP3 would not be permanently affected.

Noise and dust impacts during construction would be temporary and limited to onsite activities. Minority and low-income populations residing along site access roads could experience increased truck material and equipment delivery and commuter vehicle traffic especially during shift changes. Increased demand for inexpensive temporary housing by construction workers could disproportionately affect low-income populations; however, given the availability of rental housing in the region, impacts to minority and low-income populations would be limited. Radiation doses after the expansion of the ISFSI are expected to remain within regulatory limits.

Based on this information and the analysis of human health and environmental impacts presented in this supplement, AIM pipeline installation and ISFSI expansion would not have

disproportionately high and adverse human health and environmental effects on minority and low-income populations residing in the vicinity of the IP2 and IP3 site. When combined with other past, present, and reasonably foreseeable future activities (e.g., AIM pipeline installation and ISFSI expansion), the contributory effects of continued reactor operations at IP2 and IP3 would not likely cause disproportionately high and adverse human health and environmental effects on minority and low-income populations residing in the vicinity of the IP2 and IP3 site. Therefore, the actions and projects listed in Table 5–5 and the information provided by Entergy would not change the cumulative impacts conclusion in the 2010 FSEIS for environmental justice. Accordingly, the cumulative effects of these additional activities remain bounded by the previous assessment in the 2010 FSEIS.

5.14.12 Global Climate Change

This section addresses the impact of greenhouse gas (GHG) emissions resulting from continued operation of IP2 and IP3 on global climate change when added to the aggregate effects of other past, present, and reasonably foreseeable future actions. Climate is influenced by both natural and human-induced factors; the observed global warming (increase in the Earth's surface temperature) in the 21st century has been attributed to the increase in GHG emissions resulting from human activities (USGCRP 2009, 2014). Climate model projections indicate that future climate change is dependent on current and future GHG emissions (IPCC 2007a; USGCRP 2009, 2014). As described in Section 5.13 of this supplement, operations at IP2 and IP3 emit GHG. Therefore, GHG emissions from the continued operation of IP2 and IP3 may contribute to climate change.

The cumulative impact of a GHG emission source on climate is global. The GHG emissions are transported by wind and become well mixed in the atmosphere as a result of their long atmospheric residence time. Therefore, the extent and nature of climate change is not specific to where GHGs are emitted. In April 2015, EPA (2015d) published the official U.S. inventory of GHG emissions, which identifies and quantifies the primary anthropogenic sources and sinks of GHGs. The EPA GHG inventory has been considered to be an essential tool for addressing climate change and for participating with the United Nations Framework Convention on Climate Change to compare the relative global contribution of different emission sources and GHGs to climate change. In 2013, the United States emitted 6,673 million metric tons (MMT) of CO_{2eq}; total U.S. emissions have increased by 5.9 percent from 1990 to 2013 (EPA 2015d). In 2012 and 2013, the total amount of CO_{2eq} emissions related to electricity generation was 2,022.2 MMT and 2,039.8 MMT, respectively (EPA 2015d). The Energy Information Administration (EIA) reported that, in 2012, electricity production alone in New York was responsible for 35.6 MMT CO₂ (approximately 36.0 MMT of CO_{2eq}) (EIA 2015). Facilities that emit 0.025 MMT of CO_{2eq} or more per year are required to annually report their GHG emissions to EPA. These facilities are known as direct emitters, and the data are publicly available in the EPA's Facility Level Information on GreenHouse gases Tool (FLIGHT). In 2013, FLIGHT identified four facilities in Westchester County, New York, that emitted a total of 448,046 MT of CO_{2eq} (EPA 2015e). In 2013, FLIGHT identified 221 facilities in New York that emitted a total of 42.5 MMT of CO_{2eq} (EPA 2015e).

Permitting and licensing requirements and other mitigative measures can minimize the impacts of GHG emissions. For instance, in 2010, EPA issued a final GHG Tailoring Rule⁷ (75 FR 31514) to address GHG emissions from stationary sources under the CAA permitting requirements. The GHG Tailoring Rule establishes when an emission source will be subject to permitting requirements and control technology to reduce GHG emissions. The Clean Power Plan Final Rule⁸ (80 FR 64662), aimed at reducing carbon pollution from power plants, requires carbon emissions from the power generating sector to be reduced to a level that is 32 percent below 2005 levels. The Clean Power Plan sets forth carbon dioxide emission performance rate standards for power plants that should be achieved by 2030. Furthermore, EO 24, issued in August 2009, set a goal to reduce GHG emissions in New York State by 80 percent below 1990 levels by the year 2050 (NYSDEC 2009).

EO 24 also established a Council that was directed to develop a draft Climate Action Plan. The draft Climate Action Plan, among a number of things, identifies actions that will reduce GHG emissions in New York and identifies continued operation (i.e., license renewal) or expansion of nuclear plants to attain GHG reduction goals (New York State Climate Action Council 2010). If IP2's and IP3's generating capacity were to be replaced by the NGCC Alternative or Combination Alternatives assessed in Section 8.3 of the 2010 FSEIS, there would be an associated increase in GHG emissions. Consequently, continued operation of IP2 and IP3 (the proposed action) would be in accordance with the State's draft Climate Action Plan and GHG State reduction goals and would result in GHG emissions avoidance.

The EPA's U.S. inventory of GHG emissions illustrates the diversity of GHG source emitters, such as electricity generation, industrial processes, and agriculture. As discussed in Section 5.13 of this supplement, GHG emissions resulting from operations at IP2 and IP3 for the 2009 to 2013 timeframe ranged between 4,960 and 10,990 MT of CO_{2eq}. In comparing IP2 and IP3 GHG emission contributions to different emissions sources, whether they are total U.S. GHG emissions, emissions from New York, or emissions on a county level, GHG emissions from IP2 and IP3 are relatively minor (see Table 5–6). Climate models indicate that climate change (through the year 2030) is dependent on past GHG emissions. Climate models indicate that, even if GHG emissions were to be completely eliminated, the Earth's average surface temperature will continue to increase and climate-related changes will persist over the next few decades (USGCRP 2014). Therefore, short-term climate change is projected to occur with or without present and future GHG emissions from IP2 and IP3. The magnitude of the continued increase in GHG emission rates will determine the amount of additional future warming and long-term (beyond 2030) climate change. Climate change and climate-related changes have been observed on a global level, and climate models indicate that future climate change will depend on present and future GHG emissions. The USGCRP (2014) concludes that climate change and related impacts are happening. In summary, the cumulative impact of GHG emissions on climate change during the IP2 and IP3 license renewal timeframe (2013

⁷ On June 23, 2014, the U.S. Supreme Court issued a decision in *Utility Air Regulatory Group v. EPA*, 134 S. Ct. 2427 (2014), that EPA may not treat GHGs as an air pollutant for determining whether a source is a major source required to obtain a Prevention of Significant Deterioration (PSD) or Title V permit based solely on its GHG emissions, but could continue to require PSD and Title V permits, which are otherwise required based on emissions of conventional pollutants. On October 3, 2016, the EPA proposed revisions to the PSD and Title V permitting regulations for GHG to ensure that neither the PSD nor Title V rules require a source to obtain a permit solely because the source emits or has the potential to emit GHGs above the applicable threshold (81 FR 68110).

⁸ On February 9, 2016, the U.S. Supreme Court issued a stay of implementation of the Clean Power Plan pending judicial review in the U.S. Court of Appeals for the District of Columbia. *Chamber of Commerce v. EPA*, 136 S. Ct. 999 (2016). The Clean Power Plan requirements are therefore on hold at this time. On October 16, 2017, the EPA published a proposed rule that would rescind the Clean Power Plan (82 FR 48035).

through 2033 and 2015 through 2035, respectively) is noticeable but not destabilizing. Therefore, cumulative impacts on climate change from the proposed license renewal and other past, present, and reasonably foreseeable projects would be MODERATE. However, the incremental impact from the contribution of GHG emissions from continued operation of IP2 and IP3 on climate change would be SMALL and would have a net, beneficial contribution to GHG emissions and climate change impacts during the license renewal term as compared to the NGCC Alternative or Combination Alternatives assessed in the 2010 FSEIS.

Table 5–6. Comparison of GHG Emission Inventories

Source	CO _{2eq} (MMT/year)
Global emissions (2013) ^(a)	35,300
U.S. emissions (2013) ^(b)	6,673
New York emissions (2013) ^(c)	42.5
Westchester County emissions(2013) ^(c)	0.45
IP2 and IP3 emissions ^(d)	0.01

^(a) Source: European Commission (2014)

^(b) Source: EPA (2015d)

^(c) GHG emissions account only for direct emitters, i.e., those facilities that emit 25,000 MT or more a year (EPA 2015e).

^(d) Emissions include direct and indirect emissions from the operation of IP2 and IP3, and the highest emission from 2009 to 2013 is presented (Entergy 2015a).

5.14.13 Conclusions Regarding Cumulative Impacts

As addressed in Section 4.8.6 of the 2010 FSEIS, the NRC staff determined that the cumulative impacts to the environment surrounding IP2 and IP3 from past and present human activities (beyond impacts from IP2 and IP3) have generally been LARGE and could continue to be LARGE in some issue areas and that future development is likely to continue to affect these resources. The NRC staff has subsequently considered the actions and projects identified in Table 5–5 of this supplement and concludes that the potential cumulative impacts associated with these additional actions would continue to be bounded by the assessment in the 2010 FSEIS.

6.0 CONTINUED STORAGE OF SPENT NUCLEAR FUEL

The U.S. Nuclear Regulatory Commission's (NRC's) findings on the environmental impacts associated with the renewal of a power reactor operating license are contained in Table B-1, "Summary of Findings on NEPA Issues for License Renewal of Nuclear Power Plants," in Appendix B to Subpart A of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 51.⁹ In 1996, as part of the 10 CFR Part 51 license renewal rulemaking, the NRC determined that offsite radiological impacts of spent nuclear fuel and high-level waste disposal would be a Category 1 (generic) issue with no impact level assigned (61 FR 28467, 28495). The NRC analyzed the U.S. Environmental Protection Agency's (EPA's) generic repository standards and dose limits in existence at the time and concluded that offsite radiological impacts warranted a Category 1 determination (61 FR 28467, 28478). In its 2009 proposed rule, the NRC stated its intention to reaffirm that determination (74 FR 38117, 38127).

For the offsite radiological impacts resulting from spent fuel and high-level waste disposal and the onsite storage of spent fuel, which will occur after the reactors have been permanently shut down, the NRC's Waste Confidence Decision and Temporary Storage Rule (Waste Confidence Decision and Rule) (10 CFR 51.23) historically represented the Commission's generic determination that spent fuel can continue to be stored safely and without significant environmental impacts for a period of time after the end of the licensed life for operation. This generic determination meant that the NRC did not need to consider the storage of spent fuel after the end of a reactor's licensed life for operation in documents prepared under the National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. 4321 et seq.), that support its reactor and spent fuel storage application reviews.

The NRC first adopted the Waste Confidence Decision and Rule in 1984. The NRC amended the Waste Confidence Decision and Rule in 1990; reviewed them in 1999; and amended them again in 2010, as published in the *Federal Register* (49 FR 34685, 34694; 55 FR 38472, 38474; 64 FR 68005; and 75 FR 81032, 81037). The Waste Confidence Decision and Rule were codified in 10 CFR 51.23.

On December 23, 2010, the Commission published in the *Federal Register* a revision of the Waste Confidence Decision and Rule to reflect information gained from experience in the storage of spent fuel and the increased uncertainty in the siting and construction of a permanent geologic repository for the disposal of spent fuel and high-level waste (75 FR 81032, 81037). In response to the 2010 Waste Confidence Decision and Rule, the States of New York, New Jersey, Connecticut, and Vermont—along with several other parties—challenged the Commission's NEPA analysis in the decision, which provided the regulatory basis for the rule. On June 8, 2012, the U.S. Court of Appeals for the District of Columbia Circuit, in *New York v. NRC*, 681 F.3d 471 (D.C. Cir. 2012), vacated the NRC's 2010 Waste Confidence Decision and Rule, finding that it did not comply with NEPA.

In response to the Court's ruling, the Commission, in CLI-12-16 (NRC 2012c), determined that it would not issue licenses that rely upon the Waste Confidence Decision and Rule until the issues identified in the Court's decision are appropriately addressed by the Commission. In CLI-12-16,

⁹ The Commission issued Table B-1 in June 1996 (61 FR 28467). The Commission issued an additional rule in December 1996 that made minor clarifying changes to, and added language inadvertently omitted from, Table B-1 (61 FR 66537). The NRC revised Table B-1 and other regulations in 10 CFR Part 51, relating to the NRC's environmental review of a nuclear power plant's license renewal application, in a 2013 rulemaking (78 FR 37282).

the Commission also noted that the decision not to issue licenses only applied to final license issuance; all licensing reviews and proceedings should continue to move forward.

In addition, the Commission directed in Staff Requirements Memorandum (SRM)-COMSECY-12-0016 (NRC 2012d) that the NRC staff proceed with a rulemaking that includes the development of a generic environmental impact statement (GEIS) to support a revised Waste Confidence Decision and Rule and to publish both the EIS and the revised decision and rule in the *Federal Register* within 24 months (by September 2014). The Commission indicated that both the EIS and the revised Waste Confidence Decision and Rule should build on the information already documented in various NRC studies and reports, including existing environmental assessments that the NRC developed as part of the 2010 Waste Confidence Decision and Rule. The Commission directed that any additional analyses should focus on the issues identified in the court's decision. The Commission also directed that the NRC staff provide ample opportunity for public comment on both the draft EIS and the proposed Waste Confidence Decision and Rule. Subsequent developments concerning this issue are discussed below.

6.1 Issuance of Revised 10 CFR 51.23 and NUREG–2157

As discussed above, in *New York v. NRC*, 681 F.3d 471 (D.C. Cir. 2012), the Court vacated the Commission's 2010 Waste Confidence Decision and Rule (10 CFR 51.23). In response to the Court's vacatur, the Commission developed a revised rule and associated *Generic Environmental Impact Statement for Continued Storage of Spent-Nuclear Fuel* (GEIS) (NUREG–2157). Before the issuance of the revised 10 CFR 51.23 and NUREG–2157, the NRC issued the 2013 final license renewal rule, which amended Table B–1 in Appendix B to Subpart A of 10 CFR Part 51—along with other 10 CFR Part 51 regulations—and stated that, upon finalization of the revised Waste Confidence Decision and Rule and accompanying technical analyses,¹⁰ the NRC would make any necessary conforming amendments to Table B–1 (78 FR 37282, 37293).

On August 26, 2014, the Commission approved the Continued Storage Rule and associated NUREG–2157 (NRC 2014f). Subsequently, on September 19, 2014, the NRC published the final rule (79 FR 56238) in the *Federal Register*, and published NUREG–2157 (79 FR 53238, 56263). The Continued Storage Rule adopts the generic impact determinations made in NUREG–2157 and codifies the NRC's generic determinations regarding the environmental impacts of continued storage of spent nuclear fuel beyond a reactor's operating license (i.e., those impacts that could occur as a result of the storage of spent nuclear fuel at at-reactor or away-from-reactor sites after a reactor's licensed life for operation and until a permanent repository becomes available). As directed by 10 CFR 51.23(b), the impacts assessed in NUREG–2157 regarding continued storage are deemed incorporated by rule into this FSEIS supplement.

In the Continued Storage Rule, the NRC made conforming changes to the following two environmental issues in Table B–1 that were affected by the vacated Waste Confidence Decision and Rule: (1) "Onsite spent fuel" storage and (2) "Offsite radiological impacts (spent fuel and high-level waste disposal)."¹¹ Although NUREG–2157 (the technical basis for

¹⁰ At the time of the 2013 final license renewal rule, the Continued Storage Rule was referred to by its long-standing historical name, "Waste Confidence."

¹¹ The 2013 license renewal rule renamed these two issues as "Onsite storage of spent nuclear fuel" and "Offsite radiological impacts of spent nuclear fuel and high-level waste disposal," respectively. (See "Revisions to Environmental Review for Renewal of Nuclear Power Plant Operating Licenses," 78 FR 37282–37324).

the Continued Storage Rule) does not include high-level waste disposal in the analysis of impacts, it does address the technical feasibility of a repository in Appendix B to NUREG–2157 and concludes that a geologic repository for spent fuel is technically feasible, and that the same analysis applies to the feasibility of geologic disposal for high-level waste.

The Commission revised the Table B–1 finding for “Onsite storage of spent nuclear fuel” to add the phrase “during the license renewal term” to make clear that the finding of SMALL impact is for the license renewal term only. Some minor clarifying changes were also made to the paragraph. The first paragraph of the column entry now reads, “During the license renewal term, SMALL. The expected increase in the volume of spent nuclear fuel from an additional 20 years of operation can be safely accommodated onsite during the license renewal term with small environmental impacts through dry or pool storage at all plants.”

In addition, a new paragraph was added to address the impacts of onsite storage of spent fuel during the continued storage period. The second paragraph of the column entry reads, “For the period after the licensed life for reactor operations, the impacts of onsite storage of spent nuclear fuel during the continued storage period are discussed in NUREG–2157 and as stated in § 51.23(b), shall be deemed incorporated into this issue.” The changes reflect that this issue covers the environmental impacts associated with the storage of spent nuclear fuel during the license renewal term, as well as the period after the licensed life for reactor operations.

The Table B–1 entry for “Offsite radiological impacts of spent nuclear fuel and high-level waste disposal” also was revised to reclassify the impact determination as a Category 1 issue with no impact level assigned. The finding column entry for this issue includes reference to the EPA’s radiation protection standards for the high-level waste and spent nuclear fuel disposal component of the fuel cycle. Although the status of a repository, including a repository at Yucca Mountain, is uncertain and outside the scope of the generic environmental analysis conducted to support the Continued Storage Rule, the NRC believes that the current radiation standards for Yucca Mountain are protective of public health and safety and the environment and may properly be cited in environmental analyses prepared under NEPA.

The changes to these two issues finalize the Table B–1 entries that the NRC had intended to issue in its 2013 license renewal rulemaking but was unable to do so because the 2010 Waste Confidence Decision and Rule had been vacated.

NUREG–2157 concludes that deep geologic disposal remains technically feasible, although the bases for the specific conclusions in Table B–1 in Appendix B to Subpart A of 10 CFR Part 51 are found elsewhere (e.g., the 1996 rule that issued Table B–1 and the 1996 license renewal GEIS, which provided the technical basis for that rulemaking, as reaffirmed by the 2013 rulemaking and final license renewal GEIS). Based on the Continued Storage Rule, these two issues were revised accordingly in Table B–1.

6.1.1 CLI-14-08: Determination That Revised 10 CFR 51.23 and NUREG–2157 Satisfy the NRC’s NEPA Obligations for Continued Storage and Accounting for the Environmental Impacts in NUREG–2157

In CLI-14-08 (NRC 2014c), the Commission held that the revised 10 CFR 51.23 and associated NUREG–2157 cure the deficiencies identified by the Court in *New York v. NRC*, 681 F.3d 471 (D.C. Cir. 2012) and stated that the rule satisfies the NRC’s NEPA obligations with respect to continued storage for initial, renewed, and amended licenses for reactors.

As the Commission noted in CLI-14-08, the NRC staff must account for these environmental impacts before finalizing its licensing decision in an individual licensing proceeding. To account for these impact determinations, the generic environmental impact determinations made

pursuant to the Continued Storage Rule and the associated NUREG–2157 are deemed incorporated into this final supplemental environmental impact statement (FSEIS) supplement.

The NRC staff relies on the Continued Storage Rule and its supporting GEIS (i.e., NUREG–2157) to provide NEPA analyses of the environmental impacts of spent fuel storage at the reactor site or at an away-from-reactor storage facility beyond the licensed life for reactor operations. By virtue of the revised 10 CFR 51.23 regulation, the impact determinations in NUREG–2157 regarding continued storage complete the analysis of the environmental impacts associated with spent fuel storage beyond the licensed life for reactor operations and are deemed incorporated into this FSEIS supplement, as further described below.

6.1.1.1 At-Reactor Storage

The analysis in NUREG–2157 concludes that the potential impacts of at-reactor storage during the short-term timeframe (the first 60 years after the end of licensed life for operations of the reactor) would be SMALL (see Section 4.20 of NUREG–2157). Furthermore, the analysis in NUREG–2157 states that disposal of the spent fuel by the end of the short-term timeframe is the most likely outcome (see Section 1.2 of NUREG–2157).

However, the analysis in NUREG–2157 also evaluated the potential impacts of continued storage if the fuel is not disposed of by the end of the short-term timeframe. The analysis in NUREG–2157 determined that the impacts to historic and cultural resources from at-reactor storage during the long-term timeframe (the 100-year period after the short-term timeframe) and the indefinite timeframe (the period after the long-term timeframe) are dependent on factors that are unpredictable this far in advance and, therefore, concluded those impacts would be SMALL to LARGE (see Section 4.12 of NUREG–2157). Among other things, as discussed in NUREG–2157, the NRC cannot accurately determine at this time what resources may be present or discovered at a continued storage site a century or more in the future and whether those resources will be historically or culturally significant to future generations. Additionally, impacts greater than SMALL could occur if the activities to replace an independent spent fuel storage installation (ISFSI) and the dry transfer system (DTS) adversely affect cultural or historic resources and if the effects cannot be mitigated. As discussed in NUREG–2157, given the minimal size of an ISFSI and DTS and the large land areas at nuclear power plant sites, licensees should be able to locate these facilities away from historic and cultural resources. Potential adverse effects on historic properties or impacts on historic and cultural resources could also be minimized through development of agreements, license conditions, and implementation of the licensee’s historic and cultural resource management plans and procedures to protect known historic and cultural resources and address inadvertent discoveries during construction and replacement of these facilities. However, it may not be possible to avoid adverse effects on historic properties under the National Historic Preservation Act of 1966, as amended (NHPA) (16 U.S.C. 470 et seq.), or impacts on historic and cultural resources under NEPA; therefore, the analysis in NUREG–2157 concluded that impacts would be SMALL to LARGE (see Section 4.12.2 of NUREG–2157).

The analysis in NUREG–2157 also concludes that the impacts of nonradioactive waste in the indefinite timeframe would be SMALL to MODERATE, with the higher impacts potentially occurring if the waste from repeated replacement of the ISFSI and DTS exceeds local landfill capacity (see Section 4.15 of NUREG–2157). Although the NRC concluded that nonradioactive waste disposal would not be destabilizing (or LARGE), the range reflects uncertainty regarding whether the volume of nonradioactive waste from continued storage would contribute to noticeable waste management impacts over the indefinite timeframe when considered in the context of the overall local volume of nonradioactive waste.

As previously discussed, the NRC found in NUREG–2157 that disposal of the spent fuel is most likely to occur by the end of the short-term timeframe. Therefore, disposal during the long-term timeframe is less likely, and the scenario depicted in the indefinite timeframe—continuing to store spent nuclear fuel indefinitely—is unlikely. As a result, the most likely impacts of the continued storage of spent fuel are those considered in the short-term timeframe. In the unlikely event that fuel remains on site into the long-term and indefinite timeframes, the associated impact ranges in NUREG–2157 reflect the accordingly greater uncertainties regarding the potential impacts over these very long periods of time. Taking into account the impacts that the NRC considers most likely, which are SMALL; the greater uncertainty reflected in the ranges in the long-term and indefinite timeframes compared to the greater certainty in the SMALL findings, and the relative likelihood of the timeframes, the impact determinations for at-reactor storage presented in NUREG–2157 are deemed incorporated into this FSEIS supplement pursuant to 10 CFR 51.23.

6.1.1.2 *Away-from-Reactor Storage*

In NUREG–2157, the NRC concluded that a range of potential impacts could occur for some resource areas if the spent fuel from multiple reactors is shipped to a large (roughly 40,000 metric tons of uranium) away-from-reactor ISFSI (see Section 5.20 of NUREG–2157). The ranges for some resources are driven by the uncertainty regarding the location of such a facility and the local resources that would be affected.

As discussed in NUREG–2157, for away-from-reactor storage, the unavoidable adverse environmental impacts for most resource areas is SMALL across all timeframes, except for air quality, terrestrial resources, aesthetics, waste management, and transportation for which the impacts are SMALL to MODERATE. Socioeconomic impacts range from SMALL (adverse) to LARGE (beneficial), and historic and cultural resource impacts could be SMALL to LARGE across all timeframes. The potential MODERATE impacts on air quality, terrestrial wildlife, and transportation are based on potential construction-related fugitive dust emissions, terrestrial wildlife direct and indirect mortalities, terrestrial habitat loss, and temporary construction traffic impacts. The potential MODERATE impacts on aesthetics and waste management are based on noticeable changes to the viewshed from construction of a new away-from-reactor ISFSI and from the volume of nonhazardous solid waste generated by assumed facility ISFSI and DTS replacement activities for the indefinite timeframe, respectively. The potential LARGE beneficial impacts on socioeconomics are due to local economic tax revenue increases from an away-from-reactor ISFSI.

As further discussed in NUREG–2157, the potential impacts to historic and cultural resources during the short-term storage timeframe would range from SMALL to LARGE. The magnitude of adverse effects on historic properties and impacts on historic and cultural resources largely depends on where facilities are sited, what resources are present, what the extent of proposed land disturbance will be, whether the area has been previously surveyed to identify historic and cultural resources, and whether the licensee has management plans and procedures that are protective of historic and cultural resources. Even a small amount of ground disturbance (e.g., clearing and grading) could affect a small but significant resource. In most instances, placement of storage facilities on the site can be adjusted to minimize or avoid impacts to any historic and cultural resources in the area. However, the NRC recognizes that this may not always be possible. The NRC’s site-specific environmental review and compliance with the NHPA process could identify historic properties, identify adverse effects, and potentially resolve adverse effects on historic properties and impacts on other historic and cultural resources. Under the NHPA, mitigation does not eliminate a finding of adverse effect on historic properties. The potential impacts to historic and cultural resources during the long-term and indefinite storage timeframes would also range from SMALL to LARGE. This range takes into

consideration routine maintenance and monitoring (i.e., no ground-disturbing activities), the absence or avoidance of historic and cultural resources, and potential ground-disturbing activities that could affect historic and cultural resources. The analysis also considers uncertainties inherent in analyzing this resource area over long timeframes. These uncertainties include any future discovery of previously unknown historic and cultural resources; resources that gain significance within the vicinity and the viewshed (e.g., nomination of a historic district) due to improvements in knowledge, technology, and excavation techniques and changes associated with predicting resources that future generations will consider significant. If construction of a DTS and replacement of the ISFSI and DTS occurs in an area with no historic or cultural resource present or construction occurs in a previously disturbed area that allows avoidance of historic and cultural resources, then impacts would be SMALL. By contrast, a MODERATE or LARGE impact could result if historic and cultural resources are present at a site and, because they cannot be avoided, are affected by ground-disturbing activities during the long-term and indefinite timeframes.

NUREG–2157 indicates that impacts on Federally listed species, designated critical habitat, and essential fish habitat would be based on site-specific conditions and determined as part of consultations required by the ESA and the Magnuson–Stevens Fishery Conservation and Management Reauthorization Act of 2006, as amended (16 U.S.C. 1801–1884).

Finally, as discussed in NUREG–2157, continued storage of spent nuclear fuel at an away-from-reactor ISFSI is not expected to cause disproportionately high and adverse human health and environmental effects on minority and low-income populations. As indicated in the Commission’s policy statement on environmental justice (69 FR 52040), should the NRC receive an application for a proposed away-from-reactor ISFSI, a site specific NEPA analysis would be conducted, and this analysis would include consideration of environmental justice impacts. Pursuant to 10 CFR 51.23, the impact determinations for away-from-reactor storage presented in NUREG–2157 are deemed incorporated into this FSEIS supplement.

6.1.1.3 *Cumulative Impacts*

NUREG–2157 examines the incremental impact of continued storage on each resource area analyzed in NUREG–2157 in combination with other past, present, and reasonably foreseeable future actions. NUREG–2157 indicates ranges of potential cumulative impacts for multiple resource areas (see Section 6.5 of NUREG–2157). However, these ranges are primarily driven by impacts from activities other than the continued storage of spent fuel at the reactor site; the impacts from these other activities would occur regardless of whether spent nuclear fuel is stored during the continued storage period. In the short-term timeframe, which is the most likely timeframe for the disposal of the fuel, the potential impacts of continued storage for at-reactor storage are SMALL and, therefore, would not be a significant contributor to the cumulative impacts. In the longer timeframes for at-reactor storage, or in the less likely case of away-from-reactor storage, some of the impacts from the storage of spent nuclear fuel could be greater than SMALL. As noted in NUREG–2157, other Federal and non-Federal activities occurring during the longer timeframes include uncertainties as well. It is primarily these uncertainties (i.e., those associated with activities other than continued storage) that contribute to the ranges of potential cumulative impacts discussed throughout Chapter 6 of NUREG–2157 and summarized in Table 6–4 of NUREG–2157. Because, as stated above, the impacts from these other activities would occur regardless of whether continued storage occurs, the overall cumulative impact conclusions in NUREG–2157 would still be the stated ranges regardless of whether there are impacts of continued storage from any individual licensing action.

Taking into account the impacts that the NRC considers most likely, which are SMALL; the uncertainty reflected by the ranges in some impacts; and the relative likelihood of the

timeframes, the impact determinations for cumulative impacts presented in NUREG–2157 are deemed incorporated into this FSEIS supplement pursuant to 10 CFR 51.23.

6.1.1.4 Conclusion

Based on the information discussed above, the impacts of continued storage of spent nuclear fuel are those presented in NUREG–2157 and are deemed incorporated into this FSEIS supplement pursuant to 10 CFR 51.23. The revised 10 CFR 51.23 and NUREG–2157 have gone through a rulemaking process that involved significant input from the public. Therefore, the NRC staff concludes that the information in NUREG–2157 provides the appropriate NEPA analyses of the potential environmental impacts associated with the continued storage of spent fuel beyond the licensed life for reactor operations at IP2 and IP3.

The NRC staff concludes that the revised 10 CFR 51.23, which adopts the generic impact determination regarding continued storage from NUREG–2157, satisfies the NRC’s NEPA obligations with respect to continued storage of spent nuclear fuel as it relates to the issues “Offsite radiological impacts of spent nuclear fuel and high-level waste disposal” and “Onsite storage of spent nuclear fuel” for the environmental review associated with the license renewal for IP2 and IP3.

6.1.2 Revisions to the 2010 FSEIS Resulting from Revisions to 10 CFR 51.23

To account for the revisions to 10 CFR 51.23 and the resulting conforming changes throughout 10 CFR Part 51, the NRC staff has updated the FSEIS as described below.

Lines 28-39 on page xvi in the Executive Summary of the FSEIS are revised as follows:¹²

The supplemental environmental impact statement for license renewal is not required to include discussion of need for power or the economic costs and economic benefits of the proposed action or of alternatives to the proposed action except insofar as such benefits and costs are either essential for a determination regarding the inclusion of an alternative in the range of alternatives considered or relevant to mitigation. In addition, the supplemental environmental impact statement prepared at the license renewal stage need not discuss other issues not related to the environmental effects of the proposed action and the alternatives. ~~., or any aspect of the storage of spent fuel for the facility within the scope of the generic determination in 10 CFR 51.23(a) [“Temporary storage of spent fuel after the cessation of reactor operation—generic determination of no significant environmental impact”] and in accordance with 10 CFR 51.23(b).~~ **The analysis of alternatives in the supplemental environmental impact statement should be limited to the environmental impacts of such alternatives and should otherwise be prepared in accordance with § 51.71 and Appendix A to Subpart A of this part. As stated in § 51.23, the generic impact determinations regarding the continued storage of spent fuel in NUREG–2157 shall be deemed incorporated into the supplemental environmental impact statement.**

¹² The revised language in 10 CFR 51.95(c)(2) includes revisions made as part of the NRC’s 2013 update to 10 CFR Part 51 (78 FR 37282) that were discussed in Chapter 5 of this supplement.

Lines 7-10 on page 1-5 in Section 1.2.2 of the FSEIS are revised as follows:

- discuss **any aspect of the storage of spent fuel within the scope of the generic determination in 10 CFR 51.23(a) in accordance with 10 CFR 51.23(b) and the environmental impacts of the continued storage of spent fuel, as stated in 10 CFR 51.23; and**
- pursuant to 10 CFR 51.~~23~~53(c)(3)(~~ii~~) and (iv), contain an analysis of any Category 1 issue unless there is significant new information on a specific issue.

Table 6–1 on page 6-2 in Section 6.1 of the FSEIS is revised as follows:

Table 6–1. Category 1 Issues Applicable to the Uranium Fuel Cycle and Solid Waste Management During the Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B–1	GEIS Section
Uranium Fuel Cycle and Waste Management	
Offsite radiological impacts (individual effects from other than the disposal of spent fuel and high-level waste)	6.1; 6.2.1; 6.2.2.1; 6.2.2.3; 6.2.3; 6.2.4; 6.6
Offsite radiological impacts (collective effects)	6.1; 6.2.2.1; 6.2.3; 6.2.4; 6.6
Offsite radiological impacts (of spent nuclear fuel and high-level waste disposal)	6.1; 6.2.2.1; 6.2.2.2; 6.2.3; 6.2.4; 6.64.11.1.3^(a)
Nonradiological impacts of the uranium fuel cycle	6.1; 6.2.2.6; 6.2.2.7; 6.2.2.8; 6.2.2.9; 6.2.3; 6.2.4; 6.6
Low-level waste storage and disposal	6.1; 6.2.2.2; 6.4.2; 6.4.3; 6.4.4
Mixed waste storage and disposal	6.1; 6.4.5; 6.6
Onsite storage of spent nuclear fuel	6.1; 6.4.6; 6.64.11.1.2^(b)
Nonradiological waste	6.1; 6.5; 6.6
Transportation	6.1; 6.3, Addendum 1; 6.6

^(a) NRC 2013a

^(b) The environmental impact of this issue during the license renewal term is contained in the 2013 GEIS (NRC 2013a). The environmental impact of this issue for the timeframe beyond the licensed life for reactor operations is contained in NUREG–2157 (NRC 2014f).

Before line 5 on page 6-2 of Section 6-1 of the FSEIS, the following text is added:

The NRC staff’s evaluation of the environmental impacts associated with spent nuclear fuel is addressed in two issues in Table 6–1, “Offsite radiological impacts of spent nuclear fuel and high-level waste disposal” and “Onsite storage of spent nuclear fuel.” However, as explained later in this section, these two issues now incorporate the generic environmental impact determinations codified in the revised 10 CFR 51.23 pursuant to the Continued Storage Rule (79 FR 56238).

Regarding the remaining issues in Table 6–1, Entergy Nuclear Operations, Inc. (Entergy), stated in the IP2 and IP3 environmental report (ER) (Entergy 2007) that it is not aware of any new and significant information associated with the renewal of the IP2 and IP3 operating licenses, though it did identify leaks to groundwater as a potential new issue.

Lines 6-42 on page 6-4, lines 1-43 on page 6-5, and lines 1-33 on page 6-6 of Section 6.1 of the FSEIS are deleted.

7.0 OTHER REGULATORY REQUIREMENTS

7.1 Section 7 Consultation

7.1.1 Reinitiation of Consultation due to FWS's Listing of Northern Long-eared Bat

On April 2, 2015, the U.S. Fish and Wildlife Service (FWS) published a final rule that lists the northern long-eared bat (*Myotis septentrionalis*) as threatened throughout its range under the Endangered Species Act of 1973, as amended (ESA) (16 U.S.C. 1531 et seq.) in the *Federal Register* (FR) (80 FR 17974). On June 8, 2015, Entergy (2015e) submitted to the U.S. Nuclear Regulatory Commission (NRC) information concerning Federally listed bats at Indian Point Nuclear Generating Unit Nos. 2 and 3 (IP2 and IP3). The NRC (2015e) prepared a biological assessment that evaluated the potential effects of the proposed license renewal on the northern long-eared bat, a species that was not considered in the 2010 final supplemental environmental impact statement (FSEIS) or the 2013 supplement to the FSEIS. The biological assessment also considered whether Entergy's updated information affected the NRC's (2010) previous finding that IP2 and IP3 license renewal is "not likely to adversely affect" the Indiana bat (*Myotis sodalis*). In the biological assessment, the NRC concluded that the proposed IP2 and IP3 license renewal may affect, but is not likely to adversely affect, the northern long-eared bat and Indiana bat. This conclusion was based on the NRC's assessment of several potential effects, which are summarized as follows.

- The proposed license renewal could result in injury or mortality of northern long-eared or Indiana bat individuals through collision with plant structures, but this impact would be discountable because the impact is extremely unlikely given that no bat collisions of any species have been documented on the site since IP2 and IP3 began operating in the mid-1970s.
- The proposed license renewal would result in no habitat loss, degradation, disturbance, or fragmentation, and the continued preservation of forest habitat on the site would result in a beneficial impact to the two species, if present on the site.
- Site maintenance activities would not result in effects significantly different than those experienced by bats during the current license terms and any additional impacts resulting from the replacement of the IP2 and IP3 reactor vessel head and control rod drive mechanisms would be temporary, insignificant, and discountable.

In a letter dated July 1, 2015, the NRC (2015f) transmitted its biological assessment to the FWS for review. In a letter dated July 14, 2015, the FWS (2015) provided its concurrence with the NRC's "not likely to adversely affect" determinations for northern long-eared and Indiana bats. The FWS (2015) also confirmed that no further consultation or coordination pursuant to the ESA is required with the FWS unless project plans change or additional information on listed or proposed species or critical habitat becomes available.

7.1.2 Section 7 Conference due to NMFS's Proposed Designation of Atlantic Sturgeon Critical Habitat

On June 3, 2016, the National Marine Fisheries Service (NMFS) published proposed rules in the *Federal Register* (81 FR 35701, 81 FR 36077) to designate critical habitat for each of the five Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) distinct population segments (DPSs). The NRC (2016d) staff prepared an assessment that evaluated the potential effects of continued IP2 and IP3 operation through the proposed license renewal term on proposed Atlantic sturgeon

critical habitat in the Hudson River. In the assessment, the NRC staff found that the IP2 and IP3 action area contains habitat meeting the criteria of Essential Features 2, 3, and 4 as described in NMFS's proposed rules. The NRC staff evaluated the impacts of water withdrawals, water discharges, and non-routine and accidental events on these essential features. More specifically, the NRC staff considered impingement and entrainment of prey species, local alteration of water velocity or regimes, physical removal of habitat (water) from the aquatic environment, thermal discharges, discharge of chemicals and radionuclides, and design basis and severe accidents. The NRC staff concluded that although impacts exist, none of these impacts would affect proposed critical habitat such that continued operation and license renewal of IP2 and IP3 would inhibit the growth, development, recruitment, or survival of juvenile, subadult, or adult Atlantic sturgeon or otherwise appreciably diminish the value of the proposed critical habitat for the New York Bight DPS of Atlantic sturgeon. Accordingly, the NRC staff concluded that the proposed action may affect, but is not likely to destroy or adversely modify, proposed critical habitat of the New York Bight DPS of Atlantic sturgeon in the Hudson River. The proposed action would have no effect on proposed critical habitat for any of the other four DPSs of Atlantic sturgeon. In a letter dated September 13, 2016, the NRC (2016e) transmitted the staff's assessment to NMFS for review.

On August 17, 2017, NMFS issued a final rule designating critical habitat (82 FR 39160). On August 31, 2017, the NMFS (2017) issued a conference report to the NRC that considered the critical habitat, as designated in the final rule. In the report, NMFS concluded that "effects to the proposed critical habitat for the New York Bight DPS are insignificant or discountable" and that "[i]n sum, the effects of the action are not likely to adversely affect critical habitat proposed for the New York Bight DPS of Atlantic sturgeon." The conference report concluded the ESA Section 7 conference between NRC and NMFS.

7.1.3 Request for Amended Incidental Take Statement and the NMFS's Concurrence with the NRC Staff's Atlantic Sturgeon Critical Habitat Effect Determination

On October 13, 2017, the NRC staff participated in a meeting with the NMFS pursuant to Section 7 of the ESA and related to the NRC's ongoing IP2 and IP3 license renewal review. Entergy and the New York State Department of Environmental Conservation participated in the meeting. Discussion focused on whether reinitiation of ESA Section 7 consultation for IP2 and IP3 is appropriate at this time and on Entergy's implementation of sturgeon monitoring required by the Terms and Conditions of the NMFS's January 30, 2013, biological opinion and Incidental Take Statement (ITS). Following the meeting, the staff prepared a summary that highlights the major areas of discussion (NRC 2017e). On October 27, 2017, Goodwin Procter, LLC (2017), on behalf of Entergy, submitted a letter to the NRC and the NMFS that also summarized the October 13, 2017, meeting. Additionally, Goodwin Procter addressed several outstanding questions from the meeting related to operating conditions during the proposed license renewal term and Entergy's biological monitoring plan.

On November 27, 2017, the NRC (2017f) sent a letter to the NMFS requesting that the NMFS amend the 2013 ITS to reflect current information concerning the early retirements of IP2 and IP3; the current condition of the IP1 trash racks; and monitoring of various components of the IP2 and IP3 cooling water intake systems (i.e., the forebays, IP2 and IP3 trash racks, and IP2 and IP3 Ristroph screens). The letter also requested the NMFS's concurrence with the staff's determination that the proposed action, continued operation of IP2 and IP3 through the end of the proposed license renewal terms, is not likely to adversely affect critical habitat designated for the New York Bight DPS of Atlantic sturgeon pursuant to ESA Section 7(a)(2). The NMFS has committed to providing a response to the NRC, which is to include its concurrence determination and a final amended ITS, by February 1, 2018 (NRC 2017e). The NRC will

document the results of these communications in the record of decision associated with the NRC's IP2 and IP3 license renewal decision.

7.1.4 Revised NEPA Findings for Threatened and Endangered Species

In the 2010 FSEIS (NRC 2010), the NRC concluded that the impacts of the proposed IP2 and IP3 license renewal on Federally listed terrestrial and aquatic species would be "SMALL." In the 2013 supplement to the FSEIS (NRC 2013b), the NRC staff provided updated information related to shortnose (*Acipenser brevirostrum*) and Atlantic sturgeon and described the outcome of its ESA Section 7 consultation with NMFS, which resulted in the NMFS's (2013) issuance of a biological opinion for shortnose and Atlantic sturgeon. The NRC staff's (2013b) conclusions for these species remained "SMALL" in the 2013 supplement.

In 2013, when the NRC issued Revision 1 to NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS)* (NRC 2013a), the NRC changed how it reports impacts to ESA-listed species and habitats in its license renewal supplemental environmental impact statements (SEISs). In preparing the revised GEIS, the NRC staff determined that the levels of impact that it developed to implement the National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. 4321 et seq.), (i.e., SMALL, MODERATE, or LARGE) are not sufficiently clear with respect to the ESA because this law defines other required findings. Accordingly, the NRC determined that with respect to ESA-listed species and critical habitats, it would report its plant-specific findings in future SEISs in terms of (1) no effect, (2) not likely to adversely affect, (3) likely to adversely affect, or (4) is likely to jeopardize the listed species or adversely modify the designated critical habitat. Further, if the NRC finds that the action is "likely to adversely affect" the listed species or critical habitat, the NRC may further characterize the effects as "is [or is not] likely to jeopardize the listed species or adversely modify the designated critical habitat."

Because of the changes in how the NRC characterizes impact findings for ESA-listed species and critical habitats described above, the NRC staff revised its species-specific findings for Federally listed species and habitats for the proposed IP2 and IP3 license renewal from "SMALL" to the effect determinations listed below in Table 7-1. These findings are consistent with the findings the NRC previously made (2015e, 2016d) in biological assessments associated with IP2 and IP3 license renewal, and with findings the NMFS (2013) and the FWS (2015) made during the ESA Section 7 consultation with the NRC. Additionally, these findings do not substantively affect the NRC staff's previous evaluations of impacts to any of these species or require further consultation with the FWS or NMFS.

Table 7-1. ESA Effect Determinations for Federally Listed Species and Critical Habitats

Listed Species ^(a)	Common Name	Federal Status ^(b)	Effect Determination
<i>Acipenser brevirostrum</i>	shortnose sturgeon	FE	may affect, but not likely to jeopardize the continued existence of
<i>Acipenser oxyrinchus oxyrinchus</i>	Atlantic sturgeon	FE/T ^(c)	may affect, but not likely to jeopardize the continued existence of
<i>Clemmys muhlenbergii</i>	bog turtle	FT	no effect
<i>Myotis septentrionalis</i>	northern long-eared bat	FT	not likely to adversely affect

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<i>Myotis sodalis</i>	Indiana bat	FE	not likely to adversely affect
Critical Habitat		Federal Status ^(b)	Effect Determination
Critical habitat of the New York Bight distinct population segment (DPS) of Atlantic sturgeon		FD	not likely to destroy or adversely modify
<p>^(a) The NRC staff's (2015e) biological assessment for species under FWS's jurisdiction also addressed the New England cottontail (<i>Sylvilagus transitionalis</i>), which at the time was a candidate for Federal listing under the ESA. The NRC determined that no suitable habitat exists in the IP2 and IP3 action area for this species and that license renewal would, therefore, have "no effect" on this species. On September 15, 2015, the FWS determined that listing of the New England cottontail under the ESA is not warranted at this time (80 FR 55286). Accordingly, the NRC makes no ESA effect determination for this species.</p> <p>^(b) FE = Federally endangered under the Endangered Species Act of 1973, as amended (ESA); FT = Federally threatened under the ESA; FE/T = Federally endangered or threatened under the ESA; FD = Federally designated as critical habitat under the ESA.</p> <p>^(c) The Atlantic sturgeon is listed under the ESA as five DPSs. The New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs are FE, and the Gulf of Maine DPS is FT.</p>			

7.2 Coastal Zone Management Act

In 1972, Congress promulgated the Coastal Zone Management Act (16 USC 1451 et seq.; CZMA) to encourage and assist States and territories in developing management programs that preserve, protect, develop, and, where possible, restore the resources of the coastal zone (i.e., the coastal waters and the adjacent shore lands strongly influenced by one another, which may include islands, transitional and intertidal areas, salt marshes, wetlands, beaches, and Great Lakes waters). Individual states are responsible for developing a Federally approved Coastal Management Plan and implementing a coastal management program in accordance with such a plan. In New York, the NYSDOS administers the coastal management program.

Section 307(c)(3)(A) of the CZMA requires that applicants for Federal permits whose proposed activities could reasonably affect coastal zones certify to the licensing agency (here, the NRC) that the proposed activity would be consistent with the state's coastal management program. As described in the FSEIS (NRC 2010), IP2 and IP3 are located in Westchester County, within the State's Coastal Zone, specifically in the Peekskill South region of the Hudson River. The IP2 and IP3 site is adjacent to a Significant Coastal Fish and Wildlife Habitat (Haverstraw Bay) and south of the Hudson Highlands Scenic Area of Statewide Significance. The New York State Department of State (NYSDOS) (2012) updated the Hudson Highlands Significant Coastal Fish and Wildlife Habitat to include the area of the Hudson River from which IP2 and IP3 withdraw cooling water (i.e., River Segment 4) because it is a major spawning area for Hudson River striped bass. Based on IP2's and IP3's location within the State's Coastal Zone, license renewal of IP2 and IP3 requires the NYSDOS's consistency certification.

By letter dated December 17, 2012 (Entergy 2012d), Entergy submitted its initial consistency certification and request for concurrence to the NYSDOS. The NYSDOS initially declined to accept that certification. However, subsequent to signing the January 8, 2017, Closure Agreement (NYS et al. 2017) (herein referred to as "Closure Agreement") (see Section 2.2 of this supplement), Entergy re-submitted its consistency certification with additional supporting information. The new information included the following conditions:

- IP2 will permanently cease operations no later than April 30, 2020, and IP3 will permanently cease operations no later than April 30, 2021, unless a later date is mutually agreed upon between Entergy and the State of New York. In any event, the license renewal term will expire on April 30, 2024, and April 30, 2025, for IP2 and IP3, respectively.
- Entergy will continue to operate IP2's and IP3's existing multi-speed pumps and optimized Ristroph traveling screens and fish-handling and -return systems, and operate within the thermal and flow terms and conditions of the State Pollutant Discharge Elimination System (SPDES) permit and 401 Water Quality Certification.
- Entergy will implement an approximately 30-day outage at one unit during refueling between February 23 and August 23 annually.
- Entergy will continue to implement the Hudson River Biological Monitoring Program.

By letter dated March 2, 2017, the NYSDOS (2017) informed Entergy that it had completed its evaluation of the Federal Consistency Assessment Form, certification, project information, public comments, and publicly available information related to Entergy's license renewal application for IP2 and IP3. Based on its review of the project information submitted, the NYSDOS concurred with Entergy's consistency certification pursuant to 15 CFR 930.62.

7.3 Clean Water Act 401 Certification and State Pollutant Discharge Elimination System Permit

An applicant for a Federal license to conduct activities that may cause a discharge of regulated pollutants into navigable waters of the United States is required by Section 401 of the Clean Water Act of 1977, as amended (CWA) (33 U.S.C. 1251 et seq.), to provide the Federal licensing agency (in this case, the NRC) with a water quality certification from the State in which the discharge occurs or would occur. The certification confirms that discharges from the project or facility to be licensed will comply with CWA requirements and will not cause or contribute to a violation of State water quality standards.

On April 24, 2017, the New York State Department of Environmental Conservation (NYSDEC 2017e) issued a water quality certification to Entergy with an effective date of May 1, 2017, under the terms of the January 8, 2017, Closure Agreement (NYS et al. 2017). The NYSDEC also issued a final SPDES permit on April 24, 2017, with an effective date of May 1, 2017, in accordance with CWA Section 402 and its implementing regulations. In its 401 Water Quality Certification finding, the NYSDEC stated that continued operation of IP2 and IP3 under renewed operating licenses to be issued by the NRC will not contravene effluent limitations or water quality standards under the CWA. The NYSDEC conditioned this certification on Entergy's compliance with the requirements and limitations imposed in the final SPDES permit, as well as NRC requirements relating to radiological releases.

NRC licensees must comply with the CWA, including associated requirements imposed by the U.S. Environmental Protection Agency (EPA) or the State, as applicable, under CWA Section 401 as well as the National Pollutant Discharge Elimination System permitting program under CWA Section 402. NRC operating licenses are subject to conditions deemed imposed by the CWA as a matter of law. The NRC need not duplicate the EPA's or a delegated State agency's water quality reviews. In recognition that conditions are deemed imposed by the CWA, and to remove the need to undertake license amendments to incorporate conditions that

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could be subject to change by certifying States, the Commission added 10 CFR 50.54(aa)¹³ to specifically provide that each 10 CFR Part 50 “license shall be subject to all conditions deemed imposed as a matter of law by Sections 401(a)(2) and 401(d) of the Federal Water Pollution Control Act, as amended (33 U.S.C.A. 1341(a)(2) and (d).”

The NRC staff concludes that the NYSDEC’s issuance of a Section 401 Water Quality Certificate and a final SPDES permit provide the necessary certifications to support license renewal by the NRC.

¹³ 49 FR 9352, 9359–60. “Environmental protection regulations for domestic licensing and related regulatory functions and related conforming amendments.” March 12, 1984.

8.0 SUMMARY AND CONCLUSIONS

By letter dated April 23, 2007, Entergy Nuclear Operations, Inc. (Entergy), submitted an application to the U.S. Nuclear Regulatory Commission (NRC) to issue renewed operating licenses for Indian Point Nuclear Generating Unit Nos. 2 and 3 (IP2 and IP3) for additional 20-year periods. As required by Title 10 of the *Code of Federal Regulations* (10 CFR) 51.95(c), the NRC staff prepared a supplement to NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) (NRC 1996); the supplement to the 1996 GEIS was published on December 10, 2010 (NRC 2010). The 2010 final supplemental environmental impact statement (FSEIS) documents the NRC staff's analysis that considers and weighs the environmental effects of the proposed action (including cumulative impacts), the environmental impacts of alternatives to the proposed action, and mitigation measures available for reducing or avoiding adverse effects. The 2010 FSEIS also includes the NRC staff's recommendation regarding the proposed action—renewal of the IP2 and IP3 operating licenses for additional 20-year periods. As documented in the 2010 FSEIS, the NRC staff concluded that:

Based on (1) the analysis and findings in the [1996] GEIS, (2) the ER and other information submitted by Entergy, (3) consultation with Federal, State, Tribal, and local agencies, (4) the NRC staff's consideration of public scoping comments received, and comments on the draft SEIS, and (5) the NRC staff's independent review, the recommendation of the NRC staff is that the Commission determine 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.

In June 2013, the NRC staff issued a supplement to the 2010 FSEIS, updating its final analysis to include corrections to impingement and entrainment data presented in the FSEIS, revised conclusions regarding thermal impacts based on newly available thermal plume studies, and provided an update of the status of the NRC staff's consultation under Section 7 of the Endangered Species Act of 1973, as amended (ESA) (16 U.S.C. 1531 et seq.), with the National Marine Fisheries Service (NMFS) regarding the shortnose sturgeon and Atlantic sturgeon. As documented in the 2013 FSEIS supplement, the NRC staff revised its conclusion on the impacts of impingement and entrainment on the spottail shiner from LARGE to SMALL. However, the NRC staff's conclusion that the overall impacts due to impingement and entrainment resulting from the operation of the IP2 and IP3 cooling systems, as documented in the 2010 FSEIS, remained MODERATE. For the issue of thermal impacts, the NRC staff revised its conclusion to SMALL, from SMALL to LARGE, based on the availability of thermal plume studies that were not available at the time that the 2010 FSEIS was published. With respect to consultation under Section 7 of the ESA, the NRC staff examined the new information from consultations with the NMFS but did not revise its previous level of impact of SMALL for aquatic special status species.

The NRC staff prepared this supplement to address new information identified subsequent to publishing the 2013 FSEIS supplement. This new information was derived from (1) refined engineering project cost estimates for the 22 potentially cost-beneficial severe accident mitigation alternative (SAMAs) previously identified in the FSEIS; (2) newly available information relevant to the impacts from the operation of IP2 and IP3 on certain aquatic species in the Hudson River; (3) the NRC's amended regulations at Appendix B to Subpart A of 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory

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Functions”; and (4) the NRC’s amended regulations at 10 CFR 51.23. In addition, this supplement describes the reinitiation of consultation under Section 7 of the Endangered Species Act regarding the northern long-eared bat (*Myotis septentrionalis*), the initiation of a conference under Section 7 of the Endangered Species Act regarding proposed critical habitat of the New York Bight distinct population segment of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), and the status of IP2’s and IP3’s Coastal Zone Management Act consistency certification, water quality certification under Section 401 of the Clean Water Act, and renewed State Pollutant Discharge Elimination System Permit. This supplement also provides an update on the status of the operating licenses for IP2 and IP3; the January 8, 2017, Indian Point Closure Agreement; and Entergy’s associated license renewal application amendment to revise the license renewal term.

8.1 Environmental Impacts of License Renewal from Issues Considered in this Supplement

Based on its review of the engineering cost estimates and supplemental sensitivity analyses provided by Entergy Nuclear Operations, Inc. (Entergy), the NRC staff concludes that the approaches used, and costs and sensitivity results provided, are reasonable. For the six SAMAs that Entergy identified as no longer being potentially cost beneficial, the NRC staff concludes that, for two of the SAMAs that were identified as no longer being cost beneficial (IP2-021 and IP2-053), the incremental difference by which the SAMAs are not cost beneficial is too small to exclude them from further consideration. In addition, SAMA IP3-057 would be potentially cost beneficial for a 20-year license renewal period using the February 1 2017, MACCS2 sensitivity analysis results, but would not be potentially cost beneficial for the reduced license renewal period used in the March 31, 2017 results. However, these SAMAs do not relate to adequately managing the effects of aging during the period of extended operation. Therefore, they need not be implemented as part of license renewal pursuant to 10 CFR Part 54.

Based on its review of Entergy’s new information relating to the impacts to aquatic resources, the NRC staff concludes that the potential impacts to aquatic resources as a result of projected impingement and entrainment at IP2 and IP3 during the relicensing period would be no more than MODERATE. This conclusion is similar to that found in Entergy’s February 19, 2014, letter transmitting the new information and is not greatly different than the NRC staff’s conclusion of MODERATE found in the 2010 FSEIS, as supplemented by the 2013 FSEIS supplement.

The NRC’s 2013 amendment to its regulations at Table B–1 of Appendix B to Subpart A of 10 CFR Part 51 redefined the number and scope of the generic and site-specific environmental impact issues that must be addressed during license renewal environmental reviews. The NRC staff identified 10 Category 1 issues that either had been added to Table B–1 of Appendix B to Subpart A of 10 CFR Part 51 or had changed in scope as part of the 2013 rulemaking. Additionally, the amended regulations revised how the NRC would report its findings for species and habitats listed under the Endangered Species Act and the Magnuson–Stevens Fishery Conservation and Management Reauthorization Act (16 U.S.C. § 1801–1884) evaluated under the Category 2 issue, “Threatened, endangered, and protected species and essential fish habitat.” As part of its review of these issues, the NRC staff did not identify any new and significant information related to these Category 1 issues that would call into question the conclusions in the 2013 GEIS. Therefore, the NRC staff relied on the conclusions of the 2013 GEIS for these Category 1 issues.

For the new Category 2 issue “Effects on terrestrial resources (non-cooling system impacts),” the NRC staff concludes that issuing renewed licenses for IP2 and IP3 would have SMALL impacts. For the Category 2 issue “Radionuclides Released to Groundwater,” the NRC staff concludes that the impacts to groundwater quality due to the continued operation of IP2 and IP3 would be SMALL to MODERATE. Specifically, the NRC finds that MODERATE impacts to groundwater quality, which are a result of radiological contamination from inadvertent releases of radionuclides to groundwater, could be mitigated to SMALL during the license renewal term through the elimination of radionuclide leaks to the groundwater and the use of monitored natural attenuation.

For the two new Category 2 issues added to Table B–1 of Appendix B to Subpart A of 10 CFR Part 51 for which an analysis had been performed in the 2010 FSEIS—“Minority and low-income populations” and “Cumulative impacts”—the NRC staff concludes that the environmental impacts of issuing renewed licenses for IP2 and IP3 are bounded by the conclusions in the 2010 FSEIS.

For species and habitats evaluated under the Category 2 issue, “Threatened, endangered, and protected species and essential fish habitat,” the NRC staff revised its findings for the five Federally listed species potentially affected by the IP2 and IP3 license renewal from SMALL to either “no effect,” “not likely to adversely affect,” or “may affect, but not likely to jeopardize the continued existence of,” as discussed in Section 7.1.4 of this supplement. The NRC staff also made a finding of “not likely to destroy or adversely modify” critical habitat of the New York Bight distinct population segment of Atlantic sturgeon, which the staff had not previously evaluated.

Additionally, as discussed in Chapter 6 of this supplement, the impacts of continued storage of spent nuclear fuel are those presented in NUREG–2157 and are deemed incorporated into this FSEIS supplement pursuant to 10 CFR 51.23.

8.2 Recommendation

Based on its evaluation of information available since publication of the FSEIS in December 2010, as documented in the first FSEIS supplement published in June 2013, as well as this FSEIS supplement, the NRC staff reaffirms its recommendation in the 2010 FSEIS. Specifically, the NRC staff recommends that “the Commission determine 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.”

8.3 Revisions to Chapter 9 of the 2010 FSEIS

Lines 14-17 of page 9-1 in Section 9.0 of the FSEIS are revised as follows:

If the license renewal review is ongoing at the time of license expiration, the units will be allowed to continue operating until the NRC makes a determination. The IP2 operating license ~~will was set to~~ expire on September 28, 2013; the IP3 operating license ~~will was set to~~ expire on December 12, 2015.

Lines 28-38 on page 9-2 of Section 9.0 of the FSEIS are revised as follows:

The supplemental environmental impact statement for license renewal is not required to include discussion of need for power or the economic costs and economic benefits of the proposed action or of alternatives to the proposed action except insofar as such benefits and costs are either essential for a determination regarding the inclusion of an alternative in

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the range of alternatives considered or relevant to mitigation. In addition, the supplemental environmental impact statement prepared at the license renewal stage need not discuss other issues not related to the environmental effects of the proposed action and the alternatives. ~~or any aspect of the storage of spent fuel for the facility within the scope of the generic determination in 10 CFR 51.23(a) and in accordance with 10 CFR 51.23(b).~~⁽²⁾ **The analysis of alternatives in the supplemental environmental impact statement should be limited to the environmental impacts of such alternatives and should otherwise be prepared in accordance with § 51.71 and Appendix A to Subpart A of this part. As stated in § 51.23, the generic impact determinations regarding the continued storage of spent fuel in NUREG-2157 shall be deemed incorporated into the supplemental environmental impact statement.**

Footnote 2 on page 9-2 of Section 9.0 of the FSEIS is deleted.

Lines 7-21 on page 9-5 of Section 9.1 of the FSEIS, as modified in the 2013 FSEIS supplement, are revised as follows:

For all issues of SMALL significance, current measures to mitigate the environmental impacts of plant operation were found to be adequate. For **the** issues of MODERATE significance (~~i.e., issues~~ related to aquatic ecology), mitigation measures are addressed both in Chapter 4 and in Chapter 8 as alternatives based on determinations in the draft New York State Department of Environmental Conservation (NYSDEC) State Pollutant Discharge Elimination System (SPDES) permit proceeding, Clean Water Act Section 401 proceeding, and in draft policy statements published by the State. In Chapter 8, the NRC staff considers the impacts that may result if the plant converts from once-through cooling to a closed-cycle cooling system (Section 8.1.1).

Cumulative impacts of past, present, and reasonably foreseeable future actions were considered, regardless of what agency (Federal or non-Federal) or person undertakes such other actions. The NRC staff concludes that the cumulative impacts to the environment around IP2 and IP3 license renewal would be LARGE for some affected resources, given historical environmental impacts, current actions, and likely future actions. With the exception of aquatic resources **and radionuclides released to groundwater**, the contribution of IP2 and IP3 to cumulative impacts is SMALL.

Lines 9-12 on page 9-6 of Section 9.1.1 of the FSEIS are revised as follows:

Adverse impacts of continued operation from ~~(a) heat shock and (b)~~ the combined effects of impingement and entrainment of fish and shellfish are considered to be potentially SMALL to LARGE, ~~and MODERATE,~~ **respectively**. Other adverse impacts are considered to be of SMALL significance.

Lines 24-34 on page 9-7 of Section 9.2 of the FSEIS are revised as follows:

Table 9-1 shows the significance of the plant-specific environmental effects of the proposed action (renewal of IP2 and IP3 operating licenses) as well as the environmental effects of alternatives to the proposed

action. Impacts from license renewal would be SMALL for all impact categories except aquatic ecology, which includes the impacts of **heat shock**, impingement and entrainment, **and water use and quality, which includes the issue of radionuclides released to groundwater**. ~~Chapter 4 of this SEIS describes the MODERATE impacts~~ Impacts of plant operation on aquatic ecology through impingement and entrainment are **MODERATE to LARGE in Hudson River Segment 4 and SMALL to MODERATE riverwide** (impact levels vary by species), ~~and the potentially SMALL to LARGE impacts from thermal shock~~. Overall, impacts to aquatic ecology from continued operation of IP2 and IP3 without cooling system modifications or restoration actions are SMALL to LARGE. **License renewal will result in SMALL to MODERATE impacts to water use and quality as a result of inadvertent releases of radionuclides to groundwater.** A single significance level was not assigned for the collective offsite radiological impacts from the fuel cycle and from high-level radioactive waste spent fuel disposal (~~see Chapter 6~~) or for the impacts of greenhouse gases (GHG).

Table 9–1 on page 9-9 of Section 9.2 of the FSEIS is revised as follows:

Table 9–1. Summary of Environmental Significance of License Renewal and Alternatives

Impact Category	Proposed Action	No-Action Alternative ^(b)	License Renewal with	NGCC ^(d)	
	License Renewal	Plant Shut Down	New Closed-Cycle Cooling	At the IP Site or a Repowered Site	At a New Site
Land Use	SMALL	SMALL	SMALL to LARGE	SMALL to MODERATE	MODERATE to LARGE
Ecology—Aquatic	MODERATE and SMALL to LARGE^(a)	SMALL	SMALL	SMALL	SMALL
Ecology—Terrestrial	SMALL	SMALL	SMALL to MODERATE	SMALL	SMALL to MODERATE
Water Use and Quality	SMALL to MODERATE	SMALL	SMALL to MODERATE	SMALL	SMALL to MODERATE
Air Quality	SMALL	SMALL	SMALL to LARGE	SMALL to MODERATE	SMALL to MODERATE
Waste	SMALL	SMALL	SMALL to LARGE	SMALL	SMALL
Human Health	SMALL ^(c)	SMALL	SMALL	SMALL	SMALL
Socioeconomics	SMALL	SMALL to MODERATE	SMALL	SMALL to MODERATE	SMALL to MODERATE
Transportation	SMALL	SMALL	SMALL to LARGE	SMALL to MODERATE	SMALL to MODERATE
Aesthetics	SMALL	SMALL	MODERATE to LARGE	SMALL	SMALL to LARGE

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Historical and Archeological Resources	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE
Environmental Justice	SMALL	SMALL	SMALL	SMALL to LARGE	SMALL to LARGE

Table 9–1 on page 9-10 of Section 9.2 of the FSEIS is revised as follows:

Table 9–1 (continued)	Conservation/Energy Efficiency	Combination of Alternatives	
		Option 1: One IP Unit, Onsite Gas, Offsite Renewables, and Conservation	Option 2: Gas, Offsite Renewables, Additional Imported Power, and Conservation
Impact Category			
Land Use	SMALL	SMALL to MODERATE	SMALL to MODERATE
Ecology – Aquatic	SMALL	SMALL to LARGE	SMALL to LARGE
Ecology – Terrestrial	SMALL	SMALL to LARGE	SMALL to LARGE
Water Use and Quality	SMALL	SMALL to LARGE	SMALL to LARGE
Air Quality	SMALL	SMALL to MODERATE	SMALL to MODERATE
Waste	SMALL	SMALL to LARGE	SMALL to LARGE
Human Health	SMALL	SMALL	SMALL
Socioeconomics	SMALL to MODERATE	SMALL	SMALL to MODERATE
Transportation	SMALL	MODERATE	MODERATE
Aesthetics	SMALL	SMALL to LARGE	SMALL to LARGE
Historical and Archeological Resources	SMALL	SMALL to MODERATE	SMALL to MODERATE
Environmental Justice	SMALL	SMALL to LARGE	SMALL to LARGE

^(a) NRC staff analysis indicates that impingement and entrainment impacts are MODERATE, but that thermal shock effects could potentially range from are likely to be SMALL to LARGE MODERATE to LARGE in Hudson River Segment 4 and SMALL to MODERATE riverwide.

^(b) The No-Action Alternative does not, on its own, meet the purpose and need of the GEIS. No action would necessitate other generation or conservation actions which may include—but are not limited to—the alternatives addressed in this table.

^(c) For the collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal, a specific significance level was not assigned. **See Chapter 6 for details.**

^(d) Analysis was based on use of a closed-cycle cooling system.

9.0 REFERENCES

References with Agencywide Documents Access and Management System (ADAMS) Accession numbers can be read or downloaded using the NRC's Web-based ADAMS search engine at <http://adams.nrc.gov/wba/>. Click on the "Advanced Search" tab and choose the following entries under "Document Properties": "Accession Number" in the Property box, "is equal to" in the Operator box, and the ADAMS Accession Number of the document in the "Value" box.

10 CFR Part 2. *Code of Federal Regulations*, Title 10, *Energy*, Part 2, "Agency rules of practice and procedure."

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for protection against radiation."

10 CFR Part 50. *Code of Federal Regulations*, Title 10, *Energy*, Part 50, "Domestic licensing of production and utilization facilities."

10 CFR Part 51. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, "Environmental protection regulations for domestic licensing and related regulatory functions."

10 CFR Part 54. *Code of Federal Regulations*, Title 10, *Energy*, Part 54, "Requirements for renewal of operating licenses for nuclear power plants."

10 CFR Part 72. *Code of Federal Regulations*, Title 10, *Energy*, Part 72, "Licensing requirements for the independent storage of spent nuclear fuel, high-level radioactive waste, and reactor-related greater than Class C waste."

40 CFR Part 81. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 81, "Designation of areas for air quality planning purposes."

40 CFR Part 93. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 93, "Determining conformity of Federal actions to State or Federal implementation plans."

40 CFR Part 98. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 98, "Mandatory greenhouse gas reporting."

40 CFR Part 112. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 112, "Oil pollution prevention."

40 CFR Part 190. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 190, "Environmental radiation protection standards for nuclear power operations."

49 FR 34658. U.S. Nuclear Regulatory Commission. "Waste confidence decision and requirements for licensee actions regarding the disposition of spent fuel upon expiration of reactor operating licenses; final rules." *Federal Register* 49(171):34658–34696. August 31, 1984.

55 FR 38472. U.S. Nuclear Regulatory Commission. "Consideration of environmental impacts of temporary storage of spent fuel after cessation of reactor operation; and waste confidence decision review; final rules." *Federal Register* 55(181):38472–38514. September 18, 1990.

59 FR 7629. Executive Order 12898. "Federal actions to address environmental justice in minority populations and low-income populations." *Federal Register* 59(32):7629–7634. February 16, 1994.

References

- 61 FR 28467. U.S. Nuclear Regulatory Commission. "Environmental review for renewal of nuclear power plant operating licenses; final rule." *Federal Register* 61(109):28467–28497. June 5, 1996.
- 61 FR 66537. U.S. Nuclear Regulatory Commission. "Environmental review for renewal of nuclear power plant operating licenses." *Federal Register* 61(244):66537–66544. December 18, 1996.
- 64 FR 68005. U.S. Nuclear Regulatory Commission. "Waste confidence decision review: status." *Federal Register* 64(233):68005–68007. December 6, 1999.
- 69 FR 52040. U.S. Nuclear Regulatory Commission. "Policy statement on the treatment of environmental justice matters in NRC regulatory and licensing actions." *Federal Register* 69(163):52040–52048. August 24, 2004.
- 74 FR 38117. U.S. Nuclear Regulatory Commission. "Revisions to environmental review for renewal of nuclear power plant operating licenses; proposed rule." *Federal Register* 74(146):38117–38140. July 31, 2009.
- 74 FR 66496. U.S. Environmental Protection Agency. 2009. "Endangerment and cause or contribute findings for greenhouse gases under Section 202(a) of the Clean Air Act." *Federal Register* 74(239):66496–66546. December 15, 2009.
- 75 FR 31514. U.S. Environmental Protection Agency. Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule. *Federal Register* 75(106):31514–31608. June 3, 2010.
- 75 FR 81032. U.S. Nuclear Regulatory Commission. "Consideration of environmental impacts of temporary storage of spent fuel after cessation of reactor operation." *Federal Register* 75(246):81032–81037. December 23, 2010.
- 75 FR 81037. U.S. Nuclear Regulatory Commission. "Waste confidence decision update." *Federal Register* 75(246):81037–81076. December 23, 2010.
- 78 FR 37282. U.S. Nuclear Regulatory Commission. "Revisions to environmental review for renewal of nuclear power plant operating licenses." *Federal Register* 78(119):37282–37324. June 20, 2013.
- 78 FR 48944. National Marine Fisheries Service. "Endangered and threatened wildlife and plants; Endangered Species Act listing determination for alewife and blueback herring." *Federal Register* 78(155):48944–48994. August 12, 2013.
- 79 FR 48300. U.S. Environmental Protection Agency. "National Pollutant Discharge Elimination System—Final regulations to establish requirements for cooling water intake structures at existing facilities and amend requirements at Phase I facilities." *Federal Register* 79(158):48300–48439. August 15, 2014.
- 79 FR 56238. U.S. Nuclear Regulatory Commission. "Continued storage of spent nuclear fuel." *Federal Register* 79(182):56238–56263. September 19, 2014.
- 79 FR 56263. U.S. Nuclear Regulatory Commission. "Generic environmental impact statement for continued storage of spent nuclear fuel." *Federal Register* 79(182):56263–56264. September 19, 2014.
- 79 FR 73706. U.S. Fish and Wildlife Service. "Endangered and threatened wildlife and plants; threatened species status for the rufa red knot." *Federal Register* 79(238):73706–73748. December 11, 2014.

80 FR 17974. U.S. Fish and Wildlife Service. “Endangered and threatened wildlife and plants; threatened species status for the northern long-eared bat with 4(d) rule.” *Federal Register* 80(63):17973–18033. April 2, 2015.

80 FR 55286. U.S. Fish and Wildlife Service. “Endangered and threatened wildlife and plants; 12-month finding on a petition to list the New England cottontail as an endangered or threatened species.” *Federal Register* 80(178):55286–55304. September 15, 2015.

80 FR 64662. U.S. Environmental Protection Agency. “Carbon pollution emission guidelines for existing stationary sources: electric utility generating units.” *Federal Register* 80(205):64662–64964. October 23, 2015.

81 FR 35701. National Marine Fisheries Service. “Endangered and threatened wildlife and plants; designation of critical habitat for the Gulf of Maine, New York Bight, and Chesapeake Bay Distinct Population Segments of Atlantic sturgeon; proposed rule; request for comments.” *Federal Register* 81(107):35701–35732. June 3, 2016.

81 FR 36077. National Marine Fisheries Service. “Endangered and threatened wildlife and plants; designation of critical habitat for the Carolina and South Atlantic Distinct Population Segments of Atlantic sturgeon; proposed rule; request for comments.” *Federal Register* 81(107):36077–36123. June 3, 2016.

81 FR 68110. U.S. Environmental Protection Agency. “Revisions to the Prevention of Significant (PSD) and Title V Greenhouse Gas (GHG) permitting regulations and establishment of Significant Emissions Rate (SER) for GHG emissions under the PSD Program.” *Federal Register* 81(191):68110–68147. October 3, 2016.

82 FR 16093. Executive Order No. 13783. “Promoting energy independence and economic growth.” *Federal Register* 82(61):16093–16097. March 31, 2017.

82 FR 39160. National Marine Fisheries Service. “Endangered and threatened species; designation of critical habitat for the endangered New York bight, Chesapeake Bay, Carolina and South Atlantic distinct population segments of Atlantic sturgeon and the threatened Gulf of Maine distinct population segment of Atlantic sturgeon.” *Federal Register* 82(158):39160-39274. August 17, 2017.

6 NYCRR 201. *New York Codes, Rules, and Regulations*, Title 6, *Department of Environmental Conservation*, Chapter III, Air Resources, Part 201, “Permits and Registrations.” Available at <<http://www.dec.ny.gov/regulations/regulations.html>> (accessed 14 June 2016).

6 NYCRR 701. *New York Codes, Rules, and Regulations*, Title 6, *Department of Environmental Conservation*, Chapter X, Division of Water, Part 701, “Classifications—Surface waters and groundwaters.” Available at <<http://www.dec.ny.gov/regulations/regulations.html>> (accessed 4 April 2015).

6 NYCRR 601. *New York Codes, Rules, and Regulations*, Title 6, *Department of Environmental Conservation*, Chapter X, Division of Water, Part 601, “Water withdrawal permitting, reporting and registration (Exclusive of Long Island Wells regulated under Part 602).” Available at <<http://www.dec.ny.gov/regulations/regulations.html>> (accessed 4 April 2015).

[AACE] AACE International. 2005. AACE International Recommended Practice No. 18R-97, “Cost Estimate Classification System—As Applied in Engineering, Procurement, and Construction for the Process Industries.” February 2, 2005.

References

[AEC] United States Atomic Energy Commission. 1972. Final Environmental Statement Related to Operation of Indian Point Nuclear Generating Plant Unit No. 2. Consolidated Edison Company of New York, Inc. Docket No. 50-247. September 1972. Directorate of Licensing. ADAMS Accession Nos. ML072390276 and ML072390278.

[AKRF] AKRF, Inc. 2011a. Review of Estimates of Numbers Entrained Presented in NRC 2009 EFH Assessment and 2010 FSEIS. ADAMS Accession No. ML11286A140.

[AKRF] AKRF, Inc. 2011b. Technical Review of FSEIS for Indian Point Nuclear Generating Unit Nos. 2 and 3; Sections 4.1.1–4.1.3 and Appendices H and I. Prepared for Entergy Nuclear Operations, Inc. Hanover, MD: AKRF, Inc. March 28, 2011. ADAMS Accession No. ML110980163.

[AKRF] AKRF, Inc. 2014. Update of Aquatic Impact Analyses Presented in NRC's FSEIS (December 2010) Regarding Potential Impacts of Operation of Indian Point Units 2 and 3. Attachment 1 To NL-14-030, Entergy Nuclear Operations, Inc., Indian Point Nuclear Generating Unit Nos. 2 and 3, Docket Nos. 50-247 and 50-286. February 19, 2014. Prepared for Indian Point Energy Center, Buchanan, NY. Prepared by AKRF, Inc., Hanover, MD. ADAMS Accession No. ML14063A529.

[AKRF] AKRF, Inc. 2015. Summary of Analysis Results Based on Corrected Format 2 Data Files Dated March 2015: Update of Aquatic Impact Analyses Presented in NRC's FSEIS (December 2010) Regarding Potential Impacts of Operation of Indian Point Units 2 and 3. Prepared for Indian Point Energy Center, Buchanan, New York. ADAMS Accession No. ML15252A244.

Albani M, Moorcroft PR, Ellison AM, Orwig DA, Foster DR. 2010. Predicting the impact of hemlock woolly adelgid on carbon dynamics of eastern United States forests. *Canadian Journal of Forest Research* 40:119–133.

Applebome P. 2009. "Cool Waters, and the Lure of Danger." *The New York Times*. July 1, 2009. Available at <http://www.nytimes.com/2009/07/02/nyregion/02towns.html?_r=1> (accessed 2 March 2015).

Administrative Procedures Act, as amended. 5 U.S.C. § 500 et seq.

[ASA and AKRF] ASA Analysis & Communication, Inc. and AKRF, Inc. 2014. Data Documentation for Information Provided to U.S. Nuclear Regulatory Commission in Response to 9/26/14 Request for Additional Information. Prepared for Entergy Nuclear Operations, Inc. October 2014. ADAMS Accession No. ML14311A809.

[ASLB] Atomic Safety and Licensing Board. 2010. Memorandum and Order Ruling on the Admissibility of New York's New and Amended Contentions 12B, 16B, 35, and 36. LBP-10-13, 71 NRC 673. June 30, 2010. ADAMS Accession No. ML101810344.

[ASLB] Atomic Safety and Licensing Board. 2011. Memorandum and Order Ruling on Motion and Cross-Motions for Summary Disposition of NYS-35/36. LBP-11-17, 74 NRC 11. July 14, 2011. ADAMS Accession No. ML111950712.

[ASLB] Atomic Safety and Licensing Board. 2017. Order Granting Motion to Dismiss Contentions and to Terminate this Proceeding. March 13, 2017. ADAMS Accession No. ML17072A392.

- [ASMFC] Atlantic States Marine Fisheries Commission. 2012a. Stock Assessment Report No. 12-02 of the Atlantic States Marine Fisheries Commission. River Herring Benchmark Stock Assessment. Volume I. May 2012. Available at http://www.asmfc.org/uploads/file/riverHerringBenchmarkStockAssessmentVolumeIR_May2012.pdf (accessed 13 February 2015).
- [ASMFC] Atlantic States Marine Fisheries Commission. 2012b. Stock Assessment Report No. 12-02 of the Atlantic States Marine Fisheries Commission. River Herring Benchmark Stock Assessment. Volume II. May 2012. Available at http://www.asmfc.org/uploads/file/riverHerringBenchmarkStockAssessmentVolumeIIR_May2012.pdf (accessed 13 February 2015).
- [ASMFC] Atlantic States Marine Fisheries Commission. 2015. "Blueback herring, *Alosa aestivalis*." December 2015. Available at <http://www.asmfc.org/uploads/file//568edf19BluebackHerring.pdf> (accessed 29 March 2017).
- Bekins BA, Rittmann BE, MacDonald JA. 2001. Natural Attenuation Strategy for Groundwater Cleanup Focuses on Demonstrating Cause and Effect, *Eos*, Transactions, AGU 82, 5, p 53, 57–58. January 30, 2001. Available at <http://toxics.usgs.gov/pubs/eos-v82-n5-2001-natural/e0s-v82-n5-2001-natural.pdf> (accessed 10 November 2016).
- Ben-Horin T, Lenihan HS, Lafferty KD. 2013. Variable intertidal temperature explains why disease endangers black abalone. *Ecology*. 94(1):161–168.
- [BLS] Bureau of Labor and Statistics. 2014. "Employment Cost Index—September 2014." Available at <http://www.bls.gov/news.release/eci.nr0.htm> (accessed 21 November 2014).
- Byrne M. 2011. Impact of ocean warming and ocean acidification on marine invertebrate life history stages: Vulnerabilities and potential for persistence in a changing ocean. *Oceanography and Marine Biology: An Annual Review* 49:1–42.
- Cai H, Burnham A, Wang M. 2013. "Updated Emission Factors of Air Pollutants from Vehicle Operations in GREET Using MOVES." Available at <https://greet.es.anl.gov/publication-vehicles-13> (accessed 1 April 2015).
- [CAPS] Missouri Census Data Center Circular Area Profiling System. 2012. "Missouri Census Data Center Circular Area Profiles (CAPS)." ACS Version, Data from 5-year Period Estimates Vintage 2012, Summary of Census in a 50-mile Radius around Indian Point (Lat. 41.269724443075496, Long. -73.95263195037844). Available at <http://mcdc.missouri.edu/websas/caps10c.html> (accessed 20 May 2015).
- Carpenter SR, Brock WA. 2006. Rising variance: a leading indicator of ecological transition. *Ecology Letters* 9(3):311–318.
- [CEQ] Council on Environmental Quality. 1997. Considering Cumulative Effects under the National Environmental Policy Act. Executive Office of the President, Washington, D.C. Available at http://energy.gov/sites/prod/files/nepapub/nepa_documents/RedDont/G-CEQ-ConsidCumulEffects.pdf (accessed 15 September 2015).
- Cerrato RM. 2006. Chapter 18. "Long-Term and Large-Scale Patterns in the Benthic Communities of New York Harbor." In: Levinton JS and Waldman JR, editors. *The Hudson River Estuary*. Cambridge University Press, New York. p 242–265.

References

- [CHGE et al.] Central Hudson Gas & Electric Corp.; Consolidated Edison Company of New York, Inc.; New York Power Authority; and Southern Energy New York. 1999. Draft Environmental Impact Statement for State Pollutant Discharge Elimination System Permits for Bowline Point, Indian Point 2 & 3, and Roseton Steam Electric Generating Stations. December 1999. ADAMS Accession No. ML083400128.
- Chen IC, Hill JK, Ohlemuller R, Roy DB, Thomas CD. 2011. Rapid range shifts of species associated with high levels of climate warming. *Science* 333(6045):1024–1026.
- Clean Air Act of 1970, as amended. 42 U.S.C. § 7651 et seq.
- Clean Water Act of 1977, as amended. 33 U.S.C. § 1251 et seq.
- Code of the Village of Buchanan, New York. Chapter 211, *Zoning*.
- [Con Edison] Consolidated Edison of New York, Inc. 1971a. Environmental Report, Indian Point No. 2. Supplement No. 1. Appendices—Volume No. 2. June 1971. ADAMS Accession No. ML110310510.
- [Con Edison] Consolidated Edison of New York, Inc. 1971b. Environmental Report, Indian Point No. 3. Appendices—Volume No. 2. September 1971. ADAMS Accession No. ML100290717.51A043, ML16251A043.
- Consolidated Appropriations Act of 2012. Public Law No. 112-74, 402, 125 Stat. 786, 883 (2011), Section 402.
- [D.C. Circuit 2012] *New York v. NRC* (State of New York et al. v. U.S. Nuclear Regulatory Commission). 681 F.3d 471 (D.C. Cir. 2012). ADAMS Accession No. ML12191A407.
- Dale VH. 1997. The relationship between land use change climate change. *Ecological Applications* 7(3):753–769.
- Daniels RA, Limburg KE, Schmidt RE, Strayer DL, Chambers RC. 2005. Changes in Fish Assemblages in the Tidal Hudson River, New York. American Fisheries Society Symposium 45:471–503.
- Delisle C. 1969. Biomonthly progress of a non-lethal infection by *Glugea hertwigi* in young-of-the-year smelt *Osmerus eperlanus mordax*. *Canadian Journal of Zoology* 47(5):871–876.
- [DOE] U.S. Department of Energy. 2002. *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*. DOE-STD-1153-2002. Washington, DC: DOE. July 2002. 234 p. Available at <http://nnsa.energy.gov/sites/default/files/nnsa/inlinefiles/doe%202002a.pdf> (accessed 12 March 2015).
- [DOE] U.S. Department of Energy. 2004. RESRAD-BIOTA: A Tool for Implementing Graded Approach to Biota Dose Evaluation. User's Guide, Version 1. DOE/EH-0676. Washington, DC: DOE. January 2004. 50 p. Available at http://web.ead.anl.gov/resrad/documents/RESRAD-BIOTA_Manual_Version_1.pdf (accessed 12 Mar 2015).
- [DOT/FAA] U.S. Department of Transportation/Federal Aviation Administration. 2007a. *Final Environmental Impact Statement, New York/New Jersey/Philadelphia Metropolitan Area Airspace Redesign*. Available at https://www.faa.gov/air_traffic/nas_redesign/regional_guidance/eastern_req/nynjphl_redesign/documentation/feis/ (accessed 3 April 2015).

- [DOT/FAA] United States Department of Transportation/Federal Aviation Administration. 2007b. *Noise Mitigation Report*. Available at https://www.faa.gov/air_traffic/nas_redesign/regional_guidance/eastern_req/nynjphl_redesign/documentation/media/Noise_Mitigation_Report.pdf (accessed 16 April 2015).
- [EA] EA Engineering Science, and Technology, Inc. 1984. Indian Point Generating Station Entrainment Abundance and Outage Evaluation, 1983 Annual Report. Prepared for Consolidated Edison Company of New York, Inc., and Power Authority of the State of New York. September 1984. ADAMS Accession No. ML083101084.
- [EA] EA Engineering Science, and Technology, Inc. 1985. Indian Point Generating Station Entrainment Abundance and Outage Evaluation, 1983 Annual Report. Prepared for Consolidated Edison Company of New York, Inc., and Power Authority of the State of New York. July 1985. ADAMS Accession No. ML083101091.
- [EIA] Energy Information Administration. 2015. *U.S. Electric Power Industry Estimated Emissions by State (EIA-767, EIA-906, and EIA-923)*. Available at <http://www.eia.gov/electricity/data/state/> (accessed 30 March 2015).
- Endangered Species Act of 1973, as amended. 16 U.S.C. § 1531 et seq.
- [Enercon] Enercon Services, Inc. 2003. "Economic and Environmental Impacts Associated with Conversion of Indian Point Units 2 and 3 to a Closed-Loop Condenser Cooling Water Configuration." June 2003. ADAMS Accession No. ML14307A050.
- [Entergy] Entergy Nuclear Operations, Inc. 2006. "Indian Point Nuclear Power Plants Units 1, 2 and 3, Annual Radiological Environmental Operating Report for 2005." April 30, 2006. ADAMS Accession No. ML061290085.
- [Entergy] Entergy Nuclear Operations, Inc. 2007a. "Applicant's Environment Report, Operating License Renewal Stage." (Appendix E to Indian Point, Units 2 and 3, License Renewal Application). April 23, 2007. ADAMS Accession No. ML071210530.
- [Entergy] Entergy Nuclear Operations, Inc. 2007b. "2006 Annual Radioactive Effluent Release Report." April 25, 2007. ADAMS Accession No. ML071230305.
- [Entergy] Entergy Nuclear Operations, Inc. 2007c. Letter from F. Dacimo, Vice President of Operations License Renewal, Entergy, to NRC Document Control Desk. Subject: Supplement to License Renewal Application—Environmental Report References. December 20, 2007. ADAMS Accession Nos. ML080080199; Long River Survey: ML11279A044; and Fall Shoals Survey: ML080080291, ML080080298, ML080080306.
- [Entergy] Entergy Nuclear Operations, Inc. 2008a. Indian Point Units 2 and 3, Reply to Request for Additional Information Regarding License Renewal Application—Severe Accident Mitigation Alternatives Analysis. February 5, 2008. ADAMS Accession No. ML080420264.
- [Entergy] Entergy Nuclear Operations, Inc. 2008b. Letter from R. Walpole, Indian Point Energy Center, to NRC Document Control Desk. Subject: Document request for additional information regarding environmental review of license renewal application—Hudson River Fisheries Program data (Year Class Report). March 7, 2008. ADAMS Accession No. ML080770457.
- [Entergy] Entergy Nuclear Operations, Inc. 2008c. *2007 Annual Radioactive Effluent Release Report*. April 23, 2008. ADAMS Accession No. ML081280744.
- [Entergy] Entergy Nuclear Operations, Inc. 2008d. *Final Quarterly Long-Term Groundwater Monitoring Report No. 1*. May 1, 2008. Available at <http://www.riverkeeper.org/wp-content/uploads/2013/04/GZA-Quarterly-GW-Monitoring-Report-2007-Q1-4-IPEC00108485-optimized.pdf> (accessed 14 April 2015).

References

[Entergy] Entergy Nuclear Operations, Inc. 2008e. Indian Point Units 2 and 3, Reply to Request for Additional Information Regarding License Renewal Application—Refurbishment. May 14, 2008. ADAMS Accession No. ML081440052.

[Entergy] Entergy Nuclear Operations, Inc. 2008f. *Remediation and Long-Term Monitoring of Site Groundwater*. May 15, 2008. ADAMS Accession No. ML12339A651 and ML080350544.

[Entergy] Entergy Nuclear Operations, Inc. 2009a. *2008 Annual Radioactive Effluent Release Report*. April 17, 2009. ADAMS Accession No. ML091260208.

[Entergy] Entergy Nuclear Operations, Inc. 2009b. Letter from F. Dacimo, Indian Point Energy Center, Vice President, Operations License Renewal, to the NRC Document Control Desk. Subject: License renewal application—SAMA re-analysis using alternate meteorological tower data, Docket Nos. 50-247 and 50-286, License Nos. DPR-26 and DPR-64, NL-09-165. December 11, 2009. ADAMS Accession No. ML093580089.

[Entergy] Entergy Nuclear Operations, Inc. 2010a. *2009 Annual Radioactive Effluent Release Report, Indian Point Unit Nos. 1, 2, and 3*. April 29, 2010. ADAMS Accession No. ML101240987.

[Entergy] Entergy Nuclear Operations, Inc. 2010b. Indian Point Power Plants Units 1, 2, and 3 Annual Radiological Environmental Operating Report for 2009. ADAMS Accession No. ML101390564.

[Entergy] Entergy Nuclear Operations, Inc. 2011a. 2010 Annual Radioactive Effluent Release Report, Revision 1, Indian Point Unit Nos. 1, 2, and 3. June 10, 2011. ADAMS Accession No. ML11172A042.

[Entergy] Entergy Nuclear Operations, Inc. 2011b. Indian Point Power Plants Units 1, 2, and 3 Annual Radiological Environmental Operating Report for 2010. May 16, 2011. ADAMS Accession No. ML11143A052.

[Entergy] Entergy Nuclear Operations, Inc. 2011c. Letter from F. Dacimo, Vice President of Operations License Renewal, to B. Holian, Division Director, NRC. Subject: Comments on final supplemental environmental impact statement for Indian Point Nuclear Generating. March 29, 2011. ADAMS Accession No. ML110980073.

[Entergy] Entergy Nuclear Operations, Inc. 2012a. Testimony of Entergy Witnesses DM Mayer, AB Cox, TC Esselman, MJ Barvenik, CJ Paperiello, and FO Hoffman Regarding Consolidated Contention RK-EC-3/CWEC-I (Spent Fuel Pool Leaks), Entergy Nuclear Operations, Inc. (Indian Point Units 2 and 3), Docket Nos. 50-247-LR and 50-286-LR, ASLBP No. 07-858-03-LR-BDO1 Evidentiary Hearing, Exhibit ENT000301-00-BDO. March 29, 2012. ADAMS Accession No. ML12338A621.

[Entergy] Entergy Nuclear Operations, Inc. 2012b. 2011 Annual Radioactive Effluent Release Report, Indian Point Unit Nos. 1, 2, and 3. April 30, 2012. ADAMS Accession No. ML12132A122.

[Entergy] Entergy Nuclear Operations, Inc. 2012c. Indian Point Power Plants Units 1, 2, and 3 Annual Radiological Environmental Operating Report for 2011. May 15, 2012. ADAMS Accession No. ML12144A412.

[Entergy] Entergy Nuclear Operations, Inc. 2012d. Transmittal of Consistency Certification Pursuant to the Coastal Zone Management Act. December 17, 2012. ADAMS Accession No. ML12352A343.

[Entergy] Entergy Nuclear Operations, Inc. 2013a. 2012 Annual Radioactive Effluent Release Report, Indian Point Unit Nos. 1, 2, and 3. May 1, 2013. ADAMS Accession No. ML131570158.

[Entergy] Entergy Nuclear Operations, Inc. 2013b. Letter from F. Dacimo, Vice President of License Renewal, Entergy, to the NRC Document Control Desk. Subject: License renewal application—completed engineering cost estimates for SAMAs previously identified as potentially cost-beneficial, Indian Point Unit Nos. 2 and 3, Docket Nos. 50-247 and 50-286, License Nos. DPR-26 and DPR-64, NL-13-075. May 6, 2013. ADAMS Accession No. ML13127A459.

[Entergy] Entergy Nuclear Operations, Inc. 2013c. Indian Point Power Plants Units 1, 2, and 3. Annual Radiological Environmental Operating Report for 2012. May 15, 2015. ADAMS Accession No. ML13144A133.

[Entergy] Entergy Nuclear Operations, Inc. 2013d. Letter from J.A. Ventosa, Site Vice President, to the NRC Document Control Desk. Subject: Entergy's required response for NTF Recommendation 2.1: Flooding—Hazard Re-evaluation Report, Indian Point Unit Numbers 2 and 3, Docket Nos. 50-247 and 50-286, License Nos. DPR-26 and DPR-64, NL-13-156. December 23, 2013. ADAMS Accession Nos. ML13364A006, ML13364A007, ML13364A008, and ML13364A009.

[Entergy] Entergy Nuclear Operations, Inc. 2014a. Letter from F. Dacimo, Indian Point Energy Center, Vice President, Operations License Renewal, to the NRC Document Control Desk. Subject: Reply to request for additional information regarding the license renewal application, Indian Point Nuclear Generating Unit Nos. 2 and 3, Docket Nos. 50-247 and 50-286, License Nos. DPR-26 and DPR-64, NL-14-002. January 2, 2014. ADAMS Accession No. ML14014A276.

[Entergy] Entergy Nuclear Operations, Inc. 2014b. Letter from F. Dacimo, Vice President, Operations License Renewal, to L. James, Environmental Project Manager, Division of License Renewal, NRC. Subject: Final Supplemental Environmental Impact Statement, Indian Point Nuclear Generating Unit Nos. 2 & 3, Docket Nos. 50-247 and 50-286, License Nos. DPR-26 and DPR-64. February 19, 2014. ADAMS Accession No. ML14063A528.

[Entergy] Entergy Nuclear Operations, Inc. 2014c. Entergy Seismic Hazard and Screening Report (CEUS Sites), Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, Indian Point Unit No. 2, Docket No. 50-247, License No. DPR-26. March 31, 2014. ADAMS Accession No. ML14099A110.

[Entergy] Entergy Nuclear Operations, Inc. 2014d. Entergy Seismic Hazard and Screening Report (CEUS Sites), Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, Indian Point Unit No. 3, Docket No. 50-247, License No. DPR-26. March 31, 2014. ADAMS Accession No. ML14099A111.

[Entergy] Entergy Nuclear Operations, Inc. 2014e. Indian Point Unit 2 and Unit 3, Coastal Zone Management Act Consistency Certification in Support of Renewal of Indian Point Unit 2 and Unit 3 USNRC Operating Licenses, Supplemental Information on Groundwater Quality Issues. March 31, 2014. ADAMS Accession No. ML14097A326.

[Entergy] Entergy Nuclear Operations, Inc. 2014f. 2013 Annual Radioactive Effluent Release Report, Indian Point Unit Nos. 1, 2, and 3. April 28, 2014. ADAMS Accession No. ML14127A085.

References

[Entergy] Entergy Nuclear Operations, Inc. 2014g. Indian Point Power Plants Units 1, 2, and 3. Annual Radiological Environmental Operating Report for 2013. May 9, 2014. ADAMS Accession No. ML14142A031.

[Entergy] Entergy Nuclear Operations, Inc. 2014h. *IPEC Quarterly Long-Term Groundwater Monitoring Report, Quarter One 2014, Report No. 22*, Indian Point Energy Center Buchanan, New York. September 22, 2014. Available at <<http://www.safesecurevital.com/uploads/14-9-22.pdf>> (accessed 20 January 2015).

[Entergy] Entergy Nuclear Operations, Inc. 2014i. Letter from F. Dacimo, Vice President, Operations License Renewal, Entergy to U.S. Nuclear Regulatory Commission, Document Control Desk. Subject: Reply to request for additional information regarding the license renewal application, Indian Point Nuclear Generating Unit Nos. 2 & 3, Docket Nos. 50-247 and 50-286, License Nos. DPR-26 and DPR-64. October 27, 2014. ADAMS Accession No. ML14311A802.

[Entergy] Entergy Nuclear Operations, Inc. 2014j. Letter from F. Dacimo, Indian Point Energy Center, Vice President, Operations License Renewal, to the NRC Document Control Desk. Subject: Reply to request for additional information regarding the license renewal application, Indian Point Nuclear Generating Unit Nos. 2 and 3, Docket Nos. 50-247 and 50-286, License Nos. DPR-26 and DPR-64, NL-14-143. November 20, 2014. ADAMS Accession No. ML14337A042.

[Entergy] Entergy Nuclear Operations, Inc. 2014k. *IPEC Quarterly Long-Term Groundwater Monitoring Report, Quarter Two, 2014, Report No. 23*. December 22, 2014. Available at <<http://www.safesecurevital.com/environment/reports.html>> (accessed 27 March 2014).

[Entergy] Entergy Nuclear Operations, Inc. 2014l. Letter from L. Coyle, Indian Point Energy Center, Site Vice President, to the NRC Document Control Desk. Subject: Entergy's Supplemental Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendations 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident Indian Point Unit Numbers 2 and 3, Docket Nos. 50-247 and 50-286, License Nos. DPR-26 and 64. December 9, 2014. ADAMS Accession No. ML14357A052 (package).

[Entergy] Entergy Nuclear Operations, Inc. 2015a. Letter from F. Dacimo, Vice President of License Renewal, Entergy, to the NRC Document Control Desk. Subject: Reply to request for additional information regarding the license renewal application environmental review (TAC Nos. MD5411 and MD5412), Docket Nos. 50-247 and 50-286, License Nos. DPR-26 and DPR-64, NL-15-028. March 10, 2015. ADAMS Accession No. ML15089A338.

[Entergy] Entergy Nuclear Operations, Inc. 2015b. *IPEC Quarterly Long-Term Groundwater Monitoring Report, Quarter Three, 2014, Report No. 24*. March 20, 2015. Available at <<http://www.safesecurevital.com/environment/reports.html>> (accessed 31 March 2015).

[Entergy] Entergy Nuclear Operations, Inc. 2015c. Letter from F. Dacimo, Entergy, to Document Control Desk, NRC. Subject: Reply to request for additional information regarding the license renewal application environmental review (TAC Nos. MD5411 and MD5412), Indian Point Nuclear Generating Unit Nos. 2 & 3, Docket Nos. 50-247 and 50-286, License Nos. DPR-26 and DPR-64, NL-15-029. April 6, 2015. ADAMS Accession No. ML15114A048.

[Entergy] Entergy Nuclear Operations, Inc. 2015d. *2014 Annual Radioactive Effluent Release Report, Indian Point Unit Nos. 1, 2, and 3*. April 28, 2015. ADAMS Accession No. ML15124A715.

- [Entergy] Entergy Nuclear Operations, Inc. 2015e. Letter from F. Dacimo, Vice President Operations License Renewal, Entergy, to NRC Document Control Desk. Subject: Reply to request for additional information regarding the license renewal application environmental review. June 8, 2015. ADAMS Accession No. ML15166A069.
- [Entergy] Entergy Nuclear Operations, Inc. 2015f. *IPEC Quarterly Long-Term Groundwater Monitoring Report, Quarter Four, 2014, Report No. 25*. June 21, 2015. Available at <http://www.safesecurevital.com/environment/reports.html> (accessed 7 October 2015).
- [Entergy] Entergy Nuclear Northeast. 2016a. Letter from F. Dacimo, Vice President, Entergy to C. Bladey, Chief, Rules, Announcements, and Directives Branch, NRC. Subject: Comments on Second Draft Supplement to Final Supplemental Environmental Impact Statement for Indian Point License Renewal, Indian Point Nuclear Generating Unit Nos. 2 and 3, Docket Nos. 50-247 and 50-286, License Nos. DPR-26 and DPR-64. March 4, 2016. ADAMS Accession Nos. ML16070A053 and ML16070A054.
- [Entergy] Entergy Nuclear Northeast. 2016b. Letter from F. Dacimo, Vice President, Operations License Renewal, Entergy, to C. Bladey, Chief, Rules, Announcements, and Directives Branch, NRC. Re: Entergy's Corrections and Clarifications in Response to Third-Party Comments on the NRC Staff's Draft Second Supplement to the Final Supplemental Environmental Impact Statement for Indian Point Nuclear Generating Units 2 and 3 License Renewal, Indian Point Nuclear Generating Unit Nos. 2 and 3, Docket Nos. 50-247 and 50-286, License Nos. DPR-26 and DPR-64. April 25, 2016. ADAMS Accession No. ML16123A173.
- [Entergy] Entergy Nuclear Operations, Inc. 2016c. *2015 Annual Radioactive Effluent Release Report, Indian Point Unit Nos. 1, 2, and 3*. April 28, 2016. ADAMS Accession No. ML16131A637.
- [Entergy] Entergy Nuclear Operations, Inc. 2016d. *IPEC Quarterly Long-Term Groundwater Monitoring Report, Quarter One, Report No. 30*. 2016. September 26, 2016. Available at <http://www.safesecurevital.com/environment/reports.html> (accessed 3 November 2016).
- [Entergy] Entergy Nuclear Operations, Inc. 2016e. *IPEC Quarterly Long-Term Groundwater Monitoring Report, Quarter Two, 2016, Report No. 31*. December 21, 2016. Available at <http://www.safesecurevital.com/environment/reports.html> (accessed 6 February 2017).
- [Entergy] Entergy Nuclear Operations, Inc. 2016f. Letter from L. Coyle, Indian Point Energy Center, Site Vice President, to the NRC Document Control Desk. Subject: Notification of Full Compliance with Order EA-12-049 "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" and Order EA-12-051 "Modifying Licenses with Regard to Requirements for Reliable Spent Fuel Pool Instrumentation" (TAC Nos. MF0744 and MF0737), Indian Point Unit Number 2, Docket No. 50-247, License No. DPR-26. August 12, 2016. ADAMS Accession No. ML16235A292.
- [Entergy] Entergy Nuclear Operations, Inc. 2016g. Letter from A.J. Vitale, Indian Point Energy Center, Site Vice President, to the NRC Document Control Desk. Subject: Mitigating Strategies Assessment (MSA) for Flooding Submittal for Indian Point Units 2 and 3 (CAC Nos. MF-3313 and 3314), Docket Nos. 50-247 and 50-286, License Nos. DPR-24 and DPR-64. October 27, 2016. ADAMS Accession No. ML16305A331.
- [Entergy] Entergy Nuclear Operations, Inc. 2017a. Letter from A.J. Vitale, Site Vice President, Entergy Nuclear Operations, Inc. to the NRC Document Control Desk. Subject: Reply to a Notice of Violation: EA-16-193, Indian Point Unit Nos. 2 and 3, Docket No. 50-247, License Nos. DPR-26, NL-14-030. February 16, 2017. ADAMS Accession No. ML17054C823.

References

[Entergy] Entergy Nuclear Operations, Inc. 2017b. *IPEC Quarterly Long-Term Groundwater Monitoring Report, Quarter Three, 2016 Report No. 32*. March 24, 2017. Available at <http://www.safesecurevital.com/environment/reports.html> (accessed 13 April 2017).

[Entergy] Entergy Nuclear Operations, Inc. 2017c. Amendment to License Renewal Application—Reflecting Shortened License Renewal Terms for Units 2 and 3. February 8, 2017. ADAMS Accession No. ML 17044A005.

[Entergy] Entergy Nuclear Operations, Inc. 2017d. Response to Request for Additional Information for the Review of the Indian Point Nuclear Generating Unit Nos. 2 and 3 License Renewal Application Environmental Review—Severe Accident Mitigation Alternatives. February 1, 2017. ADAMS Accession No. ML 17040A433.

[Entergy] Entergy Nuclear Operations, Inc. 2017e. Updated Response to Request for Additional Information for the Review of the Indian Point Nuclear Generating Unit Nos. 2 and 3 License Renewal Application Environmental Review—Severe Accident Mitigation Alternatives Based on Reduced Renewal Period. March 31, 2017. ADAMS Accession No. ML17096A203.

[Entergy] Entergy Nuclear Operations, Inc. 2017f. *Final Supplemental Environmental Impact Statement New York State Department of Environmental Conservation Clean Water Act Section 401 Water Quality Certification*. April 28, 2017. ADAMS Accession No. ML17142A271.

[Entergy] Entergy Nuclear Operations, Inc. 2017g. *IPEC Quarterly Long-Term Groundwater Monitoring Report, Quarter Four, 2016 Report No. 33*. June 26, 2017. Available at <http://www.safesecurevital.com/environment/reports.html> (accessed 17 October 2017).

[Entergy] Entergy Nuclear Operations, Inc. 2017h. *IPEC Quarterly Long-Term Groundwater Monitoring Report, Quarter One, 2017 Report No. 34*. September 25, 2017. Available at <http://www.safesecurevital.com/environment/reports.html> (accessed 17 October 2017).

[Entergy] Entergy Nuclear Operations, Inc. 2017i. Letter from A.J. Vitale, Site Vice President, Entergy Nuclear Operations, Inc. to the NRC Document Control Desk. Subject: Request for Deferral of Actions Related to Beyond-Design-Basis External Events Flooding Actions—Commitment Changes, Docket Nos. 50-247 and 50-286, License Nos. DPR-26 and DPR-64. July 24, 2017. ADAMS Accession No. ML17209A740.

[EPA] U.S. Environmental Protection Agency. 1992. Clarification of Prevention of Significance Deterioration (PSD) Guidance for Modeling Class I Area Impacts. Available at <http://www.epa.gov/ttn/nsr/gen/u3-11.txt> (accessed 1 April 2015)

ML17142A271.[EPA] U.S. Environmental Protection Agency. 1994. Natural Attenuation of Hexavalent Chromium in Groundwater and Soils, Office of Research and Development, Office of Solid Waste and Emergency Response, EPA/540/5-94/505. October 1994. Available at https://www.epa.gov/sites/production/files/2015/documents/natatt_hexavalent_chromium.pdf (accessed 21 November 2016).

[EPA] U.S. Environmental Protection Agency. 1999a. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites. April 21, 1999. Available at <http://www.epa.gov/OUST/directiv/d9200417.pdf> (accessed 15 September 2015).

[EPA] U.S. Environmental Protection Agency. 1999b. Consideration of Cumulative Impacts in EPA Review of NEPA Documents. EPA-315-R-99-002. Office of Federal Activities (2252A), Washington, D.C. Available at <http://www2.epa.gov/sites/production/files/2014-08/documents/cumulative.pdf> (accessed 15 September 2015).

- [EPA] U.S. Environmental Protection Agency. 2002a. Case Study Analysis for the Proposed Section 316(b) Phase II Existing Facilities Rule. EPA-821-R-02-002, Office of Science and Technology, Washington, DC.
- [EPA] U.S. Environmental Protection Agency. 2002b. Radionuclides in Drinking Water: A Small Entity Compliance Guide. February 2002. Available at <http://www.epa.gov/ogwdw/radionuclides/pdfs/guide_radionuclides_smallsystems_compliance.pdf> (accessed 23 April 2015).
- [EPA] U.S. Environmental Protection Agency. 2002c. *EPA Facts about Cesium-137*. July 2002. Available at <<http://www.epa.gov/superfund/health/contaminants/radiation/pdfs/cesium.pdf>> (accessed 14 April 2015).
- [EPA] U.S. Environmental Protection Agency. 2002d. *EPA Facts about Cobalt-60*. July 2002. Available at <<http://www.epa.gov/superfund/health/contaminants/radiation/pdfs/cobalt.pdf>> (accessed 14 April 2015).
- [EPA] U.S. Environmental Protection Agency. 2002e. *EPA Facts about Strontium-90*. July 2002. Available at <<http://www.epa.gov/superfund/health/contaminants/radiation/pdfs/strontium.pdf>> (accessed 14 April 2015).
- [EPA] U.S. Environmental Protection Agency. 2002f. *EPA Facts about Tritium*. July 2002. Available at <http://www.trainex.org/web_courses/tritium/reference_pages/tritium%20EPA.pdf> (accessed 14 April 2015).
- [EPA] U.S. Environmental Protection Agency. 2008. Average Annual Emissions and Fuel Consumption for Gasoline-Fueled Passenger Cars and Light Trucks. Available at <<http://www.epa.gov/otaq/consumer/420f08024.pdf>> (accessed 1 April 2015).
- [EPA] U.S. Environmental Protection Agency. 2009a. Endangerment and Cause or Contribute Finding for Greenhouse Gases under Section 202(a) of the Clean Air Act. Available at <<http://www.epa.gov/climatechange/endangerment/>> (accessed 6 March 2015).
- [EPA] U.S. Environmental Protection Agency. 2009b. Assessment of the Impacts of Global Change on Regional U.S. Air Quality: A Synthesis of Climate Change Impacts on Ground-Level Ozone. April 2009. EPA/600/R-07/094F. Available at <<http://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=203459>> (accessed 23 July 2015).
- [EPA] U.S. Environmental Protection Agency. 2012. *A Citizen's Guide to Monitored Natural Attenuation*. September 2012. Available at <https://clu-in.org/download/Citizens/a_citizens_guide_to_monitored_natural_attenuation.pdf> (accessed 31 March 2012).
- [EPA] U.S. Environmental Protection Agency. 2014a. Greenhouse Gas Inventory Guidance. Direct Fugitive Emissions From Refrigeration, Air Conditioning, Fire Suppression, and Industrial Gases. Available at <<http://www.epa.gov/climateleadership/documents/resources/mfgrfg.pdf>> (accessed 3 April 2015).
- [EPA] U.S. Environmental Protection Agency. 2014b. *Climate Change Indicators in the United States, 2014*. Available at <<http://www.epa.gov/climatechange/pdfs/climateindicators-full-2014.pdf>> (accessed 24 February 2015).
- [EPA] U.S. Environmental Protection Agency. 2015a. *The Greenbook of Nonattainment Areas for Criteria Pollutants*. Available at <<http://www.epa.gov/airquality/greenbook/>> (accessed 3 March 2015).

References

- [EPA] U.S. Environmental Protection Agency. 2015b. *Enforcement and Compliance History Online, Entergy Indian Point Nuclear Generating Detailed Facility Report*. Available at <http://echo.epa.gov/?redirect=echo> (accessed 20 May 2015).
- [EPA] U.S. Environmental Protection Agency. 2015c. *EJView Census 2010 Summary Report—50 Miles around Indian Point (Lat. 41.270047, Long. -73.953352)*. Available at <http://epamap14.epa.gov/ejmap/entry.html> (accessed 20 May 2015).
- [EPA] U.S. Environmental Protection Agency. 2015d. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2013*. Available at <http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html> (accessed 16 April 2015).
- [EPA] U.S. Environmental Protection Agency. 2015e. *Facility Level Information on Greenhouse Gases Tool: New York and Westchester County*. Available at <http://ghqdata.epa.gov/ghgp/main.do> (accessed 30 March 2015).
- [EPA] U.S. Environmental Protection Agency. 2015f. *Maximum Contaminant Levels in EPA's Preliminary Remediation Goal and Dose Compliance Concentration Calculators Revised: September 2015*. Available at https://epa-prgs.ornl.gov/radionuclides/MCLs_2015.pdf (accessed 3 November 2016).
- European Commission, Joint Research Centre. 2014. "Global Carbon Dioxide Emissions Increase to New All-Time Record, But Growth is Slowing Down." *Science Daily*. Available at <http://www.sciencedaily.com/releases/2014/12/141217074442.htm> (accessed 15 April 2015).
- Federal Water Pollution Control Act of 1972 (also referred to as the CWA), as amended. 33 U.S.C. § 1251 et seq.
- [FEMA] U.S. Federal Emergency Management Agency. 2015. *Earthquake Hazard Maps*. Available at <https://www.fema.gov/earthquake/earthquake-hazard-maps#0> (accessed 27 February 2015).
- [FERC] U.S. Federal Energy Regulatory Commission. 2015. *Algonquin Incremental Market Project Final Environmental Impact Statement*. FERC/EIS-0254F. Washington, DC. Available at <http://www.ferc.gov/industries/gas/enviro/eis/2015/01-23-15-eis.asp> (accessed 27 March 2015).
- [FHWA] U.S. Federal Highway Administration. 2006. *Construction Noise Handbook*. Available at http://www.fhwa.dot.gov/environment/noise/construction_noise/handbook/ (accessed 15 April 2015).
- Fraser KC, Silverio C, Kramer P, Mickle N, Aeppli R, Stutchbury BJM. 2013. A trans-hemispheric migratory songbird does not advance spring schedules or increase migration rate in response to record-setting temperatures at breeding sites. *Plos One* 8(5):e64587.
- [FWS] U.S. Fish and Wildlife Service. 2015. Letter from D. Stilwell, New York Field Supervisor, FWS, to D. Wrona, Branch Chief, NRC. Subject: Concurrence with determination that Indian Point license renewal is not likely to adversely affect the Indiana bat or northern long-eared bat. July 14, 2015. ADAMS Accession No. ML15196A013.
- [Goodwin Proctor] Goodwin Proctor LLP. 2011. Letter from E. Zoli, Goodwin Proctor LLC to D. Wrona, Chief, Projects Branch 2, Division of License Renewal, U.S. Nuclear Regulatory Commission. Subject: Indian Point License Renewal—Entergy's comments on NMFS' essential fish habitat consultation correspondence. September 30, 2011. ADAMS Accession No. ML11286A140.

- [Goodwin Proctor] Goodwin Procter LLP. 2015. Letter from E. Zoli, Goodwin Procter LLC to D. Gray, Entergy. Re: Nuclear Regulatory Commission request for additional information for the review of the Indian Point Nuclear Generating Unit Nos. 2 and 3, License Renewal Application Environmental Review (TAC Nos. MD5411 and MD5412) dated February 18, 2015 (“RAI”). April 1, 2015. Attachment to NL-15-029 Reply to NRC Request for Additional Information Regarding the License Renewal Application Environmental Review (In Entergy 2015c). ADAMS Accession No. ML15114A048.
- [Goodwin Proctor] Goodwin Procter LLP. 2017. Letter from E. Zoli, Goodwin Procter, to B. Beasley, NRC, J. Crocker, NMFS, and J. Williams, NMFS. Subject: Reinitiation of consultation and final BMP relating to the 2013 BiOp/ITS for Indian Point. October 27, 2017. ADAMS Accession No. ML17300A180.
- [GZA] GZA GeoEnvironmental, Inc. 2008. *Hydrogeologic Site Investigation Report for the Indian Point Energy Center*. January 7, 2008. ADAMS Accession No. ML080320540.
- Hattala K, Kahnle A. 2007. Status of the Hudson River, New York, American shad stock. In ASMFC Stock Assessment Report No. 07-01 (supplement) of the Atlantic States Marine Fisheries Commission. American shad stock assessment report for peer review, Volume II. Washington, D.C., USA. (Cited in Hattala et al. 2012, p. 306).
- Hattala KA, Kahnle AW, Adams RD. 2011. Sustainable Fishing Plan for New York River Herring Stocks. Submitted for review to the Atlantic States Marine Fisheries Commission. September 2011 revised version. Available at http://www.dec.ny.gov/docs/fish_marine_pdf/rhsustplan0811.pdf (accessed 20 February 2015).
- Hattala KA, Kahnle AW, Adams RD. 2012. “Status of New York River Herring Stocks.” Chapter 10 in ASMFC (2012SAR2), Stock Assessment Report No. 12-02 of the Atlantic States Marine Fisheries Commission. River Herring Benchmark Stock Assessment. Volume II. May 2012, p 291–366. Available at http://www.asmfc.org/uploads/file/riverHerringBenchmarkStockAssessmentVolumellR_May2012.pdf (accessed 13 February 2015).
- Heimbuch DG, Young JR, Mattson MT, Barnthouse L. 2015. Responses to Nuclear Regulatory Commission Staff’s Request for Additional Information for the Review of the Indian Point Nuclear Generating Unit Nos. 2 and 3 License Renewal Application Environmental Review (TAC Nos. MD5411 and MD5412). Attachment to NL-15-029 Reply to NRC Request for Additional Information Regarding the License Renewal Application Environmental Review (In Entergy 2015c). ADAMS Accession No. ML15114A048.
- Heisig, PM. 2010. Water Resources of Rockland County, New York, 2005–07, with Emphasis on the Newark Basin Bedrock Aquifer: U.S. Geological Survey Scientific Investigations Report 2010–5245. 2010. Available at <http://pubs.usgs.gov/sir/2010/5245> (accessed 19 March 2015).
- Horton R, Bader D, Rosenzweig C, DeGaetano A, Solecki W. 2014. *Climate Change in New York State: Updating the 2011 ClimAID Climate Risk Information*. New York State Energy Research and Development Authority (NYSERDA). Available at <http://www.nysesda.ny.gov/-/media/Files/Publications/Research/Environmental/ClimAID/2014-ClimAid-Report.pdf> (accessed 6 March 2015).

References

[HRSA] Hudson River Settlement Agreement. 1980. Settlement Agreement among the U.S. Environmental Protection Agency, Department of Environmental Conservation of the State of New York, Attorney General of the State of New York, Hudson River Fisherman's Association, Inc., Scenic Hudson, Inc., Natural Resources Defensive Council, Inc., Central Hudson Gas & Electric Corporation, Consolidated Edison Company of New York, Inc., Orange & Rockland Utilities, Inc., Niagara Mohawk Power Corporation, and Power Authority of the State of New York. December 19, 1980. ADAMS Accession No. ML16251A043.

[IPCC] Intergovernmental Panel on Climate Change. 2007a. "Climate Change 2007: The Physical Science Basis." Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL, editors. Cambridge University Press, Cambridge, United Kingdom and New York, New York, USA.

[IPCC] Intergovernmental Panel on Climate Change. 2007b. "Climate Change 2007: Impacts, Adaptation and Vulnerability." Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE, editors. Cambridge University Press, Cambridge, UK.

[IPCC] Intergovernmental Panel on Climate Change. 2013. "Climate Change 2013: The Physical Science Basis." Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Stocker TF, Qin D, Plattner G-K, Tignor M, Allen SK, Boschung J, Nauels A, Xia Y, Bex V, Midgley PM, editors. Available at http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_SPM_FINAL.pdf (accessed 6 March 2015).

Jacob DJ, Winner DA. 2009. Effect of climate change on air quality. *Atmospheric Environment* 43:51–63.

Johnson DS. 2015. The savory swimmer swims north: A northern range extension of the blue crab *Callinectes sapidus*? *Journal of Crustacean Biology* 35(1):105–110.

Lafferty KD, Kuris AM. 1993. Mass mortality of abalone, *Haliotis cracherodii*, on the California Channel Islands: tests of epidemiological hypotheses. *Marine Ecology Progress Series* 96:239–248.

Magnuson–Stevens Fishery Conservation and Management Reauthorization Act of 2006, as amended. 16 U.S.C. § 1801–1884.

Merguerian C. 2010. Geology 133 Field Trip Cortlandt Igneous Complex, Buchanan, NY, Stony Point Complex, Stony Point, NY Palisades Intrusive Sheet, Fort Lee, NJ. April 25, 2010. Available at http://dukelabs.com/Publications/PubsPdf/HU1004_Geol133NYNJIntrusivesGuide.pdf (accessed 2 March 2015).

[NCDC] National Climatic Data Center. 2015. *Time Series*. Available at <http://www.ncdc.noaa.gov/caq/time-series> (accessed 6 March 2015).

[NEI] Nuclear Energy Institute. 2007. *Industry Ground Water Protection Initiative—Final Guidance Document*. NEI 07-07 [Final]. Washington, D.C. August 2007. ADAMS Accession No. ML072610036.

[NEI] Nuclear Energy Institute. 2012. *Diverse and Flexible Coping Strategies (FLEX) Implementation Guide, Revision 0*. Report 12-06. August 2012. ADAMS Accession No. ML12242A378.

- National Environmental Policy Act of 1969, as amended. 42 U.S.C. § 4321 et seq.
- National Historic Preservation Act of 1966, as amended. 16 U.S.C. § 470 et seq.
- New York State Climate Action Council. 2010. *Climate Action Plan Interim Report*. Available at <http://www.dec.ny.gov/energy/80930.html> (accessed 1 April 2015).
- [NMFS] National Marine Fisheries Service. 2009. *Ecosystem Status Report for the Northeast U.S. Continental Shelf Large Marine Ecosystem*. Ecosystem Assessment Program, Northeast Fisheries Science Center, Woods Hole, Massachusetts. Available at <http://www.nefsc.noaa.gov/publications/crd/crd0911/crd0911.pdf%3e%20> (accessed 23 March 2015).
- [NMFS] National Marine Fisheries Service. 2013. Endangered Species Act Section 7 Consultation Biological Opinion: Continued Operation of the Indian Point Nuclear Generating Station, Units 2 and 3, Pursuant to Existing and Proposed Renewed Operating Licenses, NER-2012-25252. January 30, 2013. ADAMS Accession No. ML13032A256.
- [NMFS] National Marine Fisheries Service. 2017. Letter from K. Damon-Randall, NMFS, to B. Beasley, NRC. Subject: Conference Report – Proposed Indian Point Relicensing. August 31, 2017. ADAMS Accession No. ML17243A315.
- [NOAA] National Oceanic and Atmospheric Administration. 2013. *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment: Part 1. Climate of the Northeast U.S.* NOAA Technical Report NESDIS 142-1. January 2013. Available at http://www.nesdis.noaa.gov/technical_reports/NOAA_NESDIS_Tech_Report_142-1-Climature_of_the_Northeast_U.S.pdf (accessed 23 July 2015).
- [NRC] U.S. Nuclear Regulatory Commission. 1973. *Indian Point Nuclear Generating Unit No 2. Facility Operating License DPR-26*. September 28, 1973. ADAMS Accession No. ML052720262.
- [NRC] U.S. Nuclear Regulatory Commission. 1975. *Indian Point Nuclear Generating Unit No. 3. Facility Operating License DPR-64*. December 12, 1975. ADAMS Accession No. ML052720273.
- [NRC] U.S. Nuclear Regulatory Commission. 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. Washington, DC: NRC. NUREG–1437, Volumes 1 and 2. May 1996. ADAMS Accession Nos. ML040690705 and ML040690738.
- [NRC] U.S. Nuclear Regulatory Commission. 2003. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants Regarding H.B. Robinson Steam Electric Plant, Unit No. 2*. Washington, DC: NRC. NUREG–1437, Supplement 13. Final Report. December 2003. ADAMS Accession No. ML033450517.
- [NRC] U.S. Nuclear Regulatory Commission. 2009a. *Redox and Sorption Reactions of Iodine and Cesium During Transport Through Aquifer Sediments*, NUREG/CR-6977. March 2009. ADAMS Accession No. ML090790302.
- [NRC] U.S. Nuclear Regulatory Commission. 2009b. *Duke Energy Carolinas, LLC (William States Lee III Nuclear Station, Units 1 and 2), Memorandum and Order Concerning Consideration in COL Applications of Certain Environmental Impacts Relevant to Greenhouse Gas Emissions*. CLI-09-21. 70 NRC 927. November 3, 2009. ADAMS Accession No. ML093070689.

References

[NRC] U.S. Nuclear Regulatory Commission. 2010. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants: Supplement 38, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3*. Washington, DC: NRC. NUREG-1437, Supplement 38. December 10, 2010. ADAMS Accession No. ML102990043.

[NRC] U.S. Nuclear Regulatory Commission. 2011. *Duke Energy Carolinas LLC (William States Lee III Nuclear Station, Units 1 and 2), Memorandum and Order*. CLI-11-14. 74 NRC 801. December 22, 2011. ADAMS Accession No. ML11356A112.

[NRC] U.S. Nuclear Regulatory Commission. 2012a. Letter from E.J. Leeds, Director, Office of Nuclear Reactor Regulation, and MJ Johnson, Director, Office of New Reactors, to All Power Reactor Licensees and Holders of Construction Permits in Active or Deferred Status. Subject: Request for information pursuant to Title 10 of the *Code of Federal Regulations* 50.54(F) regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident. March 12, 2012. ADAMS Accession No. ML12053A340.

[NRC] U.S. Nuclear Regulatory Commission. 2012b. *Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design Basis External Events*. NRC Order No. EA-12-049. March 12, 2012. ADAMS Accession No. ML12054A735.

[NRC] U.S. Nuclear Regulatory Commission. 2012c. *Calvert Cliffs 3 Nuclear Project, LLC and Unistar Nuclear Operating Services, LLC (Calvert Cliffs Nuclear Power Plant, Unit 3), Memorandum and Order*. CLI-12-16. 76 NRC 63. August 7, 2012. ADAMS Accession No. ML12220A094.

[NRC] U.S. Nuclear Regulatory Commission. 2012d. "Approach for Addressing Policy Issues Resulting from Court Decision to Vacate Waste Confidence Decision and Rule." SRM-COMSECY-12-0016. September 6, 2012. ADAMS Accession No. ML12250A032.

[NRC] U.S. Nuclear Regulatory Commission. 2012e. Entergy Nuclear Operations, Inc. (Indian Point Units 2 and 3), NRC Staff Testimony of SP Klementowicz and JD Noggle Concerning Contention Riverkeeper EC-3/Clearwater EC-1 (Spent Fuel Pool Leaks), Docket Nos. 50-247-LR and 50-286-LR, ASLBP No. 07-858-03-LR-BDO1 Evidentiary Hearing, Exhibit NRCR00088-00-BD01. September 21, 2012. ADAMS Accession No. ML12340A747.

[NRC] U.S. Nuclear Regulatory Commission. 2013a. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants. Revision 1*. Washington, DC: NRC. NUREG-1437, Volumes 1, 2, and 3. June 19, 2013. ADAMS Accession No. ML13107A023.

[NRC] U.S. Nuclear Regulatory Commission. 2013b. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants: Supplement 38, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3, Vol. 4*. Washington, DC: NRC. NUREG-1437, Supplement 38, Volume 4. June 20, 2013. ADAMS Accession No. ML13162A616.

[NRC] U.S. Nuclear Regulatory Commission. 2013c. Letter from L. James, NRC, to Entergy. Subject: Request for additional information for the review of the Indian Point Nuclear Generating Unit Nos. 2 and 3, license renewal application environmental review (TAC Nos. MD5411 and MD5412). November 22, 2013. ADAMS Accession No. ML13322A834.

[NRC] U.S. Nuclear Regulatory Commission. 2014a. Letter from E.J. Leeds, Director, Office of Nuclear Reactor Regulation, NRC, to All Power Reactor Licensees and Holders of Construction Permits in Active or Deferred Status. Subject: Screening and prioritization results regarding information pursuant to Title 10 of the *Code of Federal Regulations* 50.54(F) regarding seismic hazard re-evaluations for Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident. May 9, 2014. ADAMS Accession No. ML14111A147.

- [NRC] U.S. Nuclear Regulatory Commission. 2014b. *Probabilistic Seismic Hazard Analysis: Background Information*. May 20, 2014. ADAMS Accession No. ML14140A648.
- [NRC] U.S. Nuclear Regulatory Commission. 2014c. *Calvert Cliffs 3 Nuclear Project, LLC and Unistar Nuclear Operating Services, LLC (Calvert Cliffs Nuclear Power Plant, Unit 3)*, Memorandum and Order. CLI-14-08. 80 NRC 71. August 26, 2014. ADAMS Accession No. ML14238A242.
- [NRC] U.S. Nuclear Regulatory Commission. 2014d. Letter from M. Wentzel, Project Manager, NRC, to Vice President, Operations, Entergy Nuclear Operations, Inc. Subject: Request for additional information for the review of the Indian Point Nuclear Generating Unit Nos. 2 and 3, license renewal application environmental review (TAC Nos. MD5411 and MD5412). August 28, 2014. ADAMS Accession No. ML14225A847.
- [NRC] U.S. Nuclear Regulatory Commission. 2014e. Letter from M. Wentzel, Project Manager, NRC, to Vice President, Operations, Entergy Nuclear Operations, Inc. Subject: Request for additional information for the review of the Indian Point Nuclear Generating Unit Nos. 2 and 3, license renewal application environmental review (TAC Nos. MD5411 and MD5412). September 26, 2014. ADAMS Accession No. ML14261A031.
- [NRC] U.S. Nuclear Regulatory Commission. 2014f. *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel*. Washington, DC: NRC, Office of Nuclear Material Safety and Safeguards. NUREG-2157, Volumes 1 and 2. September 2014. ADAMS Accession Nos. ML14196A105 and ML14196A107.
- [NRC] U.S. Nuclear Regulatory Commission. 2014g. Summary of telephone conference call held on September 16, 2014, between the U.S. Nuclear Regulatory Commission and Entergy Nuclear Operations, Inc., concerning the request for additional information pertaining to the Indian Point Nuclear Generating Unit Nos. 2 and 3 license renewal application environmental review (TAC Nos. MD5411 and MD5412). October 6, 2014. ADAMS Accession No. ML14268A571.
- [NRC] U.S. Nuclear Regulatory Commission. 2014h. Letter from M. Wentzel, NRC, to Entergy. Subject: Request for additional information for the review of the Indian Point Nuclear Generating Unit Nos. 2 and 3, license renewal application environmental review—refined cost estimate (TAC Nos. MD5411 and MD5412). October 6, 2014. ADAMS Accession No. ML14239A380.
- [NRC] U.S. Nuclear Regulatory Commission. 2014i. Letter from M. Wentzel, Project Manager, NRC, to Vice President, Operations, Entergy. Subject: Request for additional information for the review of the Indian Point Nuclear Generating Unit Nos. 2 and 3, license renewal application environmental review (TAC Nos. MD5411 and MD5412). December 11, 2014. ADAMS Accession No. ML14308A471.
- [NRC] U.S. Nuclear Regulatory Commission. 2015a. Summary of telephone conference calls held on December 11, 2014 and January 13, 2015, between the U.S. Nuclear Regulatory Commission and Entergy Nuclear Operations, Inc. Concerning the Request for Additional Information Pertaining to the Indian Point Nuclear Generating Unit Nos. 2 and 3 License Renewal Application Environmental Review (TAC Nos. MD5411 and MD5412). February 11, 2015. ADAMS Accession No. ML15022A160.

References

[NRC] U.S. Nuclear Regulatory Commission. 2015b. Letter from M. Wentzel, Project Manager, NRC, to Vice President, Operations, Entergy Nuclear Operations, Inc. Subject: Request for additional information for the review of the Indian Point Nuclear Generating Unit Nos. 2 and 3, license renewal application environmental review (TAC Nos. MD5411 and MD5412). February 18, 2015. ADAMS Accession No. ML14329B245.

[NRC] U.S. Nuclear Regulatory Commission. 2015c. *Entergy Nuclear Operations, Inc.* (Indian Point Units 2 and 3), Memorandum and Order CLI-15-06. 81 NRC 340, 386. March 9, 2015. ADAMS Accession No. ML15068A424.

[NRC] U.S. Nuclear Regulatory Commission. 2015d. Summary of telephone conference call held on February 12, 2015, between the U.S. Nuclear Regulatory Commission and Entergy Nuclear Operations, Inc. Concerning the Request for Additional Information Pertaining to the Indian Point Nuclear Generating Unit Nos. 2 and 3 License Renewal Application Environmental Review (TAC Nos. MD5411 and MD5412). March 10, 2015. ADAMS Accession No. ML15051A502.

[NRC] U.S. Nuclear Regulatory Commission. 2015e. Biological Assessment on the Northern Long-Eared Bat (*Myotis septentrionalis*) and Indiana Bat (*Myotis sodalis*) for the Indian Point Nuclear Generating Units 2 and 3 Proposed License Renewal. July 1, 2015. ADAMS Accession No. ML15161A086.

[NRC] U.S. Nuclear Regulatory Commission. 2015f. Letter from D. Wrona, Branch Chief, NRC, to D. Stilwell, New York Field Supervisor, FWS. Subject: Request for concurrence with the NRC's determination that license renewal of Indian Point Nuclear Generating Unit Nos. 2 and 3 is not likely to adversely affect the northern long-eared bat or Indiana bat. July 1, 2015. ADAMS Accession No. ML15161A066.

[NRC] U.S. Nuclear Regulatory Commission. 2015g. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants: Supplement 38, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3.* NUREG-1437, Suppl. 38, Vol. 5. Draft Report for Comment. December 2015. ADAMS Accession No. ML15351A422.

[NRC] U.S. Nuclear Regulatory Commission. 2016a. *Entergy Nuclear Operations, Inc.* (Indian Point Units 2 and 3), Memorandum and Order. CLI-16-07. 83 NRC 293. May 4, 2016. ADAMS Accession No. ML16125A150.

[NRC] U.S. Nuclear Regulatory Commission. 2016b. Letter from G.T. Dentel, Chief, Reactor Projects Branch 2, Division of Reactor Projects, NRC to L. Coyle, Site Vice President, Entergy. Subject: Indian Point Nuclear Generating – Integrated Inspection Report 05000247/2016001 and 05000286/2016001 Glenn T. Dentel, Chief, Reactor Projects Branch 2, Division of Reactor Projects to Mr. Larry Coyle, Site Vice President Entergy Nuclear Operations, Inc. May 12, 2016. ADAMS Accession No. ML16133A597.

[NRC] U.S. Nuclear Regulatory Commission. 2016c. *Entergy Nuclear Operations, Inc.* (Indian Point Units 2 and 3), Memorandum and Order. CLI-16-10. 83 NRC 494. June 2, 2016. ADAMS Accession No. ML16154A056.

[NRC] U.S. Nuclear Regulatory Commission. 2016d. *Evaluation of Impacts to Proposed Critical Habitat for the Atlantic Sturgeon (Acipenser oxyrinchus oxyrinchus), Indian Point Nuclear Generating Units 2 and 3 Proposed License Renewal.* September 2016. ADAMS Accession No. ML16250A276.

- [NRC] U.S. Nuclear Regulatory Commission. 2016e. Letter from K. Folk, Acting Branch Chief, NRC, to K. Damon-Randall, Assistant Regional Administrator for Protected Resources, National Marine Fisheries Service. Subject: Request for Section 7 conference for Indian Point Nuclear Generating Unit Nos. 2 and 3 due to proposed rule to list Atlantic sturgeon critical habitat in the Hudson River. September 13, 2016. ADAMS Accession No. ML16236A109.
- [NRC] U.S. Nuclear Regulatory Commission. 2016f. Radioactive Effluent and Environmental Reports for Indian Point 2 & 3. 2016. Available at <<http://www.nrc.gov/reactors/operating/ops-experience/tritium/plant-specific-reports/ip2-3.html>> (accessed 11 November 2016).
- [NRC] U.S. Nuclear Regulatory Commission. 2016g. Request for Additional Information for the Review of the Indian Point Nuclear Generating Unit Nos. 2 and 3, License Renewal Application Environmental Review – Severe Accident Mitigation Alternatives 9. September 12, 2016. ADAMS Accession No. ML16232A119.
- [NRC] U.S. Nuclear Regulatory Commission. 2017a. Indian Point Nuclear Generating – Integrated Inspection Report 05000247/2016003 and 05000286/2016003 and Notice of Violation (EA-16-193), Letter from Eugene M. DiPaolo, Acting Chief, Reactor Projects Branch 2, Division of Reactor Projects to Mr. Anthony Vitale, Site Vice President, Entergy Nuclear Operations, Inc. January 17, 2017. ADAMS Accession No. ML17013A233.
- [NRC] U.S. Nuclear Regulatory Commission. 2017b. Letter from S.N. Bailey, Chief, Electrical and Reactor Systems Branch, Japan Lessons-Learned Division, Office of Nuclear Reactor Regulation, NRC, to Vice President Operations, Entergy Nuclear Operations, Inc. Subject: Indian Point Nuclear Generating Unit Nos. 2 And 3 – Safety Evaluation Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Pool Instrumentation Related to Orders EA-12-049 and EA-12-051 (CAC Nos. MF0737, MF0738, MF0744 AND MF0745). March 27, 2017. ADAMS Accession No. ML17065A171.
- [NRC] U.S. Nuclear Regulatory Commission. 2017c. Letter from J.M. Sebrosky, Senior Project Manager, Hazards Management Branch, Japan Lessons-Learned Division, Office of Nuclear Reactor Regulation, NRC, to A.J. Vitale, Vice President Operations, Entergy Nuclear Operations, Inc. Subject: Indian Point Nuclear Generating Unit Nos. 2 and 3 – Flood Hazard Mitigation Strategies Assessment (CAC Nos. MF7935 and MF7936). April 10, 2017. ADAMS Accession No. ML17059C227.
- [NRC] U.S. Nuclear Regulatory Commission. 2017d. Letter from L. Lund, Director, Division of Licensing Projects, Office of Nuclear Reactor Regulation, NRC, to Vice President Operations, Entergy Nuclear Operations, Inc. Subject: Indian Point Nuclear Generating Unit Nos. 2 and 3 – NRC Response to Request for Deferral of Actions Related to Beyond-Design-Basis Seismic and Flooding Hazard Reevaluations. October 4, 2017. ADAMS Accession No. ML17222A239.
- [NRC] U.S. Nuclear Regulatory Commission. 2017e. Summary of October 13, 2017, Meeting with the National Marine Fisheries Service Related to Indian Point Nuclear Generating Unit Nos. 2 and 3 License Renewal. November 9, 2017. ADAMS Accession No. ML17298A544.
- [NRC] U.S. Nuclear Regulatory Commission. 2017f. Letter from B. Beasley, Environmental Review and NEPA Branch Chief, NRC, to K. Damon-Randall, Assistant Regional Administrator for Protected Resources, NMFS. Subject: Request for Amended Incidental Take Statement and Concurrence with “Not Likely to Adversely Affect” Determination for Atlantic Sturgeon Critical Habitat Related to Indian Point Nuclear Generating Unit Nos. 2 and 3 License Renewal. November 27, 2017. ADAMS Accession No. ML17306A100.
- [NRG] NRG. 2015. “Our Assets.” Available at <<http://www.nrg.com/about/who-we-are/our-assets/>> (accessed 4 April 2015).

References

Nye JA, Link JS, Hare JA, Overholtz WJ. 2009. Changing spatial distribution of fish stocks in relation to climate and population size on the Northeast United States continental shelf. *Marine Ecology Progress Series* 393:111–129.

[NYPA] New York Power Authority. 1986. Size Selectivity and Relative Catch Efficiency of a 3-m Beam Trawl and a 1-m² Epibenthic Sled for Sampling Young-of-the-Year Striped Bass and Other Fishes in the Hudson River Estuary. Prepared by Normandeau Associates, Inc. January 1986. ADAMS Accession No. ML083360641.

[NYS et al.] New York State Governor, New York State Department of Environmental Conservation, New York State Department of Health, New York State Department of State, Office of the Attorney General of the State of New York, New York State Department of Public Service, Entergy Nuclear Indian Point 2 LLC, Entergy Nuclear Indian Point 3 LLC, Entergy Nuclear Operations Inc. 2017. Indian Point Agreement. January 8, 2017. ADAMS Accession No. ML17039B091.

[NYSDEC] New York State Department of Environmental Conservation. 1997. Memorandum from K. Silliman, NYSDEC. Re: NRDC vs. NYSDEC, et al. Forth Amended Consent Order. April 23, 1997. ADAMS Accession No. ML16251A053.

[NYSDEC] New York State Department of Environmental Conservation. 2000. *State Pollutant Discharge Elimination System (SPDES) Discharge Permit No. NY-0004472*. October 1, 1987. Updated November 20, 2000. In Appendix C to Entergy 2007a.

[NYSDEC] New York State Department of Environmental Conservation. 2003. “Fact Sheet. New York State Pollutant Discharge Elimination System (SPDES) Draft Permit Renewal with Modification, Indian Point Electric Generating Station, Buchanan, NY.” November 2003. Available at <http://www.dec.ny.gov/docs/permits_ej_operations_pdf/indptfs.pdf> (accessed 8 March 2017).

[NYSDEC] New York State Department of Environmental Conservation. 2007. Community Fact Sheet, Prepared for the 9/1/07 NRC Relicensing Environmental Scoping Meeting for Indian Point Energy Center. September 2007. ADAMS Accession No. ML12338A675.

[NYSDEC] New York State Department of Environmental Conservation. 2008a. *Community Fact Sheet, Prepared for the May 9, 2008 NRC Government-to-Government Meeting, Groundwater Investigation*. May 9, 2008. Available at <<http://www.dec.ny.gov/permits/44014.html>> (accessed 13 April 2015).

[NYSDEC] New York State Department of Environmental Conservation. 2008b. *Waterbody Inventory for Lower Hudson River Watershed*. Available at <http://www.dec.ny.gov/docs/water_pdf/pwllhudlhud.pdf> (accessed 4 April 2015).

[NYSDEC] New York State Department of Environmental Conservation. 2009. *Establishing a Goal to Reduce Greenhouse Gas Emissions Eighty Percent by the Year 2050 and Preparing a Climate Action Plan*. Executive Order No. 24. August 6, 2009. Available at <<http://www.dec.ny.gov/energy/71394.html>> (accessed 28 May 2015).

[NYSDEC] New York State Department of Environmental Conservation. 2010. *DER-10/Technical Guidance for Site Investigation and Remediation*. May 3, 2010. Available at <http://www.dec.ny.gov/docs/remediation_hudson_pdf/der10.pdf> (accessed 31 March 2012).

[NYSDEC] New York State Department of Environmental Conservation. 2014. *The FINAL New York State 2014 Section 303(d) List of Impaired Waters Requiring a TMDL/Other Strategy*. September 2014. Available at <http://www.dec.ny.gov/docs/water_pdf/303dlistfinal2014.pdf> (accessed 4 April 2015).

- [NYSDEC] New York State Department of Environmental Conservation. 2015a. *Air State Facility Permit, Entergy Nuclear Operations*. Available at <http://www.dec.ny.gov/dardata/boss/afs/issued_asf.html> (accessed 1 April 2015).
- [NYSDEC] New York State Department of Environmental Conservation. 2015b. *Air Facility Permits and Registrations*. Available at <<http://www.dec.ny.gov/chemical/8569.html>> (accessed 1 April 2015).
- [NYSDEC] New York State Department of Environmental Conservation. 2015c. *Indian Point Background*. 2015. Available at <<http://www.dec.ny.gov/chemical/61837.html>> (accessed 13 April 2015).
- [NYSDEC] New York State Department of Environmental Conservation. 2015d. "The Hudson Estuary: A River That Flows Two Ways." Available at <<http://www.dec.ny.gov/lands/4923.html>> (accessed 4 April 2015).
- [NYSDEC] New York State Department of Environmental Conservation. 2015e. "Lower Hudson Watershed." Available at <<http://www.dec.ny.gov/lands/48367.html>> (accessed 4 April 2015).
- [NYSDEC] New York State Department of Environmental Conservation. 2015f. "Water Withdrawal Permits and Reporting for Municipal, Industrial, and Commercial Facilities." Available at <<http://www.dec.ny.gov/lands/55509.html>> (accessed 4 April 2015).
- [NYSDEC] New York State Department of Environmental Conservation. 2016. Letter from K. Moser, Deputy Commissioner, NYSDEC, to C. Bladey, Office of Administration, NRC. Re: Comments on the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 38, Volume 5, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3, Draft Report for Comment* (NUREG-1437). March 4, 2016. ADAMS Accession No. ML16069A379.
- [NYSDEC] New York State Department of Environmental Conservation. 2017a. "Fact Sheet. New York State Pollutant Discharge Elimination System (SPDES) Draft Permit Renewal with Modification, Indian Point Electric Generating Station, Buchanan, NY." January 2017. Available at <http://www.dec.ny.gov/docs/permits_ej_operations_pdf/ipspdesfctsh.pdf> (accessed 8 March 2017).
- [NYSDEC] New York State Department of Environmental Conservation. 2017b. "Natural Resources and Environmental Protection Maps," [Data set: Water Withdrawals, Google Earth]. Available at <<http://www.dec.ny.gov/pubs/103459.html>> (accessed 2 February 2017).
- [NYSDEC] New York State Department of Environmental Conservation. 2017c. State Pollutant Discharge Elimination System (SPDES) Discharge Permit NY0004472. Issued April 24, 2017. Effective May 1, 2017. ADAMS Accession No. ML17138A236.
- [NYSDEC] New York State Department of Environmental Conservation. 2017d. Supplemental Final Environmental Impact Statement by the New York State Department of Environmental Conservation as Lead Agency Concerning the Application to Renew New York State Pollutant Discharge Elimination System (SPDES) Permits for the Indian Point 2 & 3 Steam Electric Generating Units, Orange, Rockland, and Westchester Counties, Hudson River Power Plants FEIS. April 24, 2017. ADAMS Accession No. ML17138A342.
- [NYSDEC] New York State Department of Environmental Conservation. 2017e. 401 Water Quality Certification, Entergy Nuclear Operations, Inc., Indian Point 1, 2, and 3 Nuclear Power Plant located in Buchanan in Westchester County. April 24, 2017. ADAMS Accession No. ML17138A317.

References

- [NYS DOS] New York State Department of State. 2012. Significant Coastal Fish & Wildlife Habitats, Coastal Fish and Wildlife Rating Form, Hudson Highlands. Office of Planning and Development. Updated August 15, 2012. Available at <http://www.dos.ny.gov/opd/programs/consistency/Habitats/HudsonRiver/Hudson_Highlands_FINAL.pdf> (accessed 14 March 2016).
- [NYS DOS] New York State Department of State. 2017. Letter from S. Allen, Deputy Secretary of State, NYSDOS, to F. Dacimo, Vice President Operations License Renewal, Entergy. Subject: F-2017-0010 Coastal Zone Management Act Consistency Determination, Indian Point Nuclear Generating Unit Nos. 2 & 3, NRC License Nos. DPR-26 and DPR-64, NRC Docket Nos. 50-24 7 and 50-286, Concurrence with Consistency Certification. March 2, 2017. ADAMS Accession No. ML17187A394.
- [NYSDOT] New York State Department of Transportation. 2013. *Geotechnical Design Manual, L Chapter 3, Geology of New York State*. June 17, 2013. Available at <https://www.dot.ny.gov/divisions/engineering/technical-services/geotechnical-engineering-bureau/geotech-eng-repository/GDM_Ch-3_Geology_of_NY.pdf> (accessed 2 March 2015).
- [NYSDOT and NYSTA] New York State Department of Transportation and New York State Thruway Authority. 2012. *Tappan Zee Hudson River Crossing Project—Final Environmental Impact Statement and Section 4(f) Evaluation*. July 25, 2012. Available at <<http://www.newnybridge.com/documents/feis/>> (accessed 11 September 2015).
- O'Connor MP, Juanes F, McGarigal K. 2012. Findings on American shad and striped bass in the Hudson River estuary: A fish community study of the long-term effects of local hydrology and regional climate change. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science* 4:327–336.
- O'Grady JJ, Reed DH, Brook BW, Frankhan R. 2004. What are the best correlates of predicted extinction risk? *Biological Conservation* 118(4):513–520.
- Overholtz WJ, Hare JA, Keith CM. 2011. Impacts of interannual environmental forcing and climate change on the distribution of Atlantic Mackerel on the U.S. Northeast Continental Shelf. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science* 3: 219–232.
- Perlmutter NM. 1960. *Sources of Ground Water in Southeastern New York*. Geological Survey Circular 417. U.S. Geological Survey. 1960. Available at <<http://pubs.usgs.gov/circ/1960/0417/report.pdf>> (accessed 12 January 2015).
- [PG&E] Pacific Gas and Electric Company. 2014. Diablo Canyon Units 1 and 2—10 CFR 54.21(b) Annual Update to the Diablo Canyon Power Plant License Renewal Application (LRA), Amendment 48 and LRA Appendix E, Applicant's Environmental Report—Operating License Renewal Stage, Amendment 1. San Luis Obispo, CA. December 2014. ADAMS Accession No. ML14364A259.
- Pimm SL, Jones HL, Diamond J. 1988. On the risk of extinction. *The American Naturalist* 132(6):757–785.
- [PNNL] Pacific Northwest National Laboratory. 2002. Geochemical Factors Affecting the Behavior of Antimony, Cobalt, Europium, Technetium, and Uranium in Vadose Sediments, PNNL-14126. December 2002. Available at <http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14126.pdf> (accessed 10 November 2016).
- Raimondi PT, Wilson CM, Ambrose RF, Engle JM, Minchinton TE. 2002. Continued declines of black abalone along the coast of California: are mass mortalities related to El Niño events? *Marine Ecology Progress Series* 242:143–152.

- Reuters. 2013. "INTERVIEW—NRG could help NY replace Indian Point Nuclear Plant." Available at <http://articles.chicagotribune.com/2013-01-31/news/sns-rt-utilities-nrgindianpoint-interview1n0atfx-20130131_1_energy-highway-plan-electric-market-prices-indian-point> (accessed 27 March 2015).
- Riverkeeper, Inc. 2016. Letter from J. Bacon, Attorney for Riverkeeper, to Rulemakings and Adjudications Staff, NRC. Re: Comments of Riverkeeper, Inc. on *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 38, Volume 5, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3, Draft Report for Comment* (NUREG–1437) ID NRC-2008-0672. March 4, 2016. ADAMS Accession No. ML16069A366.
- [Riverkeeper et al.] Riverkeeper, Inc., Hudson and River Sloop Clearwater, Inc., and Entergy Nuclear Operations. 2012. Joint Motion for Approval of Settlement Agreement and Dismissal of Consolidated Contention Riverkeeper EC-3 and Clearwater EC-1 (Spent Fuel Pool Leaks), Entergy Nuclear Operations, Inc. (Indian Point Units 2 and 3), Docket Nos. 50-247-LR and 50-286-LR, ASLBP No. 07-858-03-LR-BDO1 Evidentiary Hearing, before the Atomic Safety and Licensing Board. October 12, 2012. ADAMS Accession No. ML12286A178.
- Rose, GA. 2005. On distributional responses of North Atlantic fish to climate change. *ICES Journal of Marine Science* 62:1360–1374.
- Rosenzweig C, Solecki W, DeGaetano A, O'Grady M, Hassol A, Granhorn P. 2011. "Responding to Climate Change in New York State: The ClimAid Integrated Assessment for Effective Climate Change Adaptation." Available at <<http://www.nyserda.ny.gov/climaid>> (accessed 18 March 2015).
- Seekell DA, Pace ML. 2011. Climate change drives warming in the Hudson River Estuary, New York. *Journal of Environmental Monitoring* 13:2321–2327.
- Sheffield PE, Carr JL, Kinney PL, Knowlton K. 2011. Modeling of regional climate change effects on ground-level ozone and childhood asthma. *American Journal of Preventive Medicine*, Volume 41. Available at <[http://www.ajpmonline.org/article/S0749-3797\(11\)00346-1/fulltext](http://www.ajpmonline.org/article/S0749-3797(11)00346-1/fulltext)> (accessed 12 April 2015).
- Skinner LC, Sinnott TJ. 2009. "Measurement of Strontium-90 (⁹⁰Sr) and Other Radionuclides in Edible Tissues and Bone/Carapace of Fish and Blue Crabs from the Lower Hudson River, New York." New York State Department of Environmental Conservation, Division of Fish, Wildlife and Marine Resources. November 2009. Available at <http://www.dec.ny.gov/docs/materials_minerals_pdf/sr90fnlrprt.pdf> (accessed 30 March 2015).
- State of New York. 2017. "Data, Energy and Environment, Water Withdrawals by Facility: Beginning 2009." Available at <<https://data.ny.gov/Energy-Environment/Water-Withdrawals-by-Facility-Beginning-2009/94ue-tysy>> (accessed 17 February 2017).
- Strayer DL. 2006. Chapter 19. "The Benthic Animal Communities of the Tidal-Freshwater Hudson River Estuary." In: Levinton JS, Waldman JR, editors. *The Hudson River Estuary*. Cambridge University Press, New York. p 266–278.
- Sykes LR, Armbruster JG, Kim WY, Seeber L. 2008. 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* 98(4):1696–1719. August 2008. Available at <<http://www.bssaonline.org/content/98/4/1696.abstract>> (accessed 27 February 2015).

References

- Tagaris E, Manomaiphiboon K, Liao K-J, Leung LR, Woo J-H, He S, Amar P, Russell AG. 2007. Impacts of global climate change and emissions on regional ozone and fine particulate matter concentrations over the United States. *Journal of Geophysical Research* 112:D14312. Available at <<http://onlinelibrary.wiley.com/doi/10.1029/2006JD008262/full>> (accessed 28 May 2015).
- Tagaris E, Liao KJ, Delucia AJ, Deck L, Amar P, Russell AG. 2009. Potential impact of climate change on air pollution related human health effects. *Environmental Science and Technology* 43:4979–4988. Available at <<http://pubs.acs.org/doi/pdf/10.1021/es803650w>> (accessed 28 December 2014).
- [TDI] Transmission Developers, Inc. 2015. “Champlain Hudson Power Express Project Development Portal.” Available at <<http://www.chpexpress.com/>> (accessed 27 March 2015).
- Thuiller W. 2007. Biodiversity: Climate change and the ecologist. *Nature* 448:550–552.
- [TILCON] Tilcon New York, Inc. 2015. “Tomkins Cove Quarry.” Available at <<http://tilconny.com/location.htm?Stone-Quarry-Tomkins-Cove-New-York-Rockland-County-NY-6>> (accessed 2 March 2015).
- Times-Herald Record. 2013. “\$1B project would bury powerline under Hudson; 80-mile line could power a million homes.” Available at <http://westpointproject.com/wp-content/uploads/2013/08/06.15.13-1B-project-would-bury-powerline-under-Hudson-Times-H_R.pdf> (accessed 31 March 2015).
- [USCB] U.S. Census Bureau. 2015. “American FactFinder, Census 2010 Summary File 1, Population by Race, Combinations of Two Races, and Not Hispanic or Latino,” and “American FactFinder, 2013 Estimate, American Community Survey 1-Year Estimates, Table DP03— Selected Economic Characteristics.” Available at <<http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml>> (accessed 20 May 2015).
- [USDA] U.S. Department of Agriculture. 2015. *Custom Soil Resource Report for Westchester County, New York, Indian Point*. National Resources Conservation Service. 2015. Available at <<http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm>> (accessed 27 February 2015).
- [USGCRP] U.S. Global Change Research Program. 2009. *Global Climate Change Impacts in the United States*. Karl TR, Melillo JM, Peterson TC, editors. ADAMS Accession No. ML100580077.
- [USGCRP] U.S. Global Change Research Program. 2014. *Climate Change Impacts in the United States: The Third National Climate Assessment*. Melillo JM, Richmond TC, Yohe GW, editors. ADAMS Accession No. ML14129A233.
- [USGS] U.S. Geological Survey. 2015a. New York 2014 Seismic Hazard Map. Available at <http://earthquake.usgs.gov/earthquakes/states/new_york/hazards.php> (accessed 27 February 2015).
- [USGS] U.S. Geological Survey. 2015b. *New York Earthquake History*. Available at <http://earthquake.usgs.gov/earthquakes/states/new_york/history.php> (accessed 27 February 2015).
- [USGS] U.S. Geological Survey. 2015c. *New Jersey Earthquake History*. Available at <http://earthquake.usgs.gov/earthquakes/states/new_jersey/history.php> (accessed 27 February 2015).
- [USGS] U.S. Geological Survey. 2015d. *Pennsylvania Earthquake History*. Available at <<http://earthquake.usgs.gov/earthquakes/states/pennsylvania/history.php>> (accessed 27 February 2015).

- [USGS] U.S. Geological Survey. 2015e. *Connecticut Earthquake History*. Available at <<http://earthquake.usgs.gov/earthquakes/states/connecticut/history.php>> (accessed 27 February 2015).
- [USGS] U.S. Geological Survey. 2017. *USGS Water-Year Summary 2015, 01358000 Hudson River at Green Island, NY*. Available at <https://waterdata.usgs.gov/nwis/uv?site_no=01358000> accessed 23 February 2017).
- [USNY] University of the State of New York. 1970. *Geologic Map of New York, Lower Hudson Sheet. 1970*. Available at <http://www.nysm.nysed.gov/gis/bedrock_scans/Lower_Hudson_Bedrock_Sheet.jpg> (accessed 8 January 2015).
- Waldman JR, Lake TR, Schmidt RE. 2006. "Biodiversity and Zoogeography of the Fishes of the Hudson River Watershed and Estuary." In: Waldman JR, Limburg KE, Strayer DL, editors. *Hudson River Fish and Their Environment*. American Fisheries Society Symposium 51, Bethesda, MD. p 129–150.
- Wheelabrator Technologies. 2015. "Wheelabrator Westchester L.P." Available at <<http://www.wtienergy.com/plants/waste-to-energy/wheelabrator-westchester-lp/>> (accessed 4 April 2015).
- Williams JH. 2008. Flow-Log Analysis for Hydraulic Characterization of Selected Test Wells at the Indian Point Energy Center, Buchanan, New York, U.S. Geological Survey, Open-File Report 2008–1123. 2008. Available at <<http://pubs.usgs.gov/of/2008/1123/>> (accessed 20 October 2014).
- Woodall CW, Oswalt CM, Westfall JA, Perry CH, Nelson MD, Finley AO. 2009. An indicator of tree migration in forests of the eastern United States. *Forest Ecology and Management* 257, p 1434–1444.
- Wu S, Mickley LJ, Leibensperger EM, Jacob DJ, Rind D, Streets DG. 2008. Effects of 2000-2050 global change on ozone air quality in the United States. *Journal of Geophysical Research* 113:D06302. Available at <<http://onlinelibrary.wiley.com/doi/10.1029/2007JD008917/full>> (accessed 28 May 2015).

10.0 LIST OF PREPARERS

Members of the NRC’s Office of Nuclear Reactor Regulation prepared this final supplemental environmental impact statement (FSEIS) supplement with assistance from other NRC organizations, as well as contract support from the Pacific Northwest National Laboratory. Table 10–1 identifies each contributor’s name, affiliation, and function or expertise.

Table 10–1. List of Preparers

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APPENDIX A
REVISED IMPINGEMENT AND ENTRAINMENT ANALYSIS
FOR INDIAN POINT NUCLEAR GENERATING UNIT NOS. 2 AND 3

A. Revised Impingement and Entrainment Analysis for Indian Point NUCLEAR GENERATING Unit Nos. 2 and 3

A.1 Introduction

By letter dated April 23, 2007, Entergy Nuclear Operations, Inc. (Entergy) submitted an application to the U.S. Nuclear Regulatory Commission (NRC) to issue renewed operating licenses for Indian Point Nuclear Generating Unit Nos. 2 and 3 (IP2 and IP3) for additional 20-year periods. Under Title 10 of the *Code of Federal Regulations* (10 CFR) 51.20(b)(2) and the National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. 4321 et seq.), the renewal of a power reactor operating license requires preparation of an environmental impact statement (EIS) or a supplement to an existing EIS. In addition, 10 CFR 51.95(c) states that the NRC shall prepare an EIS, which is a supplement to the Commission's NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), Revision 1, which was issued in June 2013.

The NRC staff published its final supplemental environmental impact statement (FSEIS) for IP2 and IP3 in December 2010. The FSEIS (NRC 2010) considered the effects of impingement and entrainment (I&E), among other topics. In 2011, Entergy and others submitted new and revised I&E data, analyses, and comments. The NRC staff considered this new information, incorporated it into its analysis, modified some of its I&E findings, and published a supplement to the FSEIS in June 2013 (NRC 2013b). In February 2014 and April 2015, Entergy (2014, 2015) submitted additional new information that affected some of the NRC staff's results. The NRC staff has considered the new information and updated its impact assessment. This Appendix addresses Entergy's new information on the impacts of I&E at IP2 and IP3 and provides support for the discussion contained in Section 4 of the current FSEIS supplement. Additionally, this appendix includes updates related to public comments received on the draft supplement to the FSEIS (see Appendix B.2) following its issuance in December 2015. As such, it constitutes a separate analysis from the analyses presented in the 2013 FSEIS supplement and Chapter 4 and Appendices H and I of the 2010 FSEIS.

The IP2 and IP3 site is located on the Hudson River estuary at River Kilometer (RKM) 67 (River Mile (RM) 42). Cooper et al. (1988) and Levinton and Waldman (2006) describe the geological, physical, chemical, and biological setting of the Hudson River. Beebe and Savidge (1988), Daniels et al. (2005), and Waldman et al. (2006) describe the fish communities of the Hudson River estuary and their environment. IP2 and IP3 began operation in 1974 and 1976, respectively, and withdraw more cooling water than any other facility intake from the Hudson River estuary. The investigation of the effects of power plant water intakes on the Hudson River ecosystem began in the early 1960s, and the results of many I&E studies have been published. Results of early investigations into the effects of I&E at IP2 and IP3 appear in Barnhouse et al. (1988). NRC (2010) describes IP2 and IP3 and the impact of plant operation, including I&E, on the environment.

For assessing impacts under NEPA, the NRC classifies impacts into three levels using definitions found in 10 CFR Part 51 and NRC (2013a):

- **SMALL**—Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.
- **MODERATE**—Environmental effects are sufficient to alter noticeably, but not to destabilize, any important attributes of the resource.

Appendix A

- **LARGE**—Environmental effects are clearly noticeable and are sufficient to destabilize any important attributes of the resource.

The NRC's definitions of SMALL, MODERATE, and LARGE impact levels center on two properties of the response of the resource to the environmental stresses from power plant operation: Is the response detectable or noticeable and is it sufficient to destabilize any important attributes of the resource. The definitions do not define "stabilize" or "destabilize," and ecologists have adopted over a dozen different operational definitions of ecological stability, depending on application. For effects on aquatic resources, the NRC staff has adopted the concept of stability meaning not changing in time or space due to power plant operation. This concept of stability has several advantages here. Attributes of populations can be statistically tested for change using analysis of variance (ANOVA), regression (trend analysis), or other means; commercial and recreational fishing records or other information can be used in addition to local monitoring studies; and past responses of the resource to plant operation can be used to predict future impacts. The analysis below applies these concepts to determine impacts to representative species and life stages to infer an overall level of impact for aquatic resources.

Previous analyses of I&E at IP2 and IP3, as at most power plants, generally employed modified fisheries models. Fisheries biology models tend to focus on single species attributes, such as sustaining a harvest rate, regardless of any changes in the attributes of other species within the ecosystem. The Hudson River estuary is a dynamic, open-ended system containing a complex food web hydrologically connected from freshwater habitats near the Troy Dam to the Atlantic Ocean, and I&E affects the various life stages of many species, their predators, prey, and competitors simultaneously. Even under the best circumstances, the number of unknowns in such typical fisheries models greatly exceeds the number of observations in the environment, and the models have shortcomings and should be viewed skeptically (Schnute and Richards 2001). In assessing the impacts of power plant operations on Hudson River striped bass (*Morone saxatilis*), Fletcher and Deriso (1988) found that routine or creative uses of existing spawner-recruitment models were not useful for long-term impact forecasting and that the techniques and methods of analysis that fail in fishery assessments are also likely to fail in impact assessment.

The NRC staff analysis (NRC 2010, 2013b) sought to consider potential impacts across trophic levels and life history strategies by weighting two lines of evidence (LOEs), as recommended by the U.S. Environmental Protection Agency (EPA) (EPA 1998) for ecological risk assessments, to several sentinel species to achieve an ecosystem-level understanding. The approach is empirical and minimizes the number of unknowns and assumptions. A weight of evidence (WOE) approach combines the two LOEs for impact assessment loosely following Menzie et al. (1996).

The first LOE examines population trends of representative important species (RIS). In this LOE, the NRC staff considers decreasing trends in population size of crabs and young-of-year fish (together referred to as YOY) across the 27 years of monitoring data to be evidence of resource destabilization. The second LOE, called strength of connection (SOC), employs a Monte Carlo technique to determine whether statistically significant decreasing trends in abundance could be observable. The final WOE combines the two LOEs to

determine whether significant decreasing trends could be attributable to IP2 and IP3 operations and to address the components of resource stability and observability in the NRC staff's impact-level definitions. The WOE integrates the two LOEs following the logic EPA developed

A Monte Carlo Analysis is a mathematical simulation that is run several hundred times in order to characterize the probability of a certain outcome. The model is based on repeated random sampling and provides distributions, or likelihoods, for a range of outcomes.

to evaluate the ecological effects of environmental stressors (EPA 1998). In this assessment, the IP2 and IP3 cooling system operation is the stressor; the aquatic community, as represented by sentinel populations, is the receptor; the SOC qualifies degree of exposure; and the trend analysis quantifies the effect on the receptors.

In formulating the SOC, the NRC staff included terms to account for population fluctuations, trends, and random noise resulting from indirect effects. As noted by the EPA in its final Clean Water Act § 316(b) regulations (79 FR 48300), a number of indirect, ecosystem-level effects may occur as a result of power plant water withdrawals in addition to direct losses of aquatic organisms from I&E, including:

- disruption of aquatic food webs resulting from the loss of impinged and entrained organisms that provide food for other species,
- disruption of nutrient cycling and other biochemical processes,
- alteration of species composition and overall levels of biodiversity, and
- degradation of the overall aquatic environment.

For aquatic populations in the area potentially affected by the operation of a power plant's cooling water intake structure, these indirect effects can decrease the available prey and alter interspecific interactions with competitors, predators, and parasites. To some extent, a power plant's thermal effluent may also contribute to these disruptions. The effect of power plant operation on a particular population through these various pathways may be to further diminish the population or to affect the population in other ways. Already-diminished populations may suffer increased susceptibility to indirect effects as well as to natural environmental variation, which in turn could increase the magnitude of year-to-year population fluctuations. Many investigators have reported that stressed populations exhibit increased population fluctuations and that this variability can indicate population or ecosystem instability (e.g., Pimm et al. 1988; IUCN 2000; Carpenter and Brock 2006; Anderson 2008).

A.2 Methods

The NRC staff's present analysis differs somewhat from the analyses in the FSEIS (NRC 2010, 2013b), Entergy's (2014) and AKRF's (2014) submissions, and Entergy's (2015) and AKRF's (2015) submissions in response to NRC (2015a) staff requests for additional information. The NRC staff's present independent analysis uses data from 1985 through 2011 for both the population trend analyses and for the regression and variability parameters used in the Monte Carlo SOC analysis, as does AKRF (2014, 2015), but it also incorporates field data updated by Entergy following the submission of the AKRF report (reviewed in Section 4.1). In addition, another difference between AKRF's analysis and the NRC staff's present analysis is that AKRF selected periods of consistent sampling based on sample week number, whereas the NRC staff uses month designations, because of differences in the available data sets. The NRC staff's evaluation in this appendix is a "standalone" presentation that references information in previous FSEIS volumes and does not contain redline-strikeout text, figures, or tables to replace information and statements presented in the 2010 FSEIS or 2013 supplement to the FSEIS. Except where it is necessary to differentiate between the two volumes, the NRC staff collectively refers to the 2010 FSEIS (NRC 2010), as modified by the 2013 supplement to the FSEIS (NRC 2013b), as the "FSEIS" in this appendix.

Data sources

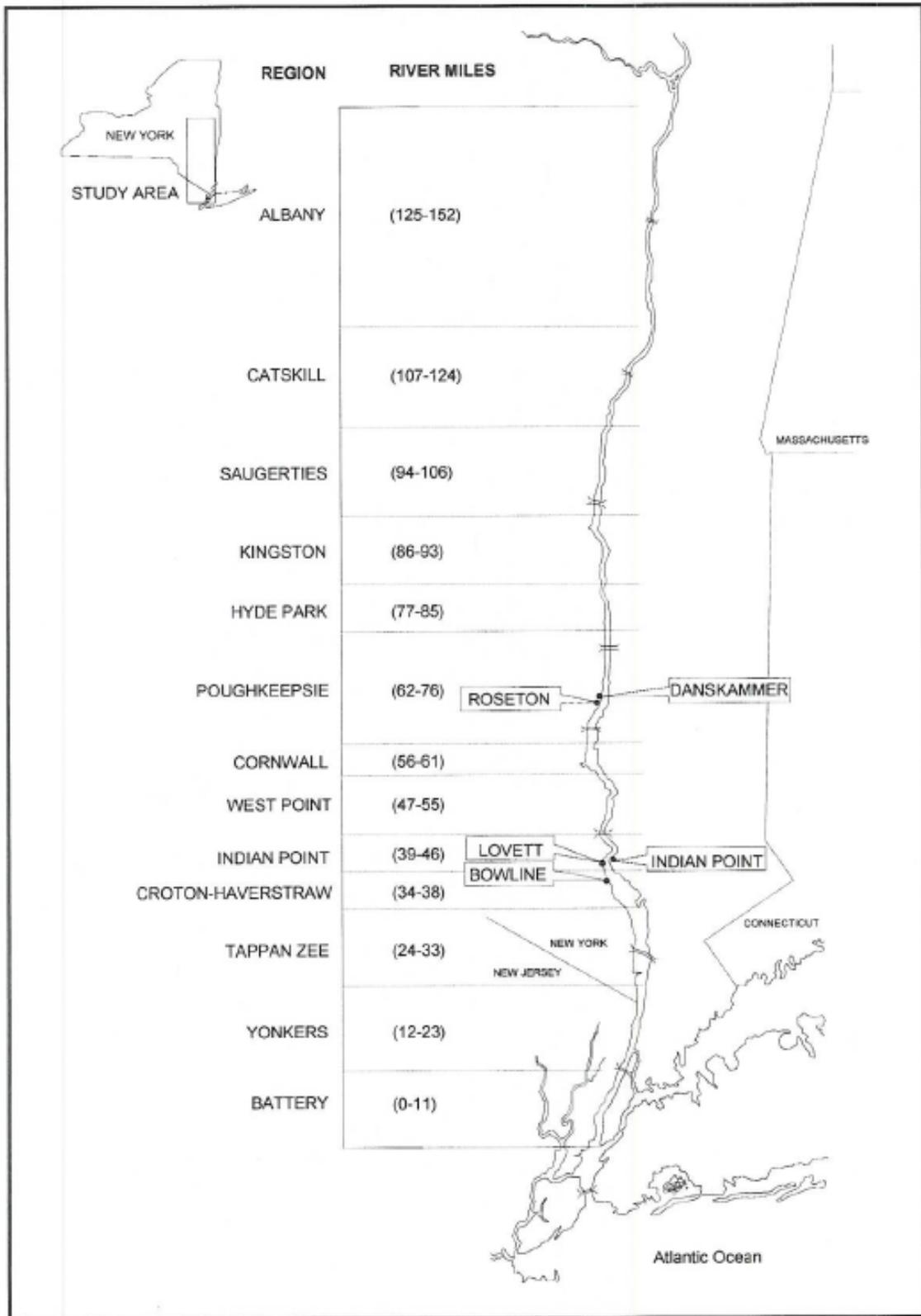
Data on fish in the Hudson River come from a multi-utility Hudson River Monitoring Program. Several Hudson River utilities have conducted monitoring studies of fish in the Hudson River

from 1975 through the present. At the NRC staff's request, Entergy supplied data from the Hudson River Estuary Monitoring Program in 2007, corrected and new information in 2008, and new information in 2011. Entergy voluntarily submitted new information in 2014, including additional years of data. In response to additional NRC staff requests, Entergy provided data from the Hudson River monitoring programs in October 2014 and corrected data in April 2015.

The Hudson River Monitoring Program (the Program) includes three surveys to sample fish in the river. The Long River Survey (LRS) collects eggs, larvae, and juvenile fish; the Fall Shoals Survey (FSS) collects juvenile and older fish in the river; and the Beach Seine Survey (BSS) collects juvenile and older fish in shallow beach areas. The Program divides the river into 13 regions or segments (Figure A–1) from the Federal dam in Troy south to the Battery in Manhattan (Klauda et al. 1988; Abood et al. 2006). IP2 and IP3 lie in River Segment 4, the Indian Point segment. Each river segment consists of four habitat strata. The shore stratum extends from the shoreline to a depth of 10 feet (ft) (3 m) (sampled by the BSS). The shoal stratum extends from the shore to a depth of 20 ft (6 m) at mean low tide on both sides of the river (sampled by the LRS and FSS). The bottom stratum extends upward from the bottom to 10 ft (3 m) above the river bottom where the water depth is greater than 20 ft (6 m) at mean low tide (sampled by the LRS and BSS). The channel stratum is the portion of the river not considered bottom where the river depth exceeds 20 ft (6 m) at mean low tide (sampled by the LRS and FSS). The Program allocates samples to segments and strata in a stratified random design. The LRS samples early in the year (Figure A–2) and is designed to capture ichthyoplankton, although it also captures YOY of some species. The FSS and BSS sample later in the year and are designed to capture YOY and older fish. ASA (2013) describes the Program and survey methods in detail.

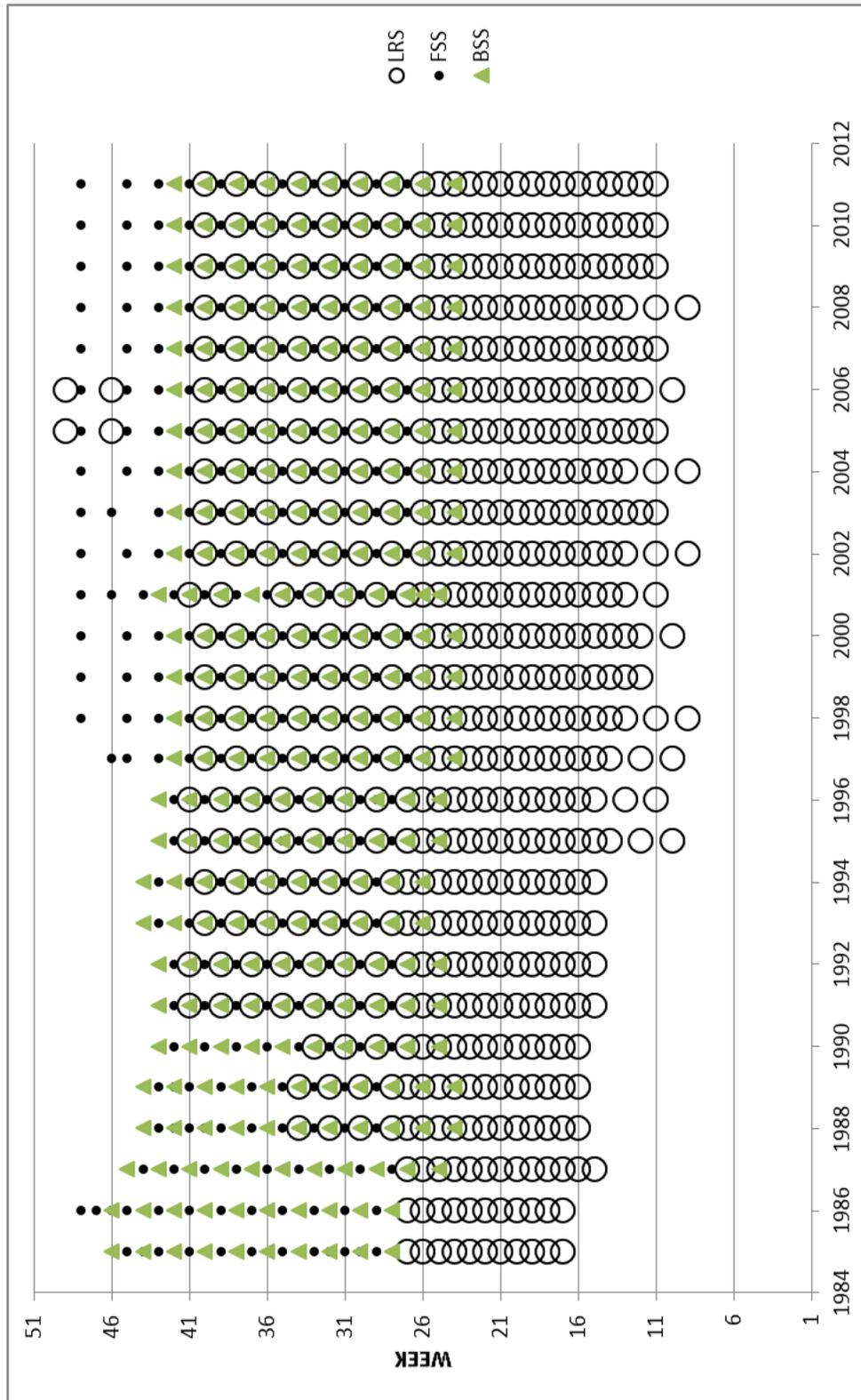
Sampling methods varied somewhat in the early years of the Program until 1985. Between 1974 and 1984, the FSS employed a 1-square meter (m²) (1-square yard (yd²)) Tucker trawl with a 3-millimeter (mm) (1/8-inch (in.)) mesh to sample the channel and a 1-m² (1-yd²) epibenthic sled with a 3-mm (1/8-in.) mesh to sample the bottom and shoal strata. From 1985 to present, a 3-meter (m) (1-yard (yd)) beam trawl with a 38-mm (1½-in.) mesh on all but the cod-end replaced the epibenthic sled. Size selectivity and relative catch efficiency between gear types was tested during nocturnal samplings between August and September 1984, and the beam trawl was found to sample bay anchovy (*Anchoa mitchilli*), American shad (*Alosa sapidissima*), and weakfish (*Cynoscion regalis*) more efficiently than the epibenthic sled (NYPA 1986).

Figure A-1. Sampling Regions of the Hudson River Monitoring Program



Source: ASA 2013

Figure A–2. Weeks Sampled by the Three Hudson River Monitoring Program Surveys (LRS, FSS, and BSS), 1985–2011



Source: Figure created with data from ASA and ASA (2014) and Entergy (2015)

This gear change does not affect samples from the shore (BSS) or channel strata (LRS and FSS), which have consistently been sampled by beach seines and Tucker trawls, respectively, since the program began. NRC (2010, Appendices H and I) analyzes the effects of the FSS gear change on abundance estimates for various Hudson River fish species. The present assessment relies primarily on data from 1985 through 2011.

Data on I&E survival at IP2 and IP3 come from Entergy (2007). Impingement was monitored from 1975 through 1990 and entrainment in 1981 and from 1983 through 1987. Fletcher (1990) reports impingement survival estimates, although these estimates have not been verified after new Ristroph screens were installed at IP2 and IP3 in 1991. The NRC staff's present analysis uses I&E data from these studies, including impingement survival estimates. Table A–1 summarizes relevant aspects of the monitoring studies that the staff used to assess impacts.

Table A–1. Hudson River Monitoring Studies Used to Assess Impacts

Study	Study Dates	Information Available
Impingement Abundance ^(a)	1975–1990	Number of fish impinged at IP2 and IP3.
Entrainment Abundance ^(a)	1981 and 1983–1987	Entrainment density by species and life stage for IP2 and IP3 combined.
Longitudinal River Ichthyoplankton or Long River Survey (LRS) ^(b)	1974–2011	Standing crop, temporal and geographic distributions, and growth rates for ichthyoplankton forms of fish species, with an emphasis on Atlantic tomcod, American shad, striped bass, white perch, and bay anchovy. Sampling generally occurred in spring, summer, and fall.
Fall Juvenile or Fall Shoals Survey (FSS) ^(b)	1974–2011	Standing crop and temporal and geographic indices for YOY fish in shoal, bottom, and channel habitats in the estuary with an emphasis on Atlantic tomcod, American shad, striped bass, and white perch. Surveys generally conducted in midsummer and fall.
Beach Seine Survey (BSS) ^(b)	1974–2011	Abundance and distribution of YOY fish in the shore-zone habitat in the estuary, with an emphasis on American shad, Atlantic tomcod, striped bass, and white perch. Surveys generally conducted in summer and fall.

^(a) Data provided by Entergy (2007)

^(b) Data provided by Entergy (2015, 2016)

Entergy (2014, 2015) provided the annual Hudson River Estuary Monitoring Program Year Class Reports for 2006 through 2011 (ASA 2008, 2009, 2010, 2011, 2012, 2013), and the data for this analysis from all three field surveys (LRS, FSS, and BSS). The three data sets included the utilities' annual YOY Abundance Index values for each requested taxon from 1974 through 2011; the weekly total catch of YOY and yearling and older fish, number of samples, and volume sampled per taxon and river segment from 1979 through 2011; and the weekly YOY catch density per taxon for each river segment for the RIS from 1979 through 2011. The weekly volume, total catch, and catch density were the combined results of each gear type. Some changes to the sampling intensity and duration occurred for all three sampling programs, including about five levels of sampling intensity in the LRS and three-to-four levels of sampling intensity in the FSS and BSS.

The NRC staff assessed population trends by examining the consistency of multiple measures of abundance for several sampling programs. Because each sampling program and measure emphasized a different season or aspect of each population, the NRC staff believes that examining consistency provides a better understanding of trends than an examination of any

single measure. The NRC staff's Population Trend LOE uses multiple measures of abundance to incorporate survey information at two geographic scales (River Segment 4 and riverwide), different sampling periods (May to July and July to October), different river strata (shore, bottom, shoals, and surface), and weighting schemes. The LRS, FSS, and BSS all employ a stratified random design to account for the variability of the timing and location of YOY in the river, and each sampling program targets a specific time period and specific river strata. The LRS targets fish from May to July within the same river strata (bottom, shoals, and surface) as the FSS, which targets fish from July to October. The BSS targets fish along the shoreline from July to October.

For data provided by week, the NRC staff used LRS data collected from May through July and FSS and BSS data collected from July through October between 1985 and 2011 to calculate annual measures of abundance for trend analysis. Data collected between 1985 and 2011 postdate the mid-1970s when operation began at IP2 and IP3. The YOY populations may have responded soon after operation began and subsequently restabilized at lower levels before 1985, which argues for using data starting in 1975 as in the FSEIS, but the sampling protocols from 1985 through 2011 were relatively consistent and did not include the gear change for bottom and shoal strata in the FSS in 1984–1985, which simplifies the analysis used here. The NRC staff recognizes that using either time period inherently introduces uncertainty into the I&E analysis. Using pre-gear change data introduces uncertainty related to the gear change itself, whereas using post-gear change data introduces uncertainty related to the response of YOY populations in the early years of IP2 and IP3 operations. The staff addresses these and other uncertainties in detail in Section 4.5 of this supplement.

The NRC staff calculated river-segment measures of YOY abundance from the LRS, FSS, and BSS as the 75th percentiles of the weekly density (provided by Entergy) and weekly catch-per unit-effort (CPUE; number caught/volume sampled) from 1985 through 2011 (n=27 annual observations for each RIS). The BSS River Segment 4 CPUE index was identical to the density index (both calculated as the number of YOY caught divided by the number of tows) and was not used in the trend analysis. The NRC staff calculated a riverwide measure of YOY abundance of total CPUE (total number caught/total volume sampled) from the LRS, FSS, and BSS for 1985 through 2011 (n=27 for each RIS).

Entergy provided the utilities' annual Abundance Index values for the YOY RIS from the LRS, FSS, and BSS from 1979 through 2011, and ASA (2013) provides index values for 1974 through 1978. The utilities' riverwide LRS and FSS Abundance Indices weight average river segment densities by the volumes of the river segments. The construction of the LRS and the FSS abundance indices is similar and provides unbiased estimates of the total and mean riverwide population abundance. The indices are constructed as a weighted mean of the average species densities, with weight given by the volume of each stratum (channel, bottom, and shoal) for a given river segment. The Poughkeepsie and West Point river segments have the greatest channel volumes, Poughkeepsie and Tappan Zee have the greatest bottom volumes, and the Tappan Zee has the greatest shoal volume (see Figure A–1). Because River Segment 4, where IP2 and IP3 lie, does not have large bottom or shoal volumes, the utilities' LRS and FSS Abundance Indices are not sensitive to changes in population trends near IP2 and IP3 and are most sensitive to the river segments and strata with greatest volumes. By weighting all regions equally, the NRC staff's measures of riverwide abundance are more sensitive to changes in population trends near IP2 and IP3. Other sources of information on population trends include the New York State Department of Environmental Conservation's (NYSDEC's) indices of riverwide abundance for YOY striped bass, YOY American shad, and Atlantic tomcod (*Microgadus tomcod*), and the National Marine Fisheries Service's (NMFS's) (2013) biological opinion on the effect of the IP2 and IP3 cooling water intake

systems on Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) and shortnose sturgeon (*A. brevirostrum*).

Following the issuance of the draft version of this supplement to the FSEIS (NRC 2015b), Entergy (2016) submitted additional data on the Atlantic menhaden (*Brevoortia tyrannus*) to the NRC as part of Entergy's public comments on the draft supplement. Entergy's newly provided data are considered in this final supplement.

Additionally, the NRC staff considered several sources of uncertainty that could affect the NRC staff's findings following issuance of the draft supplement.

Representative Important Species (RIS)

The NRC staff identified 18 RIS as sentinel species for assessing the impacts of I&E (Table A–2). This list contains RIS identified in past analyses conducted by the NYSDEC, the NRC, and the current and past owners of IP2 and IP3. The selected RIS are sentinels for the overall aquatic resources and reflect the complexity of the Hudson River ecosystem because they encompass a broad range of attributes, such as biological importance, commercial or recreational value, trophic position, commonness or rarity, interaction with other species, vulnerability to cooling system operation, and fidelity or transience in the local community. The I&E impact assessment focuses primarily on the potential impacts to YOY and yearling fish and their prey. Although fish eggs and larvae are important components of the food web, their natural mortality rates are high (Barntouse et al. 2008, Secor and Houde 1995), and fish surviving to YOY and older are more likely to add to the adult breeding population, so that mortality from the cooling system operation on these life stages more likely affects population stability.

Table A–2. Representative Important Hudson River Aquatic Species

Common Name	Scientific Name	Occurrence and Status	Predator/Prey Relationships
Alewife	<i>Alosa pseudoharengus</i>	Anadromous	Juveniles eat insect larvae and amphipods; adults eat zooplankton, small fish, and fish eggs. Species is prey of bluefish, weakfish, and striped bass.
Atlantic menhaden	<i>Brevoortia tyrannus</i>	Permanent or seasonal resident	Juveniles and adults eat phytoplankton, zooplankton, copepods, and detritus. Species is prey of bluefish and striped bass.
American shad	<i>Alosa sapidissima</i>	Anadromous	Juveniles and adults primarily eat zooplankton, small crustaceans, copepods, mysids, small fish, and fish eggs. Species is prey of oceanic species.
Atlantic sturgeon	<i>Acipenser oxyrinchus oxyrinchus</i>	Federally listed by distinct population segment; Anadromous	Juveniles and adults are bottom feeders, subsisting on mussels, worms, shrimp, and small fish.

Appendix A

Common Name	Scientific Name	Occurrence and Status	Predator/Prey Relationships
Atlantic tomcod	<i>Microgadus tomcod</i>	Anadromous permanent or seasonal resident	Diet includes crustaceans, polychaete worms, mollusks, and small fish. Juveniles are prey of striped bass when anchovies are scarce.
Bay anchovy	<i>Anchoa mitchilli</i>	Estuarine	Species primarily eats zooplankton and is prey of YOY bluefish and striped bass.
Blueback herring	<i>Alosa aestivalis</i>	Anadromous	Species' diet includes insect larvae and copepods. It is prey of bluefish, weakfish, and striped bass.
Bluefish	<i>Pomatomus saltatrix</i>	Permanent or seasonal resident	Juveniles eat bay anchovy, Atlantic silverside, striped bass, blueback herring, Atlantic tomcod, and American shad. Species is prey of a variety of birds.
Gizzard shad	<i>Dorosoma cepedianum</i>	Freshwater	Juveniles eat daphnids, cladocerans, adult copepods, rotifers, algae, phytoplankton, and detritus; adults eat phyto- and zooplankton. Species is prey of striped bass, other bass species, and catfish.
Hogchoker	<i>Trinectes maculatus</i>	Estuarine	Adults are generalists and eat annelids, arthropods, and tellinid siphons. Species is prey of striped bass.
Rainbow smelt	<i>Osmerus mordax</i>	Anadromous	Larval and juvenile smelt eat planktonic crustaceans; larger juveniles and adults feed on crustaceans, polychaetes, and fish. Adults eat anchovies and alewives. Species is prey of striped bass and bluefish.
Shortnose sturgeon	<i>Acipenser brevirostrum</i>	Federally endangered; permanent or seasonal resident	Juveniles feed on benthic insects and crustaceans.
Spottail shiner	<i>Notropis hudsonius</i>	Freshwater	Species eats aquatic insect larvae, zooplankton, benthic invertebrates, and the eggs and larvae of fish, including their own species. Species is prey of striped bass.
Striped bass	<i>Morone saxatilis</i>	Anadromous	Species eats menhaden river herring, tomcod, and smelt. Larvae are prey of spottail shiner, white perch, striped bass, bluegill, and white catfish.

Common Name	Scientific Name	Occurrence and Status	Predator/Prey Relationships
Weakfish	<i>Cynoscion regalis</i>	Permanent or seasonal resident	Small weakfish feed primarily on crustaceans, while larger weakfish feed primarily on anchovies, herrings, spot. Species is prey of bluefish, striped bass, and other weakfish.
White catfish	<i>Ameiurus catus</i>	Freshwater	Juveniles eat midge larvae. Adults are omnivores, feeding on anything from fish to insects to crustaceans.
White perch	<i>Morone americana</i>	Estuarine	Species eat eggs of other fish and larvae of walleye and striped bass. Prey of larger piscivorous fish and terrestrial aquatic vertebrates.
Blue crab	<i>Callinectes sapidus</i>	Estuarine	Zoea eat phytoplankton, and dinoflagellates; adults opportunistic. Larval crabs are the prey of fish, shellfish, jellyfish; juvenile and adult blue crabs are prey of a wide variety of fish, birds, and mammals.

Source: Reproduced and updated from NRC (2010), Table 2–4

Population Trend LOE

The Population Trend LOE uses data from the LRS, FSS, and BSS and the utilities' Abundance Index to address the stability of the populations. Population trends were calculated on two geographic scales: River Segment 4 (the Indian Point segment) and riverwide (all river regions). The River Segment 4 data are the weekly LRS and FSS CPUE (YOY catch divided by the volume sampled) and LRS, FSS, and BSS catch density from 1985 through 2011 provided by Entergy. The riverwide data are the utilities' Abundance Index (1974 through 2011) and the LRS, FSS, and BSS catch per unit effort (CPUE) calculated as the annual sum of the weekly catch over all river segments divided by the total volume (or total number of tows for the BSS) sampled. This results in several measures of abundance and trend analyses at both the River Segment 4 and riverwide scales for each RIS.

The annual River Segment 4 estimate of the population response reflects the 75th percentile of the weekly data for a given year because it was not as sensitive as the mean to the few large observations collected each year (Sunitha et al. 2014) and because a percentile provides a better measure of central tendency given the highly skewed data. The NRC staff chose the 75th percentile rather than the median because, on average, 52 and 65 percent of the weekly FSS and BSS catches were zero for the RIS. A measure of riverwide effects is based on population trends in all river segments of the 1985 through 2011 annual CPUE and on the 1974 through 2011 annual abundance index values provided by Entergy. For several of the RIS, Entergy provided annual abundance index values from multiple surveys, of which the NRC staff used only the one with the greatest median CPUE over years (Table A–3).

Appendix A

The NRC staff standardized the annual measure of abundance values by subtracting the mean and dividing by the standard deviation among years to allow comparisons of the shape of the data over time among surveys and RIS. Because of the large variability in the density measure of abundance between years (coefficients of variation (CVs) ranging from 54 to 298 percent), the NRC staff used a 3-year moving average to smooth the river-segment standardized annual density index before the trend analysis.

Table A-3. Comparison of Riverwide Median YOY CPUE Among Hudson River Estuary Monitoring Surveys, 1985–2011

RIS	Data Used for YOY and Yearling Abundance Index in Year Class Reports	FSS (no./1,000 m³)	LRS (no./1,000 m³)	BSS^(b) (no./1,000 m³)	Survey With Greatest CPUE
Alewife	FSS-Channel	0.356	1.166	2.753	BSS
American shad	BSS	0.466	0.583	15.378	BSS
Atlantic menhaden	Not modeled	0.047	0.210	1.403	BSS
Atlantic tomcod	LRS	1.771	23.107	0.026	LRS
Bay anchovy	FSS-Channel	24.467	24.128	15.420	FSS
Blueback herring	FSS-Channel	8.723	4.245	71.840	BSS
Bluefish	BSS	0.026	0.072	0.679	BSS
Hogchoker	FSS-Bottom	0.525	0.033	0.064	FSS
Rainbow smelt ^(a)	FSS-Channel and LRS	0.119	1.217	0.000	LRS
Spottail shiner	BSS	0.021	0.003	11.925	BSS
Striped bass	BSS	2.203	1.444	15.425	BSS
Weakfish	FSS-Channel	1.096	0.745	0.011	FSS
White catfish	BSS	0.097	0.006	0.002	FSS
White perch	BSS	0.866	0.149	9.736	BSS

^(a) Using years 1985 through 1998 (last observation for FSS)

^(b) Volume sampled for the BSS is calculated assuming each tow has a volume of 450 m³

Sources: CHGE et al. (1999); Entergy (2015)

The NRC staff fit a simple linear regression of each annual measure of abundance (y) against time for each RIS using GraphPad Prism Version 4.0, 2003. The form of the regression model is $y=a+Sx$, where x is the year, a is the intercept, and S is the slope of the line. Regressions were fit with and without extreme values greater than 3 standard deviations from the mean. A two-sided t-test of the null hypothesis, $H_0: S=0$ ($\alpha=0.05$), was used to determine if the trend was detectable, and the direction of the estimated slope was used to assess the population trend (increasing or decreasing).

Strength of Connection LOE

The SOC LOE represents the ability of I&E at the IP2 and IP3 cooling water intake structures to produce noticeable changes in population trends in the RIS. The SOC uses I&E monitoring data for RIS at IP2 and IP3 from 1975 through 1990 and cooling water flow volumes from the I&E monitoring studies. I&E can also remove RIS prey and reintroduce them as detritus or injured organisms into the aquatic system. This process may alter food web dynamics and produce indirect effects such as 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 structure. Changes to these processes can decrease both community and population stability, which the SOC incorporates by slope and temporal variation in species abundance. The SOC uses an estimate of uncertainty provided by a Monte Carlo simulation that examines the differences in population trends with and without losses of YOY fish by I&E.

The analysis uses the information from two types of samples: I&E data from 1975 through 1990 and long-term River Segment 4 population density data from 1985 through 2011 from the LRS, FSS, and BSS. The NRC staff determined the SOC from the uncertainty in estimating the difference in the RIS YOY population abundance with and without losses from I&E. A series of Monte Carlo simulations ($n=1,000$ for each series) was used to estimate the first and third quartiles of the modeled relative cumulative difference in the population abundance achieved over a specified number of years (i.e., $t=1$ to 27) with and without removal of eggs, larvae, and juveniles by I&E. The NRC staff used a simple exponential model to estimate the annual juvenile population abundance (N_t) as follows:

$$N_t = N_0 e^{rt} + (\delta N_0 e^{rt}) \varepsilon_{1t} \quad (1)$$

where

- t = 1 to 20 (number of years associated with relicensing) or 27 years (number of years for trend analysis, 1985–2011);
- N_0 = the initial juvenile population abundance at the beginning of the YOY life stage set to either 1,000 or 1×10^8 ;
- R = the population growth rate estimated from the slope from the linear model of standardized YOY River Segment 4 LRS, FSS, or BSS density data (1985–2011), whichever had the greatest riverwide median CPUE for a given RIS (Table A–3);
- Δ = the level of variability in the density data, which was estimated as the sum of the CV of the annual 75th percentiles from the weekly catch density and the error mean square from the linear regression; and
- ε_{1t} = an independent Normal (0,1) random variable.

Two different values for the starting population parameter N_0 and the extent of the number of years simulated (20 or 27) were used to assess their impact on the simulation results. The number of simulation runs (1,000) should be large enough such that these two parameters will not affect the results. Equation (1) models annual abundance of YOY RIS with the removal of eggs, larvae, and juveniles from I&E implicit in the parameters N_0 and r . Annual abundance of YOY RIS without losses of eggs, larvae, and juveniles from I&E (N_t^*) was estimated using the same model form but with an independent ε_t , and N_0 and r replaced with

$$N_0^* = N_0(1 + EMR) \text{ and } r^* = r_{UL}(1 - IMR)/\max(1, CV) \quad (2)$$

giving

$$N_t^* = N_0^* e^{r^* t} + (\delta N_0^* e^{r^* t}) \varepsilon_{2t} \quad (3)$$

where

- EMR* = entrainment mortality rate
IM = impingement mortality rate
 (collectively, EMR and IMR are the conditional mortality rates (CMRs) for I&E);
r_{UL} = the upper limit of the linear slope defined as the estimated slope plus one standard error of the estimated slope; and
CV = the coefficient of variation of the annual 75th percentiles from the weekly catch density.

The alternative growth rate r^* without I&E losses is a function of the CV of the density data. Division by the CV provides a growth rate closer to zero for negative values of r and either a slightly larger growth rate for positive values of r for $CV \leq 1$ and a smaller slope (closer to zero) for $CV > 1$. The CV represents the degree of population stability in River Segment 4, which can be the indirect result of IP2 and IP3 operations. When the CV is greater than 1, the value of the slope for the population without IP2 and IP3 is either increased (for slopes < 0) or decreased (for slopes > 0) toward zero (i.e., representative of greater stability). The divisor is set to 1 (allowing a maximum increase in growth rate) when the CV is less than 1. The parameter EMR for each RIS is estimated from entrainment and River Segment 4 field data supplied by Entergy (2007). The parameter IMR for each RIS is taken from conditional impingement mortality rates (CIMRs) in CHGEC et al. (1999). Estimates for EMR assume 100 percent mortality, and the IMR incorporates impingement survival rates.

If the EMR and IMR were set to zero, the relative difference in the projected YOY abundances equal to $(N_t^* - N_t)/N_0$ would be a function of the error in the estimate of the slope, the variability in trend, and random noise:

$$\frac{N_t^* - N_t}{N_0} = (e^{r^* t} - e^{rt}) + \delta(e^{r^* t} \varepsilon_{2t} - e^{rt} \varepsilon_{1t}). \quad (4)$$

The SOC analysis includes variables to account for both direct effects (I&E) and indirect effects (e.g., changes in temperature, predator-prey and other food web effects, and disease-related mortality) of the cooling water system on fish populations because operation of IP2 and IP3 may have potentially altered the aquatic environment in ways that affect the survival of YOY RIS beyond the direct loss of individuals to I&E. Direct effects are expressed by the EMR and IMR, whereas indirect effects are expressed by the CV and are also reflected in the estimated linear slope in Region 4 and the standard error of the estimated slope (see Equation (4) above).

The NRC staff estimated EMR as the ratio of the number entrained to the sum of the standing crop of eggs, larvae, and juveniles in River Segment 4 obtained from the LRS, FSS, and BSS 1981 and 1983 through 1987 data. The NRC staff used all three surveys because entrainment of juveniles was proportionally greater during July and August than during May and June, which was when the majority of the sampling for the LRS took place (Table A-4). Estimation of the number entrained and the river segment standing crop is based on the calculations presented in Table A-5.

Table A–4. Percentage of Each Life Stage Entrained by Season and the Contribution of Major Taxa Represented in the Samples

Life Stage	Season 1 January– March	Season 2 April– June	Season 3 July– September	75th Percentile of Abundance Over Years^(a)
EGG	3%	20%	78%	210,801x10³
Rainbow Smelt	99%	2%	0%	
Bay Anchovy	0%	92%	100%	
White Perch	0%	4%	<1%	
Alosa species	1%	2%	0%	
YOLK-SAC LARVA	8%	89%	3%	23,140x10³
Atlantic Tomcod	100%	0%	0%	
Herring Family	0%	91%	<1%	
Bay Anchovy	0%	2%	94%	
Striped Bass	0%	5%	1%	
Hogchoker	0%	0%	3%	
POST YOLK-SAC LARVA	<1%	52%	48%	618,393x10³
Atlantic Tomcod	100%	<%	0%	
Alosa species	0%	37%	<1%	
Bay Anchovy	0%	11%	58%	
Anchovy Family	0%	2%	39%	
White Perch	0%	12%	1%	
Striped Bass	0%	17%	1%	
Herring Family	0%	20%	<1%	
JUVENILE	2%	44%	54%	10,989x10³
White Perch	96%	10%	10%	
Atlantic Tomcod	0%	67%	2%	
Weakfish	0%	1%	50%	
Bay Anchovy	0%	1%	17%	
Rainbow Smelt	0%	9%	3%	
Striped Bass	0%	6%	5%	
Anchovy Family	0%	1%	4%	
Alosa species	0%	2%	2%	
White Catfish	4%	<1%	0%	
Blueback Herring	0%	<1%	3%	
UNDETERMINED STAGE	10%	77%	13%	4,469x10³
Atlantic Tomcod	100%	<1%	0%	

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Life Stage	Season 1 January– March	Season 2 April– June	Season 3 July– September	75th Percentile of Abundance Over Years ^(a)
Morone species	0%	88%	2%	
Bay Anchovy	0%	9%	83%	
Anchovy Family	0%	0%	10%	
Alosa species	0%	0%	4%	

^(a) Calculations are based on the 75th percentile of number of fish entrained in each season over years (1981 and 1983–1987) as reported by Entergy (2007). No entrainment sampling occurred in October through December.

Table A–5. Method for Estimating Taxon-Specific EMR Based on River Segment 4 Standing Crop for the SOC Analysis

Property or Method		Number Entrained	River Segment 4 Standing Crop
Input Data	Variables	Mean density organisms entrained by IP2 and IP3 (number per 1,000 m ³)	LRS density (by life stage) FSS density of YOY (number per 1,000 m ³) BSS density of YOY (# per haul)
		Volume of cooling water withdrawn by IP2 and IP3 (1,000 m ³ /min)	River Segment 4 volume (m ³) River Segment 4 shore zone surface area (m ²)
		Frequency	Per week of sampling
Summary Statistics	Season by year	Sum of weekly estimates of number of organisms entrained by IP2 and IP3	Sum of weekly standing crop estimates
	Annual	Sum of Season 1, 1986, with each year's totals from Season 2 and Season 3	Sum of seasonal standing crop estimates for River Segment 4
	EMR	75th percentile annual number entrained 75th percentile (annual number entrained + annual standing crop)	
	Units of numerator and denominator of EMR	number of organisms	
Years of Data		1981 and 1983–1987	1981 and 1983–1987
Life Stages		Eggs, larvae, and juveniles	Eggs, larvae, and juveniles (YOY)

Property or Method	Number Entrained	River Segment 4 Standing Crop
Taxonomic Substitutions	Alewife, blueback herring, and unidentified alosids are treated collectively as river herring. “Unidentified anchovy spp.” are allocated to bay anchovy “Unidentified <i>Morone</i> spp.” are allocated proportionally to the identified striped bass and white perch in entrainment samples.	

The number of RIS by life stage (l =eggs, yolk sac larvae, post-yolk sac larvae, juvenile, and undetermined) entrained (E_{ijk}) was calculated weekly ($k=2$ through 35) for each year ($j=1981$, 1983 through 1987) as

$$E_{ijk} = \overline{d_{ijk}} (V_{IP2} + V_{IP3})(60 \times 24 \times 7 \times 1000) \quad (5)$$

where

$\overline{d_{ijk}}$ = the input mean weekly density entrained (number/1,000 m³) for a given RIS (Table A–5) along with the associated volume of water withdrawn (1,000 m³/min) at IP2 and IP3 (V_{IP2} and V_{IP3} , respectively).

The NRC staff calculated seasonal numbers of RIS entrained by summing over life stages and weeks. Season 1 (January–March) was only sampled in 1986. Therefore, the NRC staff added the number of fish entrained during Season 1 of 1986 to the totals for all other years.

The NRC staff based the estimate of the River Segment 4 standing crop of each life stage on the combined standing crop estimates from the LRS, FSS, and BSS (Table A–5). The LRS and FSS weekly standing crops are estimated as the weekly density of fish caught times the River Segment 4 volume (208,336,266 m³; 168,901 acre feet (ac-ft)). The BSS weekly standing crop was estimated as the weekly density of fish caught times the River Segment 4 surface area of the shore stratum (4,147,000 square meters (m²); 1,025 ac) divided by the area of a seine sample (450 m²; 4,844 square feet (ft²)). The total number of RIS at risk from I&E was calculated as the sum of those RIS entrained (or impinged) and the RIS caught in the river. The annual standing crops of eggs, larvae, and juveniles estimated in River Segment 4 from the LRS, FSS, and BSS are presented in Table A–6. The estimated number of each RIS entrained for the SOC analysis is calculated from the mean density entrained (1981 and 1983 through 1987) at IP2 and IP3 (Table A–7). The estimated EMR values can be compared to the riverwide CMRs from CHGE et al. (1999) (Table A–8).

Table A–6. Estimated Annual Standing Crop of Eggs, Larvae, and Juvenile RIS within River Segment 4

Taxon ^(a)	1981	1983	1984	1985	1986	1987
Alewife and Blueback Herring	297,085	1,357,925	1,038,835	78,631	354,051	25,296
American Shad	10,499	2,913	95,680	2,544	4,237	1,193
Atlantic Menhaden	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Atlantic Sturgeon	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown

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Taxon^(a)	1981	1983	1984	1985	1986	1987
Atlantic Tomcod	200,780	25,139	135,175	401,977	151,137	207,732
Bay Anchovy	2,075,519	1,139,353	1,190,840	1,545,767	497,221	1,886,658
Bluefish	540	1,208	883	391	536	1,394
Gizzard Shad	Unknown	Unknown	Unknown	Unknown	Unknown	24.1
Hogchoker	1,897	587	1,063	1,135	3,529	6,399
Rainbow Smelt	1,341	841	16,111	992	46,771	21,926
Shortnose Sturgeon	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Spottail Shiner	29.7	103	16.1	235	38.7	16.6
Striped Bass	1,336,839	626,169	628,247	79,970	406,016	292,179
Weakfish	1,473	3,547	15,306	3,495	1,245	985
White Catfish	Unknown	1.84	27.3	215	Unknown	31.9
White Perch	796,095	913,925	438,271	92,322	758,591	69,237

^(a) In thousands of fish

Source: Entergy (2015)

Table A-7. Annual Estimated Number of RIS Entrained at IP2 and IP3

Taxa^(a)	1981	1983	1984	1985	1986	1987
Alewife and Blueback Herring	20,159	119,801	181,006	954	186	44.6
American Shad	350	359	18,175	26.0	242	9.27
Atlantic Menhaden	0	0	0	152	392	0
Atlantic Sturgeon	0	0	0	0	0	0
Atlantic Tomcod	4,231	2,951	8,557	12,737	4,925	3,714
Bay Anchovy	1,241,061	352,177	467,558	344,483	182,493	236,713
Bluefish	0	0	3.88	19.7	0	0
Gizzard Shad	0	0	0	0	0	0
Hogchoker	3,188	2,168	961	745	585	185
Rainbow Smelt	6,089	6,090	7,146	6,126	10,952	6,857
Shortnose Sturgeon	0	0	0	0	0	0
Spottail Shiner	0	9.13	3.93	0	0	0
Striped Bass	85,626	43,256	49,716	20,495	78,666	33,076
Weakfish	3,130	4,154	9,485	2,062	631	102
White Catfish	7.23	7.23	10.8	7.23	10.5	7.23

Taxa^(a)	1981	1983	1984	1985	1986	1987
White Perch	48,743	68,418	29,734	11,137	71,501	8,297
All fish taxa	1,446,376	795,342	888,363	403,092	463,644	288,208

^(a) In thousands of fish

Source: Entergy 2007

Table A–8. Estimate of the River Segment 4 EMR and the 95-Percent Confidence Limits for the Riverwide Entrainment CMR, 1974–1997

Taxa	75th Percentile Annual Number Entrained (number x 10⁶)	75th Percentile of Number at Risk (number x 10⁶)	EMR	Riverwide CMR for Entrainment at IP2 and IP3	
				Lower 95% Confidence Limit	Upper 95% Confidence Limit
Alewife and Blueback Herring	94.9	1003	0.095	0.00747	0.0324
American Shad	0.357	9.26	0.039	0	0.016696
Atlantic Menhaden	0.114	NA^(a)	NA	Not Modeled	
Atlantic Sturgeon	0	NA	NA	Not Modeled	
Atlantic Tomcod	7.65	210	0.036	0.152	0.234
Bay Anchovy	439	2065	0.212	0.0925	0.140
Bluefish	0.00291	1.13	0.003	Not Modeled	
Gizzard Shad	0	NA	NA	Not Modeled	
Hogchoker	1.87	4.84	0.385	Not Modeled	
Rainbow Smelt	7.07	27.4	0.258	Not Modeled	
Shortnose Sturgeon	0	NA	NA	Not Modeled	
Spottail Shiner	0.00295	0.0937	0.031	0.0802	0.104
Striped Bass	71.4	676	0.106	0.181	0.276
Weakfish	3.90	7.17	0.544	Not Modeled	
White Catfish	0.00965	0.0848	0.114	Not Modeled	
White Perch	63.5	841	0.075	0.0568	0.108

^(a) NA = not analyzed because of insufficient data, species not observed in survey samples, or data not available

Sources: Entergy 2007, 2015

Impingement mortality for YOY RIS is greatest in July through December (Table A–9). Although impingement data from 1981 through 1990 were not available by life stage, the NRC staff estimated IMR as the maximum cumulative CIMR (1984 through 1990; CHGE et al. 1999) for an

annual cohort from the juvenile life stage through the last age of impingement vulnerability (Table A–10). The minimum value of IMR was set at 0.0005. The CIMR values are calculated from the estimated number impinged and the Ristroph screen 8-hour mortality rate reported by Fletcher (1990).

The relative cumulative difference in the population abundance achieved over a specified number of years between models with and without the effects of I&E is estimated as the sum of the annual differences divided by N_0 (1,000 or 10^3) and the number of years of data (20 or 27). One realization of a simulation using $t=27$, $N_0=1,000$ highlights the annual difference achieved in the YOY population abundance with and without I&E effects (Figure A–3). An example frequency distribution of the relative cumulative difference in the population abundance achieved from all 1,000 simulations is presented in Figure A–4. Negative values occur when a single simulation has greater negative annual differences (i.e., greater abundance with the model incorporating I&E mortality, shown in black in Figure A–3). If the model included no variation ($\delta=0$), all differences would be positive. Allowing δ to be greater than 0 incorporates the variation observed in the YOY population and the error in the linear model used to estimate population growth. If the range of the first and third quartiles of the resulting distribution includes zero, the effect of I&E was not large enough to detect over the variation observed in the population.

Four simulation series for each RIS incorporated all possible pairs of the parameters t and N_0 ($n=1,000$ for each) and all other model parameter values for a given RIS remained the same for each simulation series. The SOC was low if the range of the first and third quartiles of the distribution of the relative cumulative difference in YOY population abundance included zero for any of the simulation series. The SOC was high if both quartiles were positive for all parameter t and N_0 pairs. The latter result occurs when the effects of I&E are consistently greater than the modeled variation.

Table A–9. Percentage of Each Life Stage Impinged by Season and the Contribution of Major Taxa Represented in the Samples

Life Stage	Season 1 Jan–Mar	Season 2 Apr–Jun	Season 3 Jul–Sep	Season 4 Oct–Dec	75th Percentile Over Years
Young-of-Year	0%	9%	43%	48%	$3,214 \times 10^3$
Atlantic Tomcod	0%	98%	60%	1%	
White Perch	0%	0%	16%	72%	
American Shad	0%	0%	6%	1%	
Blueback Herring	0%	0%	3%	24%	
Weakfish	0%	0%	5%	<1%	
Yearling	82%	17%	1%	1%	$3,747 \times 10^3$
White Perch	95%	94%	60%	93%	
Striped Bass	4%	1%	5%	1%	
Atlantic Tomcod	1%	<1%	14%	1%	
Alewife	<1%	<1%	12%	1%	
Blueback Herring	<1%	1%	9%	3%	
Older	19%	19%	53%	9%	$1,320 \times 10^3$
White Perch	83%	41%	3%	5%	
Bay Anchovy	<1%	15%	85%	40%	

Life Stage	Season 1 Jan–Mar	Season 2 Apr–Jun	Season 3 Jul–Sep	Season 4 Oct–Dec	75th Percentile Over Years
Rainbow Smelt	10%	18%	1%	12%	
Hogchoker	<1%	20%	6%	16%	
Alosa species	<1%	<1%	<1%	16%	

Note: Because only 2 years had life stage information available (1979 and 1980), calculation of the 75th percentile was based on the weighted average of the ranked observations as reported in Entergy 2007 (i.e., $y=0.25*X(1) + 0.75*X(2)$ where $X(i)$ is the ranked observation in increasing order).

Table A–10. Cumulative CIMR Estimated by Year Class for IP2 and IP3 Used to Estimate the Taxon-Specific IMR for the SOC Analysis

RIS	1984	1985	1986	1987	1988	1989	1990	Maximum = IMR ^(a)
Alewife	NA	0.002	0.002	0.001	0.001	0.001	NA	0.002
American Shad	NA	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0005
Atlantic Tomcod	NA	NA	0.008	0.030	0.005	0.003	0.004	0.030
Bay Anchovy	NA	0.002	0.004	<0.0005	<0.0005	<0.0005	<0.0005	0.004
Blueback Herring	NA	0.003	0.004	0.002	0.001	0.001	NA	0.004
Bluefish	NA	NA	NA	NA	NA	NA	NA	0.0005
Hogchoker	NA	NA	NA	NA	NA	NA	NA	0.0005
Rainbow Smelt	NA	NA	NA	NA	NA	NA	NA	0.0005
Spottail Shiner	NA	0.002	0.001	0.007	<0.0005	0.001	<0.0005	0.007
Striped Bass	0.008	0.003	0.005	0.005	<0.0005	<0.0005	0.001	0.008
Weakfish	NA	NA	NA	NA	NA	NA	NA	0.0005
White Catfish	NA	NA	NA	NA	NA	NA	NA	0.0005
White Perch	NA	0.026	0.032	0.012	0.011	0.014	0.007	0.032

^(a) IMR estimates include a correction for partial survival.

NA = Not available

Source: CIMR data from CHGE et al. (1999), Appendix VI

Figure A–3. One Realization of the Monte Carlo Simulation Using Parameter Estimates for an Example RIS

Gray and black shading represents positive and negative annual differences in abundance between the two models.

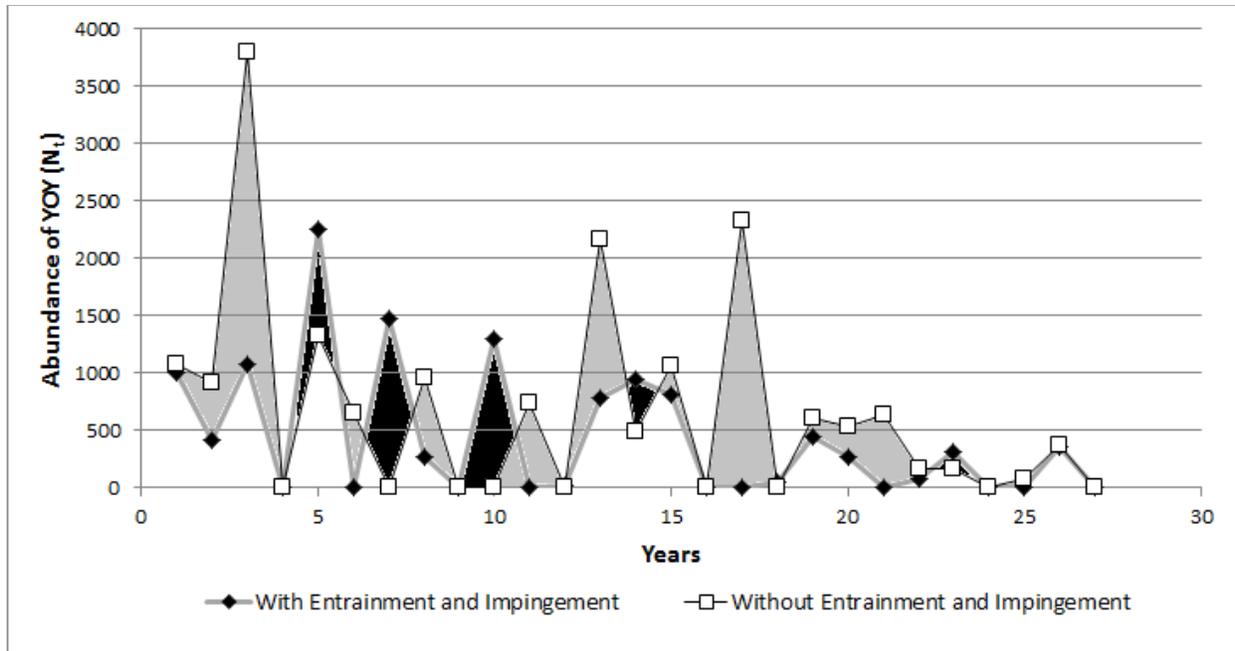
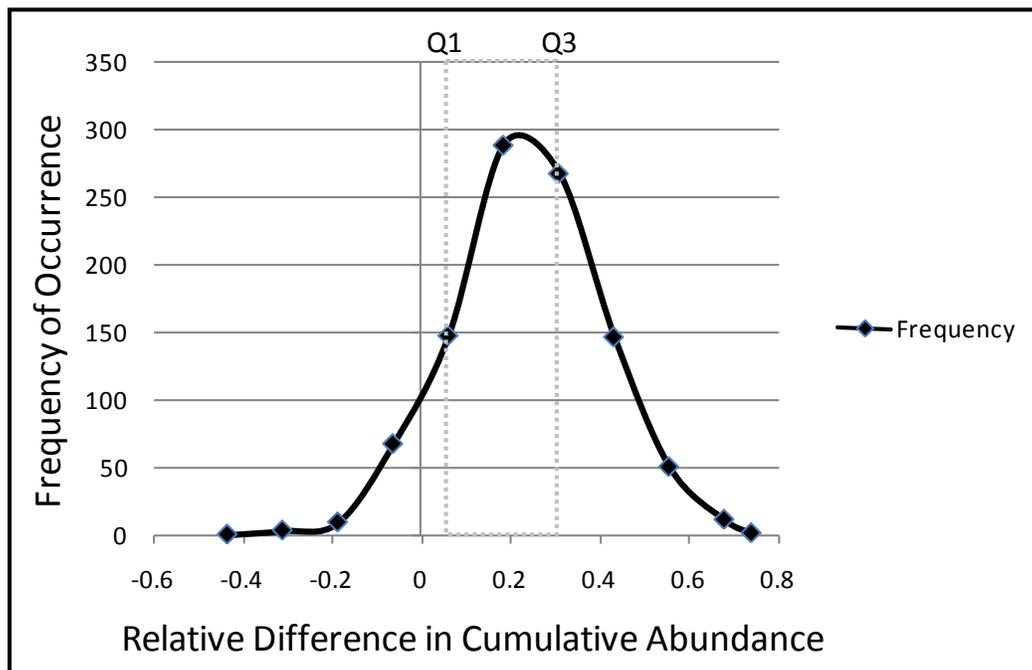


Figure A–4. Example Frequency Distribution of the Relative Difference in Cumulative Abundance from the Monte Carlo Simulation ($n=1,000$) for an Example RIS

Dashed lines indicate the first and third quartiles (Q1 and Q3) of the distribution.



Weight of Evidence Analysis

To classify impacts as “Small,” “Moderate, or Large” for each RIS, a WOE analysis combined the results of the two LOEs using both numerical scoring and decision rules. For the Population Trend LOE, the NRC staff used a simple linear regression of annual population measurements over years to assign the level of adverse impact. The statistical significance of the estimated slope ($\alpha=.05$) determines if a population trend is detectable. For each population trend, the number of data sets and measures of abundance available for each RIS and geographic scale (River Segment 4 and riverwide) varies. The following decision rules score the two possible outcomes for each trend (i.e., a statistically significant decreasing trend or not):

- RIS populations are not declining if population trends have slopes that are significantly greater than or not significantly different from zero (i.e., detectable population increase or an undetectable population trend). Trends satisfying this description receive a score of 1.
- RIS populations are declining if population trends have negative slopes that are significantly different from zero (i.e., detectable population decline). Trends satisfying this description receive a score of 4.

A value of 4 represents declining trends because it allows scaled intermediate scores when combining the results of multiple measures of abundance within each geographic scale. Each measure of abundance set within a geographic scale was considered equally relevant, and the population trend scores were then averaged, which can produce intermediate scores between 1 and 4. The NRC staff gauged the consistency of results by using trends from multiple River Segment 4 and riverwide data sets.

River segment and riverwide scores were then combined using attributes intended to reflect their use and utility for measuring total impact using methods adapted from Menzie et al. (1996). Each attribute was assigned an ordinal score corresponding to a ranking of low (1), medium (2), or high (3) based on the best professional judgment of the staff (Table A–11), and the overall use and utility scores are the averages of the individual attribute scores. The overall scores (“decision rules”) for the River Segment 4 and riverwide RIS trends characterize the use and utility of the measurement as low, medium, or high, using the following definitions:

- Low use and utility—overall score of <1.5 (questionable for decisionmaking);
- Medium use and utility—overall score of ≥ 1.5 and ≤ 2 (adequate for decisionmaking); and
- High use and utility—overall score of >2 (very useful for decisionmaking).

Table A–11. Use and Utility Attributes and Scores Used To Evaluate RIS Population Trends Associated with IP2 and IP3 Cooling System Operation

Use and Utility Attribute	River Segment 4 RIS Trends	Riverwide RIS Trends
Strength of Association between Measurement and Community Response	3	2
Stressor-specificity	2	1
Site-Specificity of Measurement in Relation to the Stressor	2	1
Sensitivity (Variability) of Measurement	2	2
Spatial Representativeness	3	2
Temporal Representativeness	3	3

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Use and Utility Attribute	River Segment 4 RIS Trends	Riverwide RIS Trends
Correlation of Stressor to Response	2	1
Overall (Mean) Utility Score	2.4	1.7
Overall Assessment ^(a)	High	Medium

^(a) Overall Assessment: Scores <1.5 are of low utility (questionable use for decisionmaking); 1.5 ≤ scores ≤ 2.0 are of medium utility (adequate for decisionmaking); scores >2.0 are of high utility (very useful for decisionmaking).

Using the decision rules above, a total impact score is calculated from the impact scores at the two geographic scales by using a weighted mean across geographic scales:

$$\text{WOE Score} = \frac{\sum_i (\text{overall utility score}_i)(\text{decision rule result score}_i)}{\sum_i \text{overall utility score}_i}$$

where $i=1$ is the number of measurements; the “overall utility score_{*i*}” is defined in Table A–11; and the “decision rule result score_{*i*}” equals the average of 1s and 4s defined in Step 4 following decision rules that characterize each trend. From the WOE scores, impact levels are characterized as follows:

- Small impact: WOE score <2.2
- Moderate impact: WOE score ≥2.2 and ≤2.8
- Large impact: WOE score >2.8

The NRC staff defined boundary values between impact categories based on the possible outcomes for each geographic scale. WOE scores of less than 2.2 occurred when population trend data produced more result scores of 1 than of 4. WOE scores greater than 2.8 occurred when population trend data produced more result scores of 4 than of 1.

For the SOC LOE associating IP2 and IP3 cooling system operation to the observability of RIS population declines, all of the RIS appeared in either the impingement or the entrainment samples, and so the connections or pathways to the population abundance from the operation of the cooling systems has been established. This LOE uses decision rules to qualify the influence of I&E on any observed population declines. The qualification depends on the ability of a simple exponential model to approximate RIS population trends through time and to estimate a biologically relevant measure of uncertainty associated with the cause of decline in RIS populations in the Hudson River. The NRC staff conducted simulation runs with different model parameter values to provide a greater sense of the separation between conclusions on the SOC and specific model assumptions.

Based on two possible outcomes in SOC (i.e., noise in the data either does or does not preclude differentiating the effect of I&E on the population trend), the following decision rules characterize the SOC:

- The RIS had a “Low” SOC if the interval between the first and third quartiles of the difference in modeled cumulative abundance for a given YOY RIS with and without mortality from I&E and loss of prey included zero for at least one of the simulation runs. That is, the variability in the species population trend was too large to enable the detection of losses from I&E, and a high level of uncertainty is associated with

the link between the population trend and the direct and indirect effects of the operation of IP2 and IP3 cooling systems.

- The RIS had a “High” SOC if the interval between the first and third quartiles of the difference in modeled cumulative abundance for a given YOY RIS with and without mortality from I&E and loss of prey did not include zero for any of the simulation runs. That is, the effects of I&E were greater than the variability in the population trend, and the direct and indirect effects of the operation of IP2 and IP3 cooling systems affected species population trends.

To address the possibility that the SOC LOE could result in false positive findings, the NRC staff also performed a sensitivity analysis to evaluate the probability of the interquartile range including zero when the EMR and IMR are set to zero—i.e., the probability of an SOC finding other than “Low” when the direct effects of IP2 and IP3 operations (I&E) are assumed not to exist. For those RIS for which the NRC staff made an SOC conclusion, the staff estimated the probability of a false positive result with 200 simulations for a range of population slopes (r) and CVs and a starting YOY population of 1,000 over a 20-year period.

Additionally, the NRC staff evaluated the effects of gear changes that occurred during the course of the Hudson River Biological Monitoring Program on the staff’s WOE results using a nonparametric Mann-Whitney U test. The staff used this test to evaluate whether statistically significant population abundance changes occurred before the gear change that were not reflected in the staff’s I&E analysis because of the staff’s use of partial (post-gear change) data sets.

A.3 Results

A.3.1 Trend Analysis

Consistency of trends can be examined across species on the River Segment 4 and riverwide scale or across sampling programs and geographic scales within species without regard to the statistical significance of slopes. Plots of YOY population density and CPUE trends from the LRS and FSS programs in River Segment 4 (Addendum A–1, Figures A1, B1, D1, E1, and L1) appear consistent: populations have been decreasing with few exceptions. Plots show decreasing trends for all species measured by LRS density and FSS density, all species except bay anchovy measured by FSS CPUE, and all species except striped bass and weakfish measured by LRS CPUE. BSS density trends vary more, with five populations appearing to decrease and four appearing to increase. Riverwide plots (Addendum A–1, Figures F1 through K1) show consistent decreases for American shad, Atlantic tomcod, and rainbow smelt (*Osmerus mordax*). Plots show either flat or decreasing trends for blueback herring (*Alosa aestivalis*), bluefish (*Pomatomus saltatrix*), weakfish, white catfish (*Ameiurus catus*), and white perch. Alewife (*Alosa pseudoharengus*) have an increasing trend for all riverwide measures of abundance. Spottail shiner (*Notropis hudsonius*) and striped bass have mixed results in riverwide population measures. Overall, a consistent pattern of decreasing trends in YOY fish abundance occurs in River Segment 4, where IP2 and IP3 are located, but a more varied pattern occurs, still with many decreases, riverwide. For population trends across sampling programs within River Segment 4 and riverwide scales, declines within both geographic scales are statistically significant ($p \leq 0.05$) for American shad, Atlantic tomcod, blueback herring, and rainbow smelt (Addendum A–2, Figures B2, D2, F2, and J2, respectively) for all or most sampling programs.

Bluefish, hogchoker (*Trinectes maculatus*), striped bass, and white catfish exhibit less consistency in trend results among measures of abundance and geographic scales.

For bluefish (Addendum A–2, Figure G2), three of the five negative slopes in River Segment 4 are significant and two are not, whereas riverwide results are more mixed. Hogchoker (Addendum A–2, Figure I2) and striped bass (Addendum A–2, Figure L2) trends are inconsistent among measures of abundance within both River Segment 4 and riverwide scales. Only riverwide sampling provided enough catches for trend analyses of white catfish (Addendum A–2, Figure N2), and the results are inconsistent.

A.3.2 Population Trend LOE

For each measure of abundance and RIS, the NRC staff applied a numerical score and decision rule to the trend results, as described in Section A.2 of this supplement, to produce a River Segment 4 assessment score (Table A–12) and a riverwide assessment score (Table A–13). Insufficient catches for some RIS resulted in “Unknown” assessment results, and absence of YOY in samples resulted in “N/A” (not applicable) results. A score of “1” indicates an undetected decline for the particular measure of abundance and RIS, while a score of “4” indicates a detected decline. The NRC staff then averaged the numerical scores to yield overall scores for each RIS for River Segment 4 and riverwide (see Table A–12 and Table A–13). Although all measures of abundance for any RIS derive from samples from the same YOY population, trend scores can differ due to different sampling efficiencies and different distributions of populations in relation to sampling locations, among other differences. Uncertainty associated with the NRC staff’s analysis is discussed in detail in Section 4.5 of this supplement.

Table A–12. Assessment of River Segment 4 Population Impacts

Species	Density ^(a)			Catch-per-Unit Effort ^(a)		River Segment 4 Assessment
	LRS	FSS	BSS	LRS	FSS	
Alewife	N/A ^(b)	4	1	N/A	1	2.0
American Shad	4	4	4	4	4	4.0
Atlantic Menhaden	1	1	1	1	1	1.0
Atlantic Sturgeon	N/A	N/A	N/A	N/A	N/A	Unknown
Atlantic Tomcod	1	4	N/A	1	4	2.5
Bay Anchovy	N/A	4	1	1	1	1.8
Blueback Herring	N/A	4	4	N/A	4	4.0
Bluefish	4	1	1	4	4	2.8
Gizzard Shad	N/A	N/A	N/A	N/A	N/A	Unknown
Hogchoker	N/A	4	1	N/A	4	3.0
Rainbow Smelt	4	4	N/A	4	4	4.0
Shortnose Sturgeon	N/A	N/A	N/A	N/A	N/A	Unknown
Spottail Shiner	N/A	N/A	1	N/A	N/A	1.0
Striped Bass	1	4	1	1	4	2.2
Weakfish	1	1	N/A	1	1	1.0
White Catfish	N/A	N/A	N/A	N/A	N/A	Unknown
White Perch	N/A	1	1	N/A	1	1.0
Blue Crab	N/A	N/A	N/A	N/A	N/A	Unknown

^(a) Tabulated values for density and CPUE data are either 1 (undetected decline) or 4 (detected decline). The river segment assessment is an average of the scores for the given row.

^(b) N/A: not applicable; YOY not present in samples.

Table A–13. Assessment of Riverwide Population Impacts

Species	CPUE ^(a)			Abundance Index ^(a)			Riverwide Assessment
	LRS	FSS	BSS	LRS	FSS	BSS	
Alewife	1	1	1	N/A ^(b)	N/A	1	1.0
American Shad	4	4	4	N/A	N/A	4	4.0
Atlantic Menhaden	1	1	1	N/A	N/A	1	1.0
Atlantic Sturgeon	N/A	N/A	N/A	N/A	N/A	N/A	Unknown
Atlantic Tomcod	4	4	4	4	N/A	N/A	4.0
Bay Anchovy	1	1	1	N/A	4	N/A	1.8
Blueback Herring	1	4	1	N/A	N/A	4	2.5
Bluefish	4	4	1	N/A	N/A	1	2.5
Gizzard Shad	N/A	1	1	N/A	N/A	N/A	1.0
Hogchoker	1	1	1	N/A	1	N/A	1.0
Rainbow Smelt	4	4	N/A	4	N/A	N/A	4.0
Shortnose Sturgeon	N/A	N/A	N/A	N/A	N/A	N/A	Unknown
Spottail Shiner	1	4	1	N/A	N/A	1	1.8
Striped Bass	1	4	1	N/A	N/A	1	1.8
Weakfish	1	1	1	N/A	4	N/A	1.8
White Catfish	1	4	1	N/A	N/A	4	2.5
White Perch	1	1	1	N/A	N/A	4	1.8
Blue Crab	N/A	N/A	N/A	N/A	N/A	N/A	Unknown

^(a) Tabulated values for the abundance index and CPUE data are either a 1 (undetected decline) or a 4 (detected decline). The riverwide assessment is an average of the scores for the given row.

^(b) N/A: not applicable; YOY not present in samples

The NRC staff combined the River Segment 4 and riverwide population assessment scores above to yield overall Population Trend LOE conclusions (Table A–14). The NRC staff calculated a Utility Score for the assessment scores and used these three scores together to yield a WOE score. The NRC staff considered a WOE score of >2.8 to indicate that a decline was detected, a WOE score of ≥ 2.2 but ≤ 2.8 to indicate variable response, and a WOE score of <2.2 to indicate that a decline was undetected. Several RIS (Atlantic sturgeon, shortnose sturgeon, and blue crab (*Callinectes sapidus*)) had too few catches to assess River Segment 4 or riverwide population trends, and results for these RIS are “Unresolved.” Four RIS (American shad, Atlantic tomcod, blueback herring, and rainbow smelt) had detected declines; three RIS (bluefish, hogchoker, and white catfish) had a variable response; and eight RIS (alewife, Atlantic menhaden bay anchovy, gizzard shad (*Dorosoma cepedianum*), spottail shiner, striped bass, weakfish, and white perch) did not exhibit detectable declines.

Table A–14. WOE Results for the Population Trend LOE

Measurement	River Segment 4 Assessment Score	Riverwide Assessment Score	WOE Score ^(b)	Population Trend LOE Conclusion
Utility Score ^(a)	2.4	1.7		
Alewife	2.0	1.0	1.6	Undetected Decline
American Shad	4.0	4.0	4.0	Detected Decline

Measurement	River Segment 4 Assessment Score	Riverwide Assessment Score	WOE Score ^(b)	Population Trend LOE Conclusion
Atlantic Menhaden	1.0	1.0	1.0	Undetected Decline
Atlantic Sturgeon	Unknown	Unknown	Unknown	Unresolved ^(c)
Atlantic Tomcod	2.5	4.0	3.1	Detected Decline
Bay Anchovy	1.8	1.8	1.8	Undetected Decline
Blueback Herring	4.0	2.5	3.4	Detected Decline
Bluefish	2.8	2.5	2.7	Variable
Gizzard Shad	Unknown	1.0	1.0	Undetected Decline
Hogchoker	3.0	1.0	2.2	Variable
Rainbow Smelt	4.0	4.0	4.0	Detected Decline
Shortnose Sturgeon	Unknown	Unknown	Unknown	Unresolved ^(c)
Spottail Shiner	1.0	1.8	1.3	Undetected Decline
Striped Bass	2.2	1.8	2.0	Undetected Decline
Weakfish	1.0	1.8	1.3	Undetected Decline
White Catfish	Unknown	2.5	2.5	Variable
White Perch	1.0	1.8	1.3	Undetected Decline
Blue Crab	Unknown	Unknown	Unknown	Unresolved ^(c)

^(a) Utility Scores are the weights for the WOE Score calculated as a weighted mean.

^(b) WOE Score: Undetected Decline <2.2; Variable ≥2.2 but ≤2.8; Detected Decline >2.8.

^(c) Unable to make a WOE conclusion because of a lack of data for trend assessment.

A.3.3 Strength of Connection LOE

The SOC analysis assumes that the IP2 and IP3 cooling system can affect aquatic resources both directly through I&E and indirectly by affecting trophic and other relationships. By examining the distribution of the simulated differences in the cumulative annual abundance of YOY RIS with and without losses from I&E, the analyst can assess the effect of the IP2 and IP3 cooling system on River Segment 4 population trends (e.g., how strongly the effects of the cooling system are connected to the RIS of interest).

To conduct the SOC analysis, the NRC staff conducted a Monte Carlo simulation and ran four simulation series for each RIS using all possible pairs of the parameters t and N_o ($n=1,000$ for each). The NRC staff estimated the growth-rate parameters for a given RIS from the linear regressions of the River Segment 4 population density and incorporated the estimated EMR and IMR (Table A–15). The NRC staff determined the SOC to be low if the range of the first and third quartiles of the distribution of the relative cumulative difference in YOY population abundance included zero for any of the simulation series. The NRC staff determined the SOC to be high if both quartiles were positive for all parameter t and N_o pairs. The latter result (a high SOC) occurs when the effects of I&E are consistently greater than the modeled variation.

Table A–15. Parameter Values Used in the Monte Carlo Simulation

RIS	Survey Used	Estimated Linear Slope (<i>r</i>)	Slope + Standard Error of the Slope Estimate (<i>r</i> _{UL})	Mean Square Error from Regression	CV of Density Data (1985–2011)	EMR	IMR
Alewife	BSS	0.050	0.060	0.123	1.290	0.095	0.0020
American Shad	BSS	-0.073	-0.064	0.117	0.689	0.039	0.0005
Atlantic Tomcod	LRS	-0.013	0.000	0.213	1.050	0.036	0.0300
Bay Anchovy	FSS	-0.053	-0.037	0.314	0.583	0.212	0.0040
Blueback Herring	BSS	-0.046	-0.033	0.232	1.629	0.095	0.0040
Bluefish	BSS	-0.019	-0.003	0.347	0.712	0.003	0.0005
Hogchoker	FSS	-0.068	-0.056	0.175	1.927	0.385	0.0005
Rainbow Smelt	LRS	-0.071	-0.056	0.300	2.067	0.258	0.0005
Spottail Shiner	BSS	-0.015	0.001	0.349	1.137	0.031	0.0070
Striped Bass	BSS	0.013	0.026	0.229	0.538	0.106	0.0080
Weakfish	FSS	-0.034	-0.016	0.399	0.877	0.544	0.0005
White Catfish ^(a)	FSS	0.007	0.010	0.010	3.520	0.114	0.0005
White Perch	BSS	-0.010	0.007	0.387	0.958	0.075	0.0320

^(a) Data for regression from 1979–2005 (last density observation was in 2003).

Source: Entergy (2015)

The NRC staff's results and SOC conclusions of the Monte Carlo simulations ($n=1,000$) for each pair of N_0 ($1,000$ and 10^8) and number of years modeled (20 and 27) are presented in Table A–16. In general, for a given RIS, the difference in the median simulation results for 20 versus 27 years modeled (t) decreased with increasing initial abundance (N_0). For $N_0=1,000$ and 1×10^8 , the median difference between the simulation results with a different number of years modeled was 2 percent across all RIS. For $t=20$ and 27 years, the median difference between the results of the simulations with different initial abundance was 1 percent and 0.2 percent respectively across all RIS. The results of the SOC analysis indicate a “High” SOC for seven species (Table A–17). For those species, the IP2 and IP3 cooling system was removing the species at levels that were proportionally higher than expected from the observed abundance in the river. For six RIS, the SOC was “Low,” indicating minimal evidence of connection between IP2 and IP3 cooling system operation and river abundance. For those RIS in which model parameter estimates were unavailable or sufficient population abundance data were lacking, the NRC staff assigned an SOC conclusion of “Cannot be Modeled.”

Table A–16. Quartiles of the Relative Difference in Cumulative Abundance and Conclusions for the SOC LOE from the Monte Carlo Simulation^(a)

Taxa	Number of Years	$N_0=1,000$			$N_0= \times 10^8$			SOC LOE Conclusion
		Median	Q1	Q3	Median	Q1	Q3	
Alewife	20	0.10	-0.38	0.57	0.14	-0.30	0.59	Low
	27	0.03	-0.45	0.53	0.09	-0.37	0.54	

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Taxa	Number of Years	N ₀ =1,000			N ₀ = x10 ⁸			SOC LOE Conclusion
		Median	Q1	Q3	Median	Q1	Q3	
American Shad	20	0.07	-0.01	0.15	0.07	-0.02	0.15	Low
	27	0.06	-0.01	0.12	0.06	0.00	0.13	
Atlantic Tomcod	20	0.20	-0.01	0.41	0.17	-0.03	0.39	Low
	27	0.22	0.06	0.41	0.22	0.05	0.38	
Bay Anchovy	20	0.27	0.14	0.39	0.26	0.12	0.38	High
	27	0.24	0.15	0.33	0.24	0.15	0.32	
Blueback Herring	20	0.34	0.10	0.57	0.32	0.12	0.54	High
	27	0.35	0.19	0.55	0.37	0.20	0.57	
Bluefish	20	0.18	-0.01	0.34	0.15	-0.01	0.34	Low
	27	0.20	0.07	0.33	0.19	0.06	0.34	
Hogchoker	20	0.68	0.42	0.95	0.67	0.41	0.94	High
	27	0.70	0.49	0.92	0.71	0.52	0.93	
Rainbow Smelt	20	0.64	0.37	0.91	0.67	0.39	0.96	High
	27	0.68	0.48	0.93	0.64	0.44	0.85	
Spottail Shiner	20	0.24	0.00	0.46	0.21	-0.03	0.44	Low
	27	0.27	0.07	0.46	0.26	0.07	0.46	
Striped Bass	20	0.31	0.11	0.52	0.32	0.13	0.54	High
	27	0.43	0.25	0.61	0.42	0.25	0.61	
Weakfish	20	0.71	0.47	0.93	0.65	0.42	0.89	High
	27	0.69	0.52	0.86	0.66	0.47	0.87	
White Catfish	20	0.14	-0.41	0.66	0.13	-0.38	0.65	Low
	27	0.12	-0.38	0.61	0.10	-0.38	0.53	
White Perch	20	0.28	0.03	0.52	0.29	0.04	0.53	High
	27	0.34	0.16	0.56	0.35	0.15	0.55	

(a) Monte Carlo simulation based on data from CHGE et al. and Entergy (2007, 2015).

Table A-17. WOE for the SOC LOE for YOY RIS Based on the Monte Carlo Simulation

RIS	SOC LOE Conclusion	RIS	SOC LOE Conclusion
Alewife	Low	Hogchoker	High
American shad	Low	Rainbow smelt	High
Atlantic menhaden	Cannot be Modeled ^(a)	Shortnose sturgeon	Cannot be Modeled ^(a)
Atlantic sturgeon	Cannot be Modeled ^(a)	Spottail shiner	Low
Atlantic tomcod	Low	Striped bass	High
Bay anchovy	High	Weakfish	High
Blueback herring	High	White catfish	Low
Bluefish	Low	White perch	High

RIS	SOC LOE Conclusion	RIS	SOC LOE Conclusion
Gizzard shad	Cannot be Modeled ^(a)	Blue crab	Cannot be Modeled ^(a)

^(a) Model parameter estimates were unavailable or sufficient population abundance data was lacking.

The unmodeled RIS were Atlantic menhaden, Atlantic and shortnose sturgeon, gizzard shad, and blue crab. The NRC staff did not model these species due to insufficient data. Atlantic menhaden only occurred in entrainment samples in 1985 and 1986 and occurred in low numbers (approximately 630 annually) in impingement samples. The number impinged represented 0.05 percent of all fish and blue crab impinged (1975–1990). Neither Atlantic nor shortnose sturgeon occurred in entrainment samples (1981, 1983–1987), and an estimated total of 71 shortnose sturgeon and 1,334 Atlantic sturgeon occurred in impingement samples from 1974 through 1990 (NMFS 2013). Gizzard shad did not occur in entrainment samples (1981, 1983–1987) but appeared regularly in impingement samples, increasing from about 2,400 annually from 1975 to 1984 to about 7,700 annually from 1985 to 1990. Sampling for blue crab in impingement samples began in 1983, with numbers increasing from about 2,000 annually from 1983 to 1987 to 56,600 annually from 1988 to 1990. Despite the increase in impingement, gizzard shad and blue crab represent only about 1 percent of all RIS impinged.

SOC Sensitivity Analysis

In response to public comments on the draft version of this supplement to the FSEIS, the NRC staff performed a sensitivity analysis to evaluate the potential for its SOC analysis to result in false positive conclusions (i.e., whether the SOC analysis could indicate a “High” SOC when the direct effects of IP2 and IP3 operations (I&E) are assumed not to exist).

To perform the SOC sensitivity analysis, the NRC staff conducted a new Monte Carlo simulation for the 13 RIS for which the NRC made an SOC LOE conclusion in Table A–17. The staff used the new Monte Carlo simulation to estimate the probability of the interquartile range including zero with 200 simulations for a range of slopes and CVs and a starting YOY population of 1,000 for a 20-year time period. In the new simulation, the staff set the EMR and IMR, which represent the direct effects of IP2 and IP3 operations, to zero. The staff did not change CV values, which represent the indirect effects of IP2 and IP3 operations, or any other parameters (see Table A–15) for a full list of parameters and associated values). The results of the new Monte Carlo simulation appear below in Table A–18.

Table A–18. SOC Sensitivity Analysis Monte Carlo Simulation Results

RIS ^(a)	Interquartile Range Includes Zero ^(b)				Combined Loss SOC	SOC LOE Conclusion ^(c)
	n=1,000, t=20	n=1,000, t=27	n=10 ⁸ , t=20	n=10 ⁸ , t=27		
Alewife	1	1	1	1	Low	Low
American shad	1	1	1	1	Low	Low
Atlantic tomcod	1	0	1	0	Low	Low
Bay anchovy	1	0	1	0	Low	High
Blueback herring	0	0	0	0	High	High
Bluefish	1	0	1	0	Low	Low
Hogchoker	0	0	0	0	High	High
Rainbow smelt	0	0	0	0	High	High

RIS ^(a)	Interquartile Range Includes Zero ^(b)				Combined Loss SOC	SOC LOE Conclusion ^(c)
	n=1,000, t=20	n=1,000, t=27	n=10 ⁸ , t=20	n=10 ⁸ , t=27		
Spottail shiner	1	0	1	0	Low	Low
Striped bass	1	0	1	0	Low	High
Weakfish	1	0	1	0	Low	High
White catfish	1	1	1	1	Low	Low
White perch	1	0	1	0	Low	High

^(a) For the purposes of the sensitivity analysis, EMR and IMR are assumed to be zero for all RIS.

^(b) 0=no; 1=yes.

^(c) The NRC staff's SOC LOE conclusions in this final supplement to the FSEIS are unchanged from those published in the draft version (NRC 2015b) of this supplement.

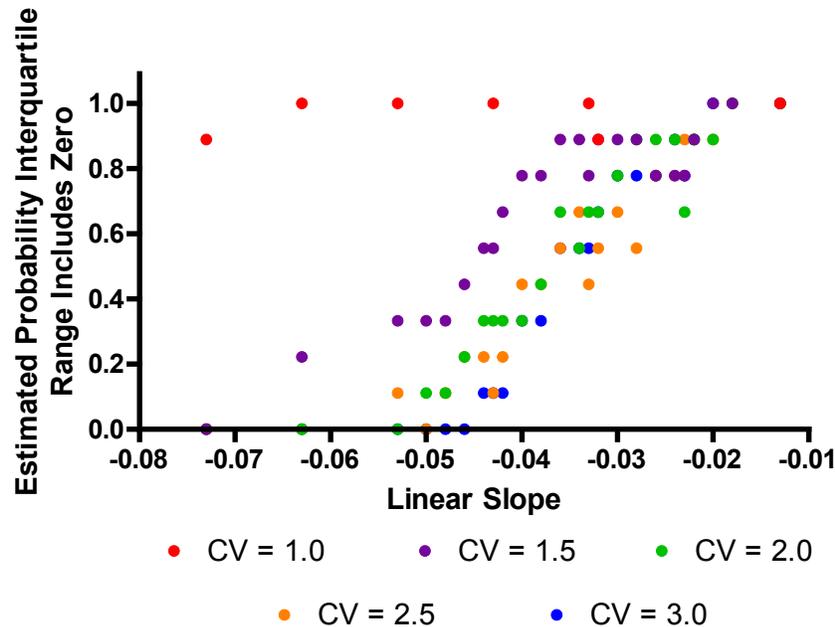
The results of the new Monte Carlo simulation indicate that for RIS with CVs of <1 and a larger negative slope, such as American shad, the probability of the interquartile range including zero is large (see Figure A–5). For these RIS, applying an EMR and IMR of zero is unlikely to produce a “High” SOC and, therefore, a false positive “High” result is also unlikely. However, for RIS with CVs >1 and a larger negative slope, such as blueback herring, hogchoker, and rainbow smelt, the probability of the interquartile range including zero is small (see Figure A–5). For these RIS, a “High” SOC can result even when the EMR and IMR are set to zero. Because a high CV is indicative of population instability, the NRC staff's sensitivity analysis indicates that the SOC findings for RIS that exhibit instability (CVs >1 and a larger negative slope) are more uncertain than for other RIS. SOC findings of “High” for these RIS may or may not be false positive findings. Several factors and uncertainties influence the results of the SOC analysis such that a “High” SOC could be an accurate result for these RIS for the reasons described below.

The NRC staff's SOC formulation includes terms to account for both direct and indirect effects of IP2 and IP3 operations. Direct effects (i.e., I&E) are represented by the EMR and IMR, whereas indirect effects (e.g., changes in temperature, predator-prey and other food web effects, and disease-related mortality) are incorporated into the CV, which is a component of the alternate growth rate (r^*) calculation. Thus, depending on the CV value, an SOC result other than “Low” is possible even when no I&E is assumed and EMR and IMR values are set to zero. Such a scenario would indicate that while a given RIS population is not highly affected *directly* by I&E of IP2 and IP3 cooling water intake structures, IP2 and IP3 operations are likely affecting that population *indirectly* to a great enough extent for those effects to be reflected in the SOC analysis results. Accordingly, a “High” SOC finding when the EMR and IMR are set to zero does not necessarily indicate a false positive finding.

The NRC staff recognizes that various uncertainties may affect its SOC analysis in a manner that could indicate that an SOC exists between IP2 and IP3 operations and a given RIS's population trend that is not actually present. The staff accounted for some uncertainty in its SOC formulation through the regression error mean square and the density CV in the modeled annual YOY population abundances, N_t (with IP2 and IP3 operations) and N_t^* (without IP2 and IP3 operations). The standard error in the estimated linear slopes, variability in trends, and random noise could also affect the relative differences in the N_t and N_t^* populations (see Equation (4) in Section A.2 of this supplement) and, thus, could affect the SOC results. Other uncertainties that could affect the SOC results include sampling quality, data accuracy, data quantity, and the interactions of multiple environmental stressors. These uncertainties and

the potential effects on the staff's I&E analysis are summarized below in Section A.4.3 and discussed in detail in Section 4.5 of this supplement.

Figure A–5. Estimated Probability of the Interquartile Range Including Zero



The figure above represents the probability as the slope increases; the CV of the density data decreases; and the standard error of the slope estimate, mean square error from regression, EMR, and IMR are set equal to 0.015, 0.3, 0, and 0, respectively.

A.3.4 WOE Integration and Final RIS Impact Findings

The WOE integrates the Population Trend LOE and SOE LOE into final RIS impact findings (Table A–19). Assignment of a level of impact for any aquatic species (“Small,” “Moderate,” or “Large”) requires information on both a measurable response in the RIS population and modeling showing that the RIS is influenced to an observable degree by IP2 and IP3 cooling system operation. If the SOC is “Low,” the impact level will not be greater than “Small” because of little evidence that an observable relationship exists between IP2 and IP3 operations and an RIS’s population trend. Conversely, if an RIS exhibits a “High” SOC to IP2 and IP3 operations but no statistically significant population decline, the final determination will also be “Small.” For RIS where the Population Trend LOE conclusion is “Unresolved” and the SOC LOE conclusion is “Cannot be Modeled,” the WOE conclusion is “Unresolved.”

Both Atlantic and shortnose sturgeon populations are listed under the Endangered Species Act of 1973, as amended (ESA). As discussed in the 2013 supplement to the FSEIS (NRC 2013b), the NRC staff and NMFS conducted formal ESA Section 7 consultation, and NMFS (2013) issued a biological opinion on the effects of IP2 and IP3 operation on the two species. In the biological opinion, the NMFS concluded that the continued operation of IP2 and IP3 is likely to adversely affect but is not likely to jeopardize the continued existence of these species. In Section 7.1.4 of this supplement, the NRC staff revises its NEPA findings for these and other Federally listed species as a result of the issuance of Revision 1 of the GEIS (NRC 2013a) and the outcome of the staff’s consultations with NMFS and the U.S. Fish and Wildlife Service (FWS). As stated in that section, the NRC staff’s revised finding for Atlantic and shortnose

sturgeon is “may affect, but not likely to jeopardize the continued existence of” both species. For consistency, the NRC staff uses this conclusion as a final RIS impact finding for these species in lieu of “Small,” “Moderate,” or “Large.” The NRC staff’s use of this conclusion for shortnose and Atlantic sturgeon and its revised findings for other ESA-listed species is described in more detail in Section 7.1.4 of this supplement and in the staff’s public comment responses in Appendix B, Section B.2.4.1.

Table A–19. I&E Impact Summary for Hudson River YOY RIS

Species	Population Trend LOE Conclusion	SOC LOE Conclusion	Final RIS Impact Finding
Alewife	Undetected Decline	Low	Small
American Shad	Detected Decline	Low	Small
Atlantic Menhaden	Undetected Decline ^(d)	Unresolved ^(b)	Unresolved
Atlantic Sturgeon	Unresolved ^(a)	Unresolved ^(b)	May affect, but not likely to jeopardize the continued existence of ^(c)
Atlantic Tomcod	Detected Decline	Low	Small
Bay Anchovy	Undetected Decline	High	Small
Blueback Herring	Detected Decline	High	Large
Bluefish	Variable	Low	Small
Gizzard Shad	Undetected Decline	Unresolved ^(b)	Unresolved
Hogchoker	Variable	High	Moderate
Rainbow Smelt	Detected Decline	High	Large
Shortnose Sturgeon	Unresolved ^(a)	Unresolved ^(b)	May affect, but not likely to jeopardize the continued existence of ^(c)
Spottail Shiner	Undetected Decline	Low	Small
Striped Bass	Undetected Decline	High	Small
Weakfish	Undetected Decline	High	Small
White Catfish	Variable	Low	Small
White Perch	Undetected Decline	High	Small
Blue Crab	Unresolved ^(a)	Unresolved ^(b)	Unresolved

^(a) Population Trend LOE could not be established.

^(b) SOC could not be established using Monte Carlo simulation.

^(c) In Supplement 1 to the FSEIS, the NRC staff described the unresolved impacts to Atlantic and shortnose sturgeon as “Small.” In Section 7.1.4 of this supplement, the NRC staff revises its NEPA finding for these species as a result of the revised GEIS (NRC 2013a) and the outcome of formal consultation with the NMFS for IP2 and IP3 license renewal. The NRC staff incorporated these revised findings into its final RIS impact findings and WOE results.

^(d) Based on newly submitted information from Entergy (2016) during the public comment period of the draft of this supplement, the NRC staff revised its finding for Atlantic menhaden from “Unresolved” to “Undetected Decline.”

A.3.5 Accounting for Uncertainty Due to Gear Changes and Partial Data Sets

As described above, the Hudson River Biological Monitoring Program changed sampling gears in 1985. To remove this potentially confounding factor, the NRC staff’s present analysis analyzes population trends from 1985 through 2011, to ensure consistent sampling gear and methodology throughout the time period examined. The NRC staff acknowledges that by not including the

earlier data, the staff's statistical analyses do not examine whether any RIS populations experienced declines soon after IP2 and IP3 operations began before the 1985 gear change.

To examine whether RIS population declines may have occurred prior to 1985, the NRC staff performed a nonparametric Mann-Whitney *U* test. Such a test can be used to compare the medians of two non-normally distributed populations (e.g., an RIS population before and after the 1985 gear change) and determine if there are true differences before versus after an event. A "significant" outcome in the test would show a difference in medians, which in this case would indicate that pre-1985 population changes likely occurred that are not reflected in the post-1985 data that the staff used in its I&E analysis. The results of the NRC staff's Mann-Whitney *U* test for each RIS and population metric appear in Table A–20. Significant p-values, or calculated probabilities, are noted by asterisks (*) and indicate cases in which at least one significant difference between pre- and post-1985 populations can be assumed.

Table A–20. P-Values for Mann–Whitney *U* Test of Equal Median Abundance Pre- and Post-1985 for Each Population Metric

Species	River Segment 4 Population Metrics			Riverwide Population Metrics			Abundance Index	Proportion Detected Change		
	LRS Density	FSS Density	BSS Density	LRS CPUE	FSS CPUE	BSS CPUE				
Alewife	--	0.22	0.06	--	<0.01*	N/A	<0.01*	0.50	N/A	0.29
American Shad	0.22	0.01*	<0.01*	0.28	<0.01*	0.05*	<0.01*	0.02*	0.04	0.78
Atlantic Menhaden	--	--	N/A	--	--	N/A	N/A	N/A	N/A	0.00
Atlantic Tomcod	0.10	0.04*	<0.01*	0.07	0.05*	0.31	0.10	<0.01*	0.40	0.44
Bay Anchovy	--	0.01*	N/A	N/A	<0.01*	N/A	<0.01*	0.19	0.14	0.38
Blueback Herring	--	0.01*	0.15	--	<0.01*	N/A	<0.01*	0.01*	0.02*	0.71
Bluefish	0.27	<0.01*	0.02*	0.49	<0.01*	N/A	<0.01*	0.02*	0.02*	0.67
Gizzard Shad	--	--	--	--	--	--	N/A	N/A	--	0.00
Hogchoker	--	0.17	0.03*	--	0.38	0.28	N/A	0.19	0.25	0.14
Rainbow Smelt	0.05	0.06	--	0.03	0.01*	0.04*	0.01*	0.06	0.03*	0.75
Spottail Shiner	--	--	0.07	--	--	N/A	0.25	N/A	0.44	0.00
Striped Bass	N/A	N/A	N/A	N/A	0.42	N/A	N/A	N/A	N/A	0.00
Weakfish	N/A	0.01*	--	N/A	<0.01*	N/A	<0.01*	0.02*	0.03*	0.63
White Catfish	--	--	--	--	--	0.31	0.06	0.45	<0.01*	0.25
White Perch	--	0.23	0.01*	--	0.06	N/A	0.03*	<0.01*	<0.01*	0.57

N/A=Not applicable because pre-1985 median < post-1985 median; * indicates significant, $\alpha=0.05$; and --=Not enough data.

Appendix A

Species	River Segment 4 Population Metrics					Riverwide Population Metrics			Proportion Detected Change
	LRS Density	FSS Density	BSS Density	LRS CPUE	FSS CPUE	LRS CPUE	FSS CPUE	BSS CPUE	

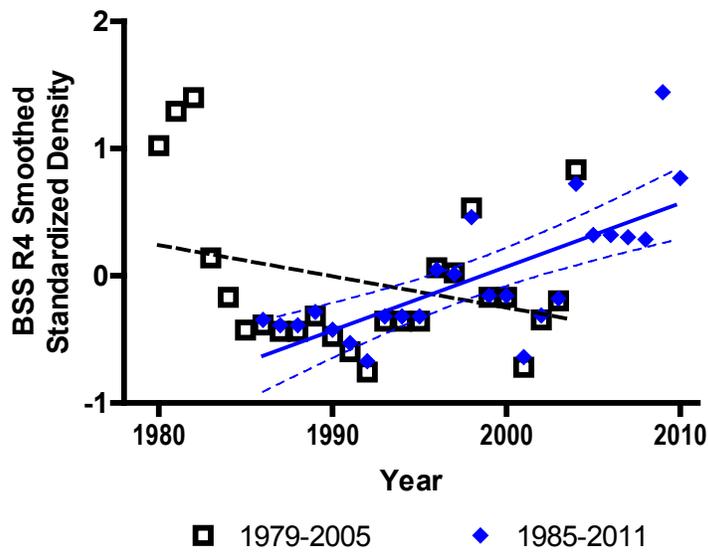
Source: Entergy (2015)

Two RIS (American shad and rainbow smelt) had at least 75 percent of their population metrics showing a reduction in the median abundance post-1985 (indicated by the “Proportion Detected Change” column in Table A–20). As described in Sections A.3.2 and A.3.3 of this supplement, the Population Trend LOE conclusions for both of these RIS were “Detected Decline,” and the slopes of the BSS and LRS River Segment 4 density metrics used in the SOC analysis for American shad and rainbow smelt, respectively, were also significantly decreasing. Thus, it is unlikely that the decision to use only post-1985 data affected the final RIS impact finding of LARGE.

Seven RIS (alewife, Atlantic tomcod, bay anchovy, blueback herring, bluefish, weakfish, and white perch) had greater than 25 percent, but less than 75 percent, of their population metrics showing a reduction in the median abundance post-1985 (see Table A–20). Of these RIS, the NRC staff changed its WOE impact conclusions for alewife, weakfish, and white perch from the conclusions that the NRC staff previously described in the FSEIS (NRC 2010). In the FSEIS, the NRC staff concluded that the impacts of I&E on these species would be “Moderate,” “Moderate,” and “Large,” respectively. In the present analysis, the NRC staff concluded that the impacts to all three of these RIS would be “Small.” Figure A–6, Figure A–7, and Figure A–8 show the differences in observed River Segment 4 population trends when two different data year subsets (1979–2005 and 1985–2011) are used for these RIS. As illustrated in the figures, the decision to use only post-1985 data is one source of uncertainty that could affect the final RIS impact finding for alewife, weakfish, and white perch. This uncertainty, among others, is discussed in detail in Section 4.5 of this supplement.

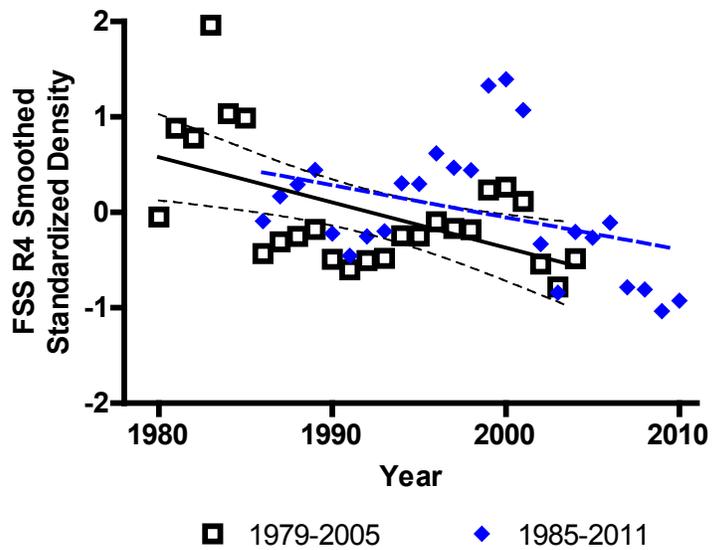
The remaining six RIS (Atlantic menhaden, gizzard shad, hogchoker, spottail shiner, striped bass, and white catfish) had less than 15 of their population metrics showing a reduction in the median abundance post-1985 (see Table A–20). For these species, the use of only post-1985 data was not likely a large source of uncertainty.

Figure A–6. River Segment 4 Alewife Population Trends Based on the BSS Standardized Density for Two Subsets of Years of Monitoring Data



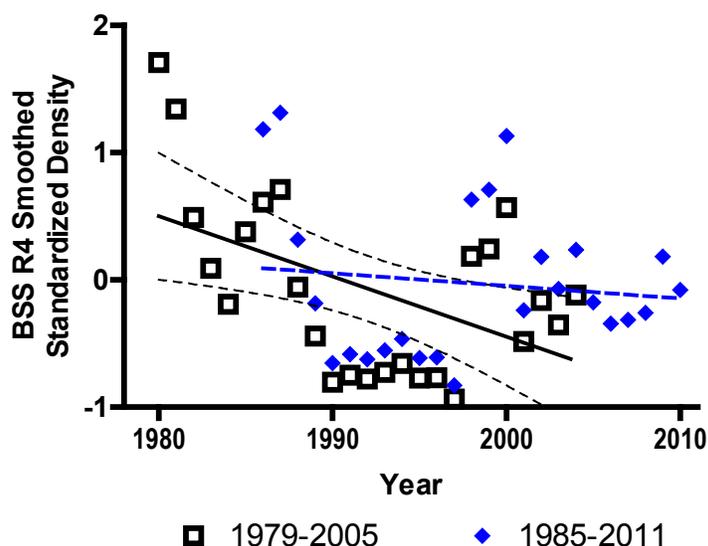
Source: Entergy 2015

Figure A–7. River Segment 4 Weakfish Population Trends Based on the FSS Standardized Density for Two Subsets of Years of Monitoring Data



Source: Entergy 2015

Figure A–8. River Segment 4 White Perch Population Trends Based on the BSS Standardized Density for Two Subsets of Years of Monitoring Data



Source: Entergy 2015

A.4 Discussion and Conclusions

A.4.1 Discussion of RIS Findings

Population trends of many species appear to be decreasing, particularly in River Segment 4. These decreases occur in spite of a long-term trend of better water quality (Levinton and Waldman 2006) and no evidence that populations are adjusting to overly high population levels in the past. The NRC staff's analysis identified four species with statistically significant declines consistently across all measures of abundance and both geographic scales: American shad, Atlantic tomcod, blueback herring, and rainbow smelt. The results of the NRC's I&E analysis for these and other RIS are discussed in detail below.

American Shad

American shad YOY population trends for all measures of abundance for both River Segment 4 and riverwide scales are negative and statistically significant (Addendum A–2, Figure B2). These results reflect a coastwide decline. East coast commercial fishery landings of American shad have been declining since the late 1800s (NMFS 2015). In the Hudson River, several measures of shad abundance have decreased, including commercial landings, since the late 1800s (Hattala and Kahnle 2009); abundance of YOY American shad since 1980 (NYSDEC 2015); and spawning stocks since 1985 (Hattala and Kahnle 2009). Commercial landings are currently at historic lows (NYNJHEP 2012). The decline in American shad has been principally attributed to overfishing, not only in the Hudson River but along the Atlantic coast; habitat loss and degradation; and cooling water intakes (Hattala and Kahnle 2009, Kahnle and Hattala 2010). Examining potential effects of striped bass predation on American shad has not yielded evidence that an increase in the striped bass population has caused a decline in the shad population (ASMFC 2007, Hattala and Kahnle 2009, NYSDEC 2009, Kahnle and Hattala 2010). Both NYSDEC and Cornell (2015) and NYSDEC (2015) present an index of Hudson River YOY American shad abundance from 1984 through 2013 and find that highs in

the 1980s were much lower than historical highs; production of YOY decreased significantly in 2002 and continued to decline through 2013.

The NRC staff found the SOC for Hudson River American shad to be “Low” (Table A–17), and so the impacts of I&E associated with IP2 and IP3 license renewal would be “Small” (Table A–19). This finding is consistent with Hattala and Kahnle’s (2009) conclusion that I&E losses of American shad due to once-through cooling water intakes at power generating stations on the Hudson River south of Newburgh Bay, such as IP2 and IP3, are relatively small because the spawning habitat is well upstream. When added to other more serious stresses, however, power plant impingement mortality in the Hudson River can contribute to increased mortality rates (ASMFC 2009).

Alewife and Blueback Herring

Like American shad, alewife and blueback herring are anadromous alosid species that spawn upstream of IP2 and IP3 and their YOY pass the plant on the downstream migration. Due to difficulties in distinguishing between alewife and blueback herring, these congeneric species are collectively called “river herring.” They have similar ranges and life histories, are often caught together in commercial and recreational fisheries, and are managed together. River herring populations are well below historic levels of the mid-20th century, possibly because of overfishing and habitat destruction. Severe declines in coastwide river herring populations starting in the 1970s led NMFS to consider listing river herring as threatened or endangered species (78 FR 48944). Both are anadromous species that, in the Hudson River, spawn upriver from IP2 and IP3 in tributaries and shallow areas of the main stem (Hattala et al. 2011), and YOY are vulnerable to impingement during the seaward migration.

In the Population Trend LOE, the NRC staff observed a decline in the blueback herring YOY population that appeared consistently in River Segment 4 measures of abundance but less consistently riverwide (Addendum A–2, Figure F2; Table A–12; and Table A–13). For alewife, however, results were mixed (Addendum A–2, Figure A2; Table A–12; and Table A–13). Statistically significant trends in River Segment 4 are positive for BSS density and negative for FSS density (Addendum A–1, Figures C1 and B1, respectively), although both surveys sample the YOY population at the same time of year and the riverwide trend in FSS CPUE is positive (but not significant). Trends in other measures of abundance are mixed and not significant. Using a variety of fishery-dependent and fishery-independent data from the Hudson River, Hattala et al. (2011) found that yearly recruitment has become extremely variable for both species and that a decline is occurring in YOY blueback herring, whereas an increasing trend is occurring in YOY alewife. NMFS found similar results on a larger scale for the stock complexes, which typically include populations from several rivers. The Southern New England alewife stock complex, which includes the Hudson River, appears stable, whereas the mid-Atlantic blueback herring stock complex, which includes the Hudson River, is significantly decreasing (78 FR 48944). The Population Trend LOE (Table A–12, Table A–13, Table A–14) also shows a decrease in YOY Hudson River blueback herring but mixed trends for alewife that partially depend on how YOY abundance is measured, perhaps due to high alewife recruitment variability combined with a lower population density of alewife compared to blueback herring.

The NRC staff found the SOC to be “Low” for alewife and “High” for blueback herring (Table A–16), which, together with the Population Trend LOE conclusions of “Undetected Decline” and “Detected Decline,” respectively (Table A–14), results in a final RIS impact findings of “Small” for alewife and “Large” for blueback herring (Table A–19) for IP2 and IP3 license renewal. In IP2 and IP3 I&E samples, some young alosids cannot be further identified to species and are reported as unidentified alosids. The NRC staff allocated these in proportion to the identified river herring in the SOC estimate of EMR, but this introduces a measure of

uncertainty into the analysis. This and other uncertainties associated with the NRC staff's I&E analysis are discussed in detail in Section 4.5 of this supplement.

In its blueback herring factsheet, the ASMFC (2015) considers both "water withdrawal facilities" and "thermal and toxic discharges" as two of seven identified threats to blueback herring habitat. ASMFC's (2015) recommendations to improve the habitat quality include "[a]lter water withdrawal rates or water intake velocities to reduce alosine mortality." Hattala et al. (2012) could not identify the reason for the wide variation in YOY river herring indices and note that the same erratic trend that occurs since 1998 in river herring is also evident for American shad. They conclude that the trend of increasing recruitment variability in all three alosines may indicate a change in overall stability of the Hudson River system.

Rainbow Smelt

Rainbow smelt is an anadromous species once common in the Hudson River, but it has undergone an abrupt population decline in the Hudson River since 1994, and the species may no longer have a viable population within the Hudson River. The last tributary run of rainbow smelt was recorded in 1988, and the post-yolk sac larvae essentially disappeared from LRS samples after 1995 (Daniels et al. 2005). Rainbow smelt YOY were last captured in the LRS, FSS, and BSS in 1995, 1998 (one fish), and 1993, respectively (Addendum A-1, Figures F1 and G1). In the Population Trend LOE, statistically significant declines in YOY rainbow smelt occurred in all (4 of 4) of the River Segment 4 and all (3 of 3) riverwide measures of abundance. The EMR is the fourth highest of all species analyzed (25.8 percent, Table A-15), and the NRC staff found the SOC to be "High" (Table A-17), indicating that the effect of IP2 and IP3 on the rainbow smelt population would be observable. The NRC staff's final RIS impact finding for the species is "Large" (Table A-19).

Large cooling water withdrawals may be a source of adverse impact to rainbow smelt coastwide. For example, NRC (2007) found that the I&E impacts of Pilgrim Nuclear Power Station license renewal on rainbow smelt and winter flounder populations in the Jones River are "MODERATE," whereas effects on other marine aquatic species would be "SMALL to MODERATE." Daniels et al. (2005) note slowly increasing water temperatures in the Hudson River and suggest that the disappearance of rainbow smelt can be attributed to global warming, and NYSDEC (2003) indicates that thermal effluents from Hudson River power plants may have contributed to its disappearance. Additional factors contributing to rainbow smelt population declines include dams, overfishing, pollution, changes in trophic interactions, shifts in aquatic communities, and watershed land use (Enterline et al. 2012).

Although rainbow smelt became absent from LRS, FSS, and BSS about midway through the period considered here, this RIS is retained in the analysis. The fate of an RIS helps inform the impact determination, because it stands as a surrogate for other species in the aquatic community. The RIS are sentinel species: the extirpation of an RIS stands as a warning that other species with similar attributes could suffer similar adverse impacts.

Atlantic Tomcod

Like rainbow smelt, Atlantic tomcod is a cold-water, anadromous species, and the only winter-spawning fish species in the Hudson River (Dew and Hecht 1994). Although its range once extended as far south as Virginia, the Hudson River is now the southern limit (Stewart and Auster 1987). Tomcod larvae hatch upriver from IP2 and IP3 and pass by the plant on their spring seaward migration, where, because of their vertical migration patterns and tidal currents in this two-layered estuarine system, individuals may be exposed to the cooling water withdrawal several times (Dew and Hecht 1994). The lifespan of Hudson River tomcod is relatively short, perhaps not much over 1 year.

Population trends for YOY Atlantic tomcod are consistently negative (Addendum A–2, Figure D2), with statistically significant trends for 2 of 4 measures of abundance for River Segment 4 (Table A–12) and 4 of 4 riverwide (Table A–13), indicating an unstable population. The NYSDEC and Cornell (2015) present an Atlantic tomcod index of abundance for the Hudson River from 1974 through 2014 that shows a continual decline with high variability. However, the NRC staff found the SOC to be “Low” (Table A–17), which indicates that the effect of IP2 and IP3 license renewal on the population would not be observable. The NRC staff’s final RIS impact finding for the species is “Small” (Table A–19). The causes of the decline of Atlantic tomcod in the Hudson River have not been clearly identified but may be similar to those affecting rainbow smelt, which is also a cold water, anadromous species. Particular threats include global warming and the thermal environment as well as pollution (Daniels et al. 2005), and thermal stress could increase tomcod susceptibility to other stresses.

Hogchoker

One species, hogchoker, had varied population trends and a “High” SOC. Hogchoker is a semi-anadromous flatfish species in the Hudson River estuary, surrounding bays, and coastal waters. Adults tend to live in low salinity waters from late fall through spring, migrate downstream into high salinity waters to spawn in spring and summer, and then migrate back upstream. In summer and fall, the larvae and early juveniles migrate from marine waters upriver to low salinity areas. The NRC staff calculated the EMR for this species to be relatively high (38.5 percent) (Table A–15). The Population Trend LOE showed variable trends with consistent declines in River Segment 4 but not riverwide (Table A–12, Table A–13, and Table A–14). The statistically significant trends, however, were all negative: FSS density and CPUE in River Segment 4 (Addendum A–2, Figure I2). The NRC staff determined the SOC to be “High,” indicating that the effect of I&E at IP2 and IP3 license renewal would be observable. The NRC staff’s final RIS impact finding for the species is “Moderate” (Table A–19). The relatively high EMR and decreasing trends of abundance in River Segment 4 but not riverwide suggest that the river habitat near IP2 and IP3 is becoming poorer for hogchoker.

Bay Anchovy

The SOC LOE was “High” although population levels did not consistently decline for four species: bay anchovy, striped bass, weakfish, and white perch. Bay anchovy are part of a coastal population that spawns not only in the Hudson River but in many other parts of the Hudson-Raritan estuary complex. For this species, only one of four trends in both River Segment 4 and riverwide scales is significant, and both are negative: FSS density (Table A–12) and the FSS Abundance Index (Table A–13), respectively. Trends of the other measures of abundance are not statistically significant, resulting in a finding of “Undetected Decline” for the Population Trend LOE.

The bay anchovy EMR in River Segment 4 is relatively high at about 21 percent (Table A–15), and the SOC is “High” (Table A–17). However, the Population Trend LOE conclusion for this species was “Undetected Decline,” resulting in a final RIS impact finding of “Small” (Table A–19). Bay anchovy live about 2 years, and adults move out of the estuary to the continental shelf in the fall and back into the estuary in the spring. Vouglitois et al. (1987) found that, in Barnegat Bay, New Jersey, the population levels appear to be regulated largely by the survival rate and migratory patterns of the overwintering population on the shelf and to a lesser degree by events occurring within the estuary during the first few months of life. Bay anchovy in the Chesapeake Bay compensate for high mortality rates by maturing early and having high reproductive capacity (Newberger and Houde 1995). The same may be true in the Hudson River estuary.

Weakfish

Hudson River weakfish are also seasonal residents that are part of a coastal population. Weakfish overwinter in deeper waters of the continental shelf, generally between Chesapeake Bay and Cape Fear, North Carolina (Wilk 1979), and older weakfish begin to move toward shore and then head north along the coast when inshore waters begin to warm in spring. Spawning occurs in nearshore coastal and marine waters in spring and summer, and the larvae move into bays and estuaries. Weakfish typically occur in the Hudson River from July through mid-August. In fall, juvenile weakfish begin to leave northern estuaries and move toward southern overwintering areas.

Trends in 6 of 8 total measures of abundance appear to be negative (Addendum A–2, Figure M2). Only one trend, the Riverwide FSS Abundance Index, is statistically significant (Table A–13), and it is negative, which leads to a Population Trend LOE conclusion of “Undetected Decline” (Table A–14). The EMR for this species is high (54.4 percent) (Table A–15), and the NRC staff found the SOC to be “High.” Because the weakfish population is only seasonal in the Hudson River and spends much of the year off shore, the high EMR of individuals that do reside in River Segment 4 does not appear to result in long-term population declines.

Striped Bass

Striped bass are anadromous. Adults live along the coast in nearshore waters and tend to migrate north in winter and return to aggregate near the mouths of their natal rivers before the spring spawning migration. Spawning occurs primarily between mid-May and mid-June in the middle portion of the Hudson River estuary, which renders the early life stages susceptible to both I&E at IP2 and IP3. By the end of their first summer, many of the juvenile striped bass move to the southern extreme of the estuary, and at age 2 or 3, leave the estuary to begin seasonal migrations along the coast. Because of the commercial and recreational importance of Hudson River striped bass, the LRS, FSS, and BSS originally were focused on this species. Population trends in 3 of 9 indices of abundance are statistically significant, and all are negative (Addendum A–2, Figure L2): 2 of 4 in River Segment 4 (FSS Density and FSS CPUE, Table A–12) and 1 of 4 (FSS CPUE, Table A–13) riverwide. However, the inconsistency of results yields an “Undetected Decline” finding for the Population Trend LOE (Table A–14). The NYSDEC also monitors the abundance of Hudson River YOY striped bass with a BSS and calculates a riverwide abundance index. In reviewing the NYSDEC striped bass YOY Index of Abundance values from 1984 through 2014, NYSDEC and Cornell (2015) conclude that “[w]hile 2014 was a good year for production of young striped bass in the Hudson, the overall trend in recent years has been downward.” The NRC staff found the SOC to be “High,” which suggests that effects of I&E may be observable, and combined with the Population Trend LOE conclusion, results in an RIS impact finding of “Small” (Table A–19).

White Perch

White perch is a congener of striped bass, a resident species throughout the Hudson River from Albany south to Manhattan and a numerically dominant species in many parts of the river (Bath and O’Connor 1982). It is semi-diadromous and migrates within the Hudson River but does not go to sea. Adults move shoreward and upriver to spawn in freshwater and brackish water of low salinity (<4.2 parts per thousand) in spring and early summer, the larvae drift downstream, and fry and juveniles migrate downstream (Stanley and Danie 1983). White perch, along with hogchoker, is one of the few species that can tolerate the interannual transitions between limnetic and oligohaline conditions in River Segment 4 and is a dominant year-round resident there (Bath and O’Connor 1982). Population trends in 7 of 7 measures of abundance are negative (Addendum A–2, Figure O2), although only one trend was statistically significant, and

so the Population Trend LOE conclusion for white perch was “Undetected Decline” (Table A–14). The EMR is 7.5 percent of the River Segment 4 YOY population annually (Table A–15), and the NRC staff found the SOC to be “High” (Table A–17), indicating that the effects of I&E could be observable. The NRC staff’s final RIS impact finding for the species is “Small” (Table A–19) due to the undetectable population trend.

Bluefish

Besides weakfish, two other species, bluefish and Atlantic menhaden, are marine and use the estuary primarily as a nursery. Hudson River bluefish YOY population trends appear to be consistently negative with one exception, the riverwide BSS CPUE (Addendum A–2, Figure F2), which is not statistically significant. The statistically significant trends are negative in River Segment 4 (3 of 5, Table A–12) and riverwide (2 of 4, Table A–13). The EMR is low (0.3 percent, Table A–15) and the NRC staff found the SOC to be “Low.” Adult bluefish are marine and pelagic, and the YOY are seasonal visitors to the estuary. The NRC staff’s final RIS impact finding for this species is “Small” (Table A–19).

Atlantic Menhaden

Atlantic menhaden belong to a single stock. Rogers and Van Den Avyle (1983) report that over winter, fish of all ages congregate in the ocean south of Cape Hatteras, North Carolina. In spring, they migrate north and inshore and spawn as they move inshore. Larvae enter estuaries after 1 to 3 months at sea, and move into low salinity (<5 parts per thousand) parts of the estuary. Juveniles emigrate from the estuaries in fall. Menhaden have been heavily fished historically, and fishery landings fell drastically in the 1960s, rebounded somewhat in the 1980s, and have declined since then (SEDAR 2015). Catches in the LRS, BSS, and FSS remained at relatively low levels without population trends in River Segment 4 or riverwide (Addendum A–2, Figure C2; Table A–12; and Table A–13). The NRC staff was unable to model the SOC because of insufficient data to estimate the annual standing crop of eggs, larvae, and juvenile RIS within River Segment 4 (Table A–6); as a result, the NRC staff’s final RIS impact finding for this species is “Unresolved” (Table A–19).

Gizzard Shad, Spottail Shiner, and White Catfish

Gizzard shad, spottail shiner, and white catfish are freshwater species. For all of these species, population trends were variable or had undetected declines. Too few gizzard shad were caught to assess trends in River Segment 4, and two trends, not statistically significant, could be assessed riverwide. The NRC staff was unable to model the SOC because of insufficient data to estimate model parameters; therefore, the NRC staff’s final RIS impact finding for gizzard shad is “Unresolved” (Table A–19). Spottail shiner trends were inconsistent, the SOC was “Low,” and the final RIS impact finding for this species is “Small” (Table A–19). Too few white catfish were caught in River Segment 4 to assess trends (Table A–12). Trends could be calculated riverwide, however, and the two statistically significant trends were both negative (Table A–13). The NRC staff found the SOC for this species to be “Low,” and the final RIS impact finding for this species is “Small” (Table A–19).

Atlantic and Shortnose Sturgeon

Atlantic and shortnose sturgeon were not captured often enough to determine trends. Although the present assessment found no significant population trends for YOY Atlantic sturgeon for any measure of abundance, the NYSDEC also calculates an index of relative abundance from Hudson River fisheries surveys. The NYSDEC and Cornell (2015) report that, although the Atlantic sturgeon YOY index has high interannual variability, the trend in abundance is increasing from 2006 through 2014, and is attributable to the 1996 closure of the Hudson River sturgeon fishery. Both Atlantic and shortnose sturgeon populations are greatly reduced from

past levels, however, and both are listed under the ESA. The NRC staff and NMFS conducted a formal ESA Section 7 consultation related to the impacts of continued operation and license renewal of IP2 and IP3 on these species. Atlantic sturgeon is listed by distinct population segment (DPS), of which three occur in the Hudson River: the New York Bight and Chesapeake Bay DPSs are endangered and the Gulf of Maine DPS is threatened. The shortnose sturgeon is listed as endangered wherever found. The NMFS (2013) issued a biological opinion, which concluded that the continued operation of IP2 and IP3 is likely to adversely affect but is not likely to jeopardize the continued existence of shortnose sturgeon or the three DPSs of Atlantic sturgeon in the Hudson River. No critical habitat for the shortnose sturgeon is designated in the action area. As discussed in Sections 7.1.2 and 7.1.3 of this supplement, the NMFS recently designated critical habitat for the New York Bight DPS of Atlantic sturgeon in the Hudson River in the vicinity of IP2 and IP3, and the NRC and NMFS completed an ESA Section 7 conference to address potential effects to the critical habitat, resulting from IP2 and IP3 operations. Following the NMFS's final critical habitat designation, the NRC (2017f) requested the NMFS's concurrence with the staff's determination that the proposed action, continued operation of IP2 and IP3 through the end of the proposed license renewal terms, is not likely to adversely affect critical habitat designated for the New York Bight DPS of Atlantic sturgeon, pursuant to ESA Section 7(a)(2). Additionally, in accordance with the 2013 biological opinion, Entergy is conducting monitoring studies to provide more information on the impacts to these species. The NRC staff's final RIS impact finding for both of these species is "May affect, but not likely to jeopardize the continued existence of" (Table A-19).

Blue Crab

Blue crab were not captured often enough to determine River Segment 4 or riverwide population trends or to determine the SOC. The NRC staff's assessment could, therefore, not resolve the impact of I&E on this species, and the final RIS impact finding for this species is "Unresolved" (Table A-19).

A.4.2 Synthesis

Mitigation measures have been deployed at IP2 and IP3 since the 1970s, including variable and two-speed cooling water pumps and modified Ristroph traveling screens at the intake; nonetheless, the impacts to aquatic resources generally comport well with AEC's (1972) overall predictions in the *Final Environmental Statement Related to Operation of Indian Point Nuclear Generating Plant Unit No. 2 (FES)*, particularly in the years after 1995, although observed impacts differ from predictions for a few species. The 1972 FES stated:

Because of the location of the Station in the low salinity zone of the Hudson Estuary, operation of Indian Point Units Nos. 1 and 2 with the present once-through cooling system will adversely influence the fish populations that use the area for spawning and initial periods of growth and development. Recruitment rates and standing crops of several species may be appreciably lowered in response to the increased mortality caused by entrainment of eggs and larvae and of impingement of young-of-the-year.

Those species most likely to be affected include the tomcod, bay anchovy, blueback herring, alewife, American eel, smelt, American shad, white perch, and striped bass. Direct effects on the freshwater species such as the two sturgeons that commonly occur in the vicinity of Indian Point are not expected to be severe.

The staff believes adequate evidence is not available to properly evaluate the qualitative or quantitative aspects of the indirect effects of the operation of the Indian Point Station but that a high potential for important changes do exist.

An assessment of individual RIS can be used to understand the impact to the Hudson River ecosystem as a whole. The NRC staff's final findings for the effects of I&E on Hudson River populations of the 18 RIS include the following impact levels: 10 "Small," 1 "Moderate," 2 "Large," 3 "Unresolved," and 2 Federally listed species under the ESA that are described according to language in the NMFS's (2013) biological opinion as "May affect, but not likely to jeopardize the continued existence of." The Population Trend LOE found that population densities of many RIS species are declining, particularly in River Segment 4, in spite of improving water quality. These results indicate that the Hudson River ecosystem, at least in River Segment 4, has been noticeably altered in a manner indicating local ecological instability. IP2 and IP3 operation is one of many stressors of Hudson River fish populations. As discussed in Section 4.5 of this supplement, individual stressors can combine to create synergistic effects on populations.

The importance of River Segment 4 to the Hudson River ecosystem is recognized in the update to the Hudson Highlands Significant Coastal Fish and Wildlife Habitat (SCFWH) recently finalized by the New York State Department of State (NYSDOS 2012). This update added the reach of river from which IP2 and IP3 withdraw cooling water (i.e., River Segment 4) to the boundary of the Hudson Highlands SCFWH because it is a major spawning area for Hudson River striped bass. In the SCFWH Assessment for the Hudson Highlands, NYSDOS stated that "[e]ntrainment and impingement causes significant mortality to all life stages of fish, including endangered species."

Early on, investigators began to report indications of Hudson River fish population instability due to power plant operation. Barnthouse and van Winkle (1988) used conditional impingement mortality rates to analyze the effects of power plant operation on Hudson River fish populations and noted that impingement may be an important source of mortality when added to other stresses on populations. Goodyear (1988) assessed the implications of power plant mortality on Hudson River fish populations and found that "it is apparent that serious stock reductions attributable to the power plants could occur during the plants' anticipated operational lifetimes[.]"

More recently, other investigators have also reported signs of instability of the Hudson River ecosystem. In an assessment of the Hudson River stocks of American shad, blueback herring, and alewife (all alosine herring species), Hattala et al. (2012) observed that:

The underlying reason for the wide variation in yoy [YOY, young-of-year] river herring indices is not clear. The same erratic trend that occurs since 1998 is also evident for American shad (Hattala and Kahnle 2007). The trend in all three alosines may indicate a change in overall stability in the system.

Hurst et al. (2004) used canonical correlation analysis to examine the fish community in the Tappan Zee-Haverstraw Bay region of the Hudson River (just below IP2 and IP3), from 1980 through 2000. They observed "a decline in diversity of the fish community during the 21-yr study period" and concluded that:

In addition to interannual variation in community composition related to summer flow regime, there were significant directional changes in community composition between 1980 and 2000. These changes

included an increased dominance of Atlantic silversides, decreases in freshwater and estuarine species, and declines in diversity and stability.

The New York–New Jersey Harbor & Estuary Program (NYNJHEP 2012), in assessing the state of the Hudson River estuary, noted several signs of instability including the increasing abundance fluctuations of blueback herring similar to those observed for American shad before its population declined dramatically in the 2000s, and the declines in Hudson River populations of American eel (*Anguilla rostrata*), white perch, and banded killifish (*Fundulus diaphanus*). O'Connor et al. (2012), using multivariate redundancy analysis, found “a significant long-term trend in the selected species–stage abundances from 1974 to 2005, indicating that the [Hudson River estuary] fish community has changed significantly over this period.”

Many biotic and abiotic factors may contribute to the changes in the Hudson River fish community (Daniels et al. 2005). For example, O'Connor et al (2012) noted that the abundance of certain Hudson River species' life history stages exhibited some correlations with local hydrology (freshwater flow and water temperature), regional climate, and sea surface temperatures for anadromous species. Strayer et al. (1998, 2014) reported that in 1991, zebra mussels (*Dreissena polymorpha*) first invaded the tidal freshwater portion of the Hudson River (north of Newburgh at about Rkm 100 or RM 62), below which they observed no effects on plankton due to invasion by these freshwater mussels (IP2 and IP3 lie downstream at Rkm 67 or RM 42). In the first few years after the zebra mussel invasion, declines were observed in populations of phytoplankton, small zooplankton, and deepwater zoobenthos that are the base of the food chains supporting many fish species. Populations of zooplankton and deepwater zoobenthos subsequently recovered to pre-invasion levels; phytoplankton has not recovered; and the effects on fish populations typically were inconsistent and weak (Strayer et al. 2014). In comments on the draft of this supplement, Normandeau (2016) reported infestation of Hudson River rainbow smelt by a microsporidian parasite, *Glugea hertwigi*, in samples from 1992, 1994, and 1995, and AKRF (2016) presented a population projection model simulating how the failure of rainbow smelt year classes due to reproductive failures (such as from parasitism) might result in “a catastrophic decline like the one suffered by the Hudson River rainbow smelt stock.” Young (2016) reported that short-term changes in Hudson River flow influenced the temporal and spatial distribution of river herring in early life stages and their vulnerability to entrainment at IP2 and IP3.

A.4.3 Uncertainty Associated with the Impingement and Entrainment Analysis

The NRC staff used a retrospective assessment of the past I&E impacts to provide a prospective assessment of potential future impacts. This approach inherently includes some degree of uncertainty both with interpreting the results of past studies as well as predicting future trends. Section 4.5 describes in detail the main sources of uncertainty related to the NRC staff's analysis, which are summarized below.

- **Sampling quality:** Variations in sampling equipment, the frequency and timing of sampling events, and sampling locations decrease the ability of statistical tests to accurately detect changes in population structures. Uncertainty within the NRC staff's analysis is in part based on a sampling gear change that occurred in the Hudson River Biological Monitoring Program in 1985. To remove this potentially confounding factor, the NRC staff analyzed population trends in the present analysis from 1985 through 2011. Excluding the earlier data means that the statistical analyses do not examine whether a species declined soon after IP2 and IP3 operations began but before the 1985 gear change.
- **Data accuracy:** The ability to accurately identify the species of fish eggs and larvae due to morphological similarities among species within the same family (i.e., herring)

in early life stages can increase uncertainty. For instance, if herrings had been identified to the species in the IP2 and IP3 entrainment study, the conditional entrainment mortality rates of species in the herring family would likely be higher and the SOC analysis would be more likely to discern adverse entrainment effects for these species. Thus, the NRC staff's entrainment estimates for species within the herring family may underestimate entrainment rates because some specimens were likely reported within the "herring family" category rather than reported for the actual species.

- **Data quantity:** Insufficient data increase uncertainty because statistical analyses are more able to accurately detect significant trends with more data points. In addition, a sufficient amount of data is required to run statistical tests. For the NRC staff's analysis, several RIS (Atlantic sturgeon, shortnose sturgeon, and blue crab) had too few catches or observations to assess River Segment 4 or riverwide population trends, and results of the Population Trend LOE for these RIS are "Unresolved."
- **Interacting Multiple Environmental Stressors:** Ecological communities within the Hudson River are complex systems that have been exposed to a variety of anthropogenic (e.g., I&E and thermal and chemical effluents) and natural (e.g., low recruitment, parasites, predation) stressors. These stressors often interact with one another whereby the effects of multiple stressors may be synergetic or more intense than if the ecological community were exposed to individual stressors during separate and discrete time periods. These complex, interrelated factors add uncertainty when attributing population declines to specific stressors. Often, there is some level of uncertainty regarding which stressors contributed to a decline, the relative contribution of each stressor, and how multiple stressors interacted to contribute to a decline.
- **Future Trends:** As previously described, the NRC staff's analysis uses a retrospective assessment of the impacts to the aquatic ecosystem resulting from IP2 and IP3 operation in order to provide a prospective assessment for future impacts. This prospective assessment requires the staff to assume whether environmental and operational conditions will change or continue during the license renewal period. Unexpected changes in flow or other operational and environmental conditions in the future will affect the accuracy of the staff's predictions.

A.4.4 Overall Impingement and Entrainment Conclusion

The NRC staff used a WOE approach to combine a Population Trend LOE and an SOC LOE to assess the impact of I&E at IP2 and IP3 on YOY Hudson River fish and on blue crab. The NRC staff assessed population trends by examining the consistency of multiple measures of abundance for several sampling programs at two geographic scales. Because each sampling program and measure emphasized a different season or aspect of each population, the NRC staff believes that examining consistency provides a better understanding of trends than examination of any single measure. Across species, population trends of many species appear to be decreasing, particularly in River Segment 4, and four species (American shad, Atlantic tomcod, blueback herring, and rainbow smelt) had consistent statistically significant declines among measures of abundance. The NRC staff's final findings for the 18 RIS are:

- 10 "Small,"
- 1 "Moderate,"
- 2 "Large,"

- 3 “Unresolved,” and
- 2 “May affect, but not likely to jeopardize the continued existence of.”

In Section 4.1.3.5 of the FSEIS (NRC 2010), the NRC staff expressed the RIS impact findings numerically as “Small” impacts=1, “Moderate” impacts=2, and “Large” impacts=4. The staff then used these scores to calculate an average, which is representative of the overall impact on aquatic resources that would result from I&E associated with IP2 and IP3 license renewal. This type of scoring is reflective of an equally spaced interval on a logarithmic scale for which the magnitude of harm is doubled each step, and an average of these scores results in an overall conclusion. The NRC’s calculation resulted in a conclusion of MODERATE impacts.

The NRC staff used the same approach with the revised RIS impact findings in this supplement, where “Small” = 1, “Moderate” = 2, “May affect, but not likely to jeopardize the continued existence of” = 2, and “Large” = 4. The NRC staff did not assign a numerical score to “Unresolved” findings and did not include these RIS in the calculation of the average. Using this approach, the average of the RIS impact findings is 1.6, which indicates a MODERATE impact. Thus, while the NRC staff’s revised I&E analysis documented in this supplement resulted in revised RIS impact findings for certain RIS, the NRC staff’s overall conclusion regarding the impacts of I&E on aquatic resources resulting from the proposed IP2 and IP3 license renewal remains MODERATE as previously documented in Section 4.1.3.5 of the FSEIS (NRC 2010). The NRC staff recognizes that its approach of using a retrospective assessment of past I&E impacts to predict potential future I&E impacts inherently includes some degree of uncertainty. Uncertainty generally increases with natural variability, inconsistent or infrequent sampling, and poorer data quality and availability. These uncertainties are summarized above in Section A.4.3 and discussed in detail in Section 4.5 of this supplement.

A.5 References

References with Agencywide Documents Access and Management System (ADAMS) Accession numbers can be read or downloaded using the NRC’s Web-based ADAMS search engine at <http://adams.nrc.gov/wba/>. Click on the “Advanced Search” tab and choose the following entries under “Document Properties”: “Accession Number” in the Property box, “is equal to” in the Operator box, and the ADAMS Accession Number of the document in the “Value” box.

10 CFR Part 51. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, Subpart A, Appendix B, “Environmental effect of renewing the operating license of a nuclear power plant.”

78 FR 48944. National Marine Fisheries Service. “Endangered and threatened wildlife and plants; Endangered Species Act listing determination for alewife and blueback herring.” *Federal Register* 78(155):48944–48994. August 12, 2013.

79 FR 48300. U.S. Environmental Protection Agency. “National pollutant discharge elimination system; Final regulations to establish requirements for cooling water Intake structures at existing facilities and amend requirements at phase I facilities.” *Federal Register* 79(158):48300–48439. August 15, 2014.

Abood, KA, Englert TL, Metzger SG, Beckers CV, Groninger TJ, Mallavarah S. 2006. Current and evolving physical and chemical conditions in the Hudson River Estuary. *American Fisheries Society Symposium* 51:39-61.

[AEC] United States Atomic Energy Commission. 1972. Final Environmental Statement Related to Operation of Indian Point Nuclear Generating Plant Unit No. 2. Consolidated Edison Company of New York, Inc. Docket No. 50-247. September 1972. Directorate of Licensing. ADAMS Accession Nos. ML072390276 and ML072390278.

[AKRF] AKRF, Inc. 2014. Update of Aquatic Impact Analyses Presented in NRC's FSEIS (December 2010) Regarding Potential Impacts of Operation of Indian Point Units 2 and 3. Attachment 1 to NL-14-030, Entergy Nuclear Operations, Inc., Indian Point Nuclear Generating Unit Nos. 2 & 3, Docket Nos. 50-247 and 50-286. February 19, 2014. Prepared for Indian Point Energy Center, Buchanan, NY. Prepared by AKRF, Inc., Hanover, MD. ADAMS Accession No. ML14063A529.

[AKRF] AKRF, Inc. 2015. Summary of Analysis Results Based on Corrected Format 2 Data Files Dated March 2015: Update of Aquatic Impact Analyses Presented in NRC's FSEIS (December 2010) Regarding Potential Impacts of Operation of Indian Point Units 2 and 3. Prepared for Indian Point Energy Center, Buchanan, New York. ADAMS Accession No. ML15252A244.

[AKRF] AKRF, Inc. 2016. Appendix 2A: Hudson River Rainbow Smelt Population Projection Model for Examining Conditions That Could Have Led to Catastrophic Decline. March 2016. Submitted as an attachment to Entergy 2016a.

Anderson CNK, Hsieh CH, Sandin SA, Hewitt R, Hollowed A, Beddington J, May RM, Sugihara G. 2008. Why fishing magnifies fluctuations in fish abundance. *Nature* 452(17):835–839.

[ASA] ASA Analysis & Communication. 2008. 2006 Year Class Report for the Hudson River Estuary Monitoring Program. Prepared for Dynergy Roseton LLC, New Windsor, New York. ADAMS Accession No. ML15114A081.

[ASA] ASA Analysis & Communication. 2009. 2007 Year Class Report for the Hudson River Estuary Monitoring Program. Prepared for Dynergy Roseton LLC, New Windsor, New York. ADAMS Accession No. ML15114A082.

[ASA] ASA Analysis & Communication. 2010. 2008 Year Class Report for the Hudson River Estuary Monitoring Program. Prepared for Dynergy Roseton LLC, New Windsor, New York. ADAMS Accession No. ML15114A083.

[ASA] ASA Analysis & Communication. 2011. 2009 Year Class Report for the Hudson River Estuary Monitoring Program. Prepared for Dynergy Roseton LLC, New Windsor, New York. ADAMS Accession No. ML15114A080.

[ASA] ASA Analysis & Communication. 2012. 2010 Year Class Report for the Hudson River Estuary Monitoring Program. Prepared for Dynergy Roseton LLC, New Windsor, New York. ADAMS Accession No. ML15114A084.

[ASA] ASA Analysis & Communication. 2013. 2011 Year Class Report for the Hudson River Estuary Monitoring Program. Prepared for Dynergy Roseton LLC, New Windsor, New York. ADAMS Accession No. ML15114A085.

[ASA and AKRF] ASA Analysis & Communication, Inc. and AKRF, Inc. 2014. Data Documentation for Information Provided to U.S. Nuclear Regulatory Commission in Response to 9/26/14 Request for Additional Information. Prepared for Entergy Nuclear Operations, Inc. October 2014. ADAMS Accession No. ML14311A809.

Appendix A

[ASMFC] Atlantic States Marine Fisheries Commission. 2007. American Shad Stock Assessment Report for Peer Review. Stock Assessment Report No. 07-01 (Supplement). Available at <<http://www.asmfc.org/uploads/file/2007ShadStockAssmtReportVolumel.pdf>> (accessed 28 July 2015).

[ASMFC] Atlantic States Marine Fisheries Commission. 2009. Shad and River Herring Plan Development Team. 2009. Amendment 2 to the Interstate Fishery Management Plan for Shad and River Herring. Prepared by the Shad and River Herring Plan Development Team. May 2009. Available at <http://www.asmfc.org/uploads/file/amendment2_RiverHerring.pdf> (accessed 11 February 2015).

[ASMFC] Atlantic States Marine Fisheries Commission. 2015. "Blueback herring, *Alosa aestivalis*." December 2015. Available at <<http://www.asmfc.org/uploads/file//568edf19BluebackHerring.pdf>> (accessed 29 March 2017).

Barnhouse LW, Heimbuch DG, Van Winkle W, Young J. 2008. Entrainment and Impingement at Indian Point: A Biological Impact Assessment. January 2008. ADAMS Accession No. ML080390059.

Barnhouse LW, Klauda DS, Vaughn DS, Kendall RL, editors. 1988. Science, law, and Hudson River power plants: A case study in environmental impact assessment. *American Fisheries Society Monograph* 4, 347 p. Bethesda, Maryland.

Bath DW, O'Connor JM. 1982. The biology of the white perch, *Morone americana*, in the Hudson River Estuary. *Fishery Bulletin* 80(3):599–610.

Beebe CA, Savidge IR. 1988. Historical perspective on fish species composition and distribution in the Hudson River Estuary. *American Fisheries Society Monograph* 4:25–36.

Carpenter SR, Brock WA. 2006. Rising variance: a leading indicator of ecological transition. *Ecology Letters* 9(3):311–318.

[CHGE et al.] Central Hudson Gas & Electric Corporation, Consolidated Edison Company of New York, Inc., New York Power Authority, and Southern Energy New York. 1999. 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. December 1999. ADAMS Accession No. ML083400128.

Cooper JC, Cantelmo FR, Newton CE. 1988. Overview of the Hudson River Estuary. *American Fisheries Society Monograph* 4:11–24.

Daniels RA, Limburg KE, Schmidt RE, Strayer DL, and Chambers RC. 2005. Changes in fish assemblages in the tidal Hudson River, New York. *American Fisheries Society Symposium* 45:471–503.

Dew CB, Hecht JH. 1994. Hatching, estuarine transport, and distribution of larval and early juvenile Atlantic tomcod, *Microgadus tomcod*, in the Hudson River. *Estuaries* 17(2):472–488.

[Entergy] Entergy Nuclear Operations, Inc. 2007. Letter from F. Dacimo, Vice President, Entergy Nuclear Operations, Inc. to Document Control Desk, U.S. Nuclear Regulatory Commission. Subject: Entergy Nuclear Operations, Inc., Indian Point Nuclear Generating Unit Nos. 2 & 3; Docket Nos. 50-247 and 50-286; supplement to license renewal application (LRA)—environmental report references. December 20, 2007. ADAMS Accession Nos. ML080080205; ML080080199, ML080080313, ML11279A029 (Impingement and Entrainment); ML11279A044 (Long River Survey); ML080080291, ML080080298, and ML080080306 (Fall Shoals Survey).

[Entergy] Entergy Nuclear Operations, Inc. 2014. Letter from F. Dacimo, Vice President of License Renewal, Entergy, to the NRC Document Control Desk. Subject: Final supplemental environmental impact statement Indian Point Unit Nos. 2 and 3, Docket Nos. 50-247 and 50-286, License Nos. DPR-26 and DPR-64, NL-14-030. February 19, 2014. ADAMS Accession No. ML14063A528.

[Entergy] Entergy Nuclear Northeast. 2015. Letter from F. Dacimo, Entergy, to Document Control Desk, NRC. Subject: Reply to request for additional information regarding the license renewal application environmental review (TAC Nos. MD5411 and MD5412), Indian Point Nuclear Generating Unit Nos. 2 & 3, Docket Nos. 50-247 and 50-286, License Nos. DPR-26 and DPR-64, NL-15-029. April 6, 2015. ADAMS Accession No. ML15114A048.

[Entergy] Entergy Nuclear Operations, Inc. 2016. Letter from F. Dacimo, Vice President, Operations License Renewal, Entergy, to C. Bladey, Chief, Rules Operations, and Directives Branch, NRC. Subject: Comments on Second Draft Supplement to Final Supplemental Environmental Impact Statement for Indian Point License Renewal, Indian Point Nuclear Generating Unit Nos. 2 and 3, Docket Nos. 50-247 and 50-286, License Nos. DPR-26 and DPR-64. March 4, 2016. ADAMS Accession Nos. ML16070A053 and ML16070A054.

Enterline CL, Chase BC, Carloni JM, Mills KE. 2012. A Regional Conservation Plan for Anadromous Rainbow Smelt in the U.S. Gulf of Maine. National Oceanic and Atmospheric Administration, Massachusetts Division of Marine Fisheries, New Hampshire Fish and Game Department, and Maine Department of Natural Resources. Available at <<http://www.wildlife.state.nh.us/marine/documents/smelt-conservation-plan.pdf>> (accessed 8 July 2015).

[EPA] U.S. Environmental Protection Agency. 1998. Guidelines for Ecological Risk Assessment. EPA/630/R-95/002F. Risk Assessment Forum, Washington, DC. Available at <http://www2.epa.gov/sites/production/files/2014-11/documents/eco_risk_assessment1998.pdf> (accessed 13 July 2015).

Fletcher RI. 1990. Flow dynamics and fish recovery experiments: Water intake systems. *Transactions of the American Fisheries Society* 119:393–415.

Fletcher RI, Deriso RB. 1988. Fishing in dangerous waters: Remarks on a controversial appeal to spawner-recruitment for long-term impact assessment. *American Fisheries Society Monograph* 4:232–244.

Goodyear CP. 1988. Implications of power plant mortality for management of the Hudson River striped bass fishery. *American Fisheries Society Monograph* 4:245–254.

Hattala K, Kahnle A. 2007. Status of the Hudson River, New York, American shad stock. In ASMFC Stock Assessment Report No. 07-01 (supplement) of the Atlantic States Marine Fisheries Commission. American shad stock assessment report for peer review, Volume II. Washington, D.C. (Cited in Hattala et al. 2012, p 306).

Hattala K, Kahnle A. 2009. Status of American Shad in the Hudson River, New York Updated August 2009. New York State Department of Environmental Conservation, Hudson River Fisheries Unit. Available at <http://www.dec.ny.gov/docs/fish_marine_pdf/hrshadstatus.pdf> (accessed 27 July 2015).

Hattala KA, Kahnle AW, Adams RD. 2011. Sustainable Fishing Plan for New York River Herring Stocks. Submitted for review to the Atlantic States Marine Fisheries Commission. September 2011 revised version. Available at <http://www.dec.ny.gov/docs/fish_marine_pdf/rhsustplan0811.pdf> (accessed 20 February 2015).

Appendix A

Hattala KA, Kahnle AW, Adams RD. 2012. Status of New York river herring stocks. Chapter 10 in ASMFC (2012SAR2), Stock Assessment Report No. 12-02 of the Atlantic States Marine Fisheries Commission. River Herring Benchmark Stock Assessment. Volume II. May 2012. Pages 291–366. Available at <http://www.asmfc.org/uploads/file/riverHerringBenchmarkStockAssessmentVolumellR_May2012.pdf> (accessed 13 February 2015).

Hurst TP, McKown KA, Conover DO. 2004. Interannual and long-term variation in the nearshore fish community of the mesohaline Hudson River estuary. *Estuaries* 27(4):659–669.

[IUCN] International Union for Conservation of Nature. 2000. IUCN Red List Categories and Criteria, Version 3.1. Species Survival Commission, IUCN, Gland, Switzerland. Available at <http://jr.iucnredlist.org/documents/redlist_cats_crit_en.pdf> (accessed 29 June 2016).

Kahnle A, Hattala K. 2010. Hudson River American Shad, an Ecosystem-Based Plan for Recovery. Revised: January 2010. New York State Department of Environmental Conservation, Hudson River Fisheries Unit. Available at <http://www.dec.ny.gov/docs/remediation_hudson_pdf/shadrecoveryplan.pdf> (accessed 27 July 2015).

Klauda, RJ, Muessig PH, Matousek JA. 1988. Fisheries data sets compiled by utility sponsored research in the Hudson River Estuary. Pages 7–85 in C. L. Smith, editor. Fisheries Research in the Hudson River. State University of New York Press, Albany.

Levinton JS, Waldman JR, editors. 2006. The Hudson River Estuary. Cambridge University Press.

Menzie, C, Henning MH, Cura J, Finkelstein K, Gentile J, Maughan J, Mitchell D, Petron S, Potocki B, Svirsky S, Tyler P. 1996. Special report of the Massachusetts weight-of-evidence workgroup: A weight of evidence approach for evaluating ecological risks. *Human and Ecological Risk Assessment* 2(2):277–304.

Newberger TA, Houde ED. 1995. Population biology of bay anchovy *Anchoa mitchilli* in the mid Chesapeake Bay. *Marine Ecology Progress Series* 116:25–37.

[NMFS] National Marine Fisheries Service. 2013. Letter from J.K. Bullard, Regional Administrator, NMFS, to A. Hull, Branch Chief, NRC. Regarding: Biological opinion for the continued operations of Indian Point Nuclear Generating Units 2 and 3. ADAMS Accession No. ML13032A256. Available at <http://www.greateratlantic.fisheries.noaa.gov/protected/section7/bo/actbiops/nrc_indian_point_2_and_3.pdf> (accessed 4 August 2015).

[NMFS] National Marine Fisheries Service. 2015. Commercial Fisheries Statistics. Office of Science and Technology. Available at <<http://www.st.nmfs.noaa.gov/commercial-fisheries/commercial-landings/annual-landings/index>> (accessed 27 July 2015).

[Normandeau] Normandeau Associates, Inc. 2016. Appendix 2B: Hudson River Rainbow Smelt Infestation by the Microsporidian Parasite *Glugea hertwigi*. March 3, 2016. Submitted as an attachment to Entergy 2016a.

[NRC] U.S. Nuclear Regulatory Commission. 2007. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants: Supplement 29, Regarding Pilgrim Nuclear Power Station*. Washington, DC: NRC. NUREG–1437, Supplement 29, Volumes 1-2. July 2007. ADAMS Accession Nos. ML110600912 and ML071990027.

- [NRC] U.S. Nuclear Regulatory Commission. 2010. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants: Supplement 38, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3*. Washington, DC: NRC. NUREG-1437, Supplement 38. December 10, 2010. ADAMS Accession No. ML102990043.
- [NRC] U.S. Nuclear Regulatory Commission. 2013a. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. Washington, DC: NRC. NUREG-1437, Revision 1. June 2013. ADAMS Accession No. ML13107A023.
- [NRC] U.S. Nuclear Regulatory Commission. 2013b. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants: Supplement 38, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3, Vol. 4*. Washington, DC: NRC. NUREG-1437, Supplement 38, Volume 4. June 20, 2013. ADAMS Accession No. ML13162A616.
- [NRC] U.S. Nuclear Regulatory Commission. 2015a. Letter from M. Wentzel, Project Manager, NRC to Vice President, Operations, Entergy Nuclear Operations, Inc. Subject: Request for additional information for the review of the Indian Point Nuclear Generating Unit Nos. 2 and 3, license renewal application environmental review (TAC Nos. MD5411 and MD5412). February 18, 2015. ADAMS Accession No. ML14329B245.
- [NRC] U.S. Nuclear Regulatory Commission. 2015b. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants: Supplement 38, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3*. NUREG-1437, Suppl. 38, Vol. 5. Draft Report for Comment. December 2015. ADAMS Accession No. ML15351A422.
- [NYNJHEP] New York – New Jersey Harbor & Estuary Program. 2012. *The State of the Estuary 2012: Environmental Health and Trends of the New York-New Jersey Harbor Estuary*. New York, New York. Available at <http://www.harborestuary.org/pdf/StateOfTheEstuary2012/SOE_ExpdRpt_HiRes.pdf> (accessed 12 April 2016).
- [NYPA] New York Power Authority. 1986. Size selectivity and relative catch efficiency of a 3-m beam trawl and a 1-m epibenthic sled for sampling young of the year striped bass and other fishes in the Hudson River Estuary. Prepared by Normandeau Associates, Inc. January 1986. (HR Library #7180). ADAMS Accession No. ML083360641.
- [NYSDEC] New York State Department of Environmental Conservation. 2003. *Final Environmental Impact Statement for SPDES Permit Renewals at Roseton 1 & 2, Bosline 1 & 2 and Indian Point 2 & 3 Steam Electric Generating Stations*. June 25, 2003. Available at <<http://www.dec.ny.gov/permits/54649.html>> (accessed 23 February 2015).
- [NYSDEC] New York State Department of Environmental Conservation. 2009. Delaware River American Shad Stock Status. Updated 2009. Delaware River Fish and Wildlife Cooperative. Available at <<http://www.dec.ny.gov/animals/57679.html>> (accessed 27 July 2015).
- [NYSDEC] New York State Department of Environmental Conservation. 2015. Young of Year American Shad Abundance. Hudson River Fisheries Unit. Available at <<http://www.dec.ny.gov/animals/26741.html>> (accessed 28 July 2015).
- [NYSDEC and Cornell] New York State Department of Environmental Conservation and Cornell University. 2015. *The State of the Hudson 2015*. Hudson River Estuary Program, Albany. Available at <<http://www.dec.ny.gov/lands/51492.html>> (accessed 4 August 2015).
- [NYSDOS] New York State Department of State. 2012. Significant Coastal Fish & Wildlife Habitats, Coastal Fish and Wildlife Rating Form, Hudson Highlands. Office of Planning and Development. Updated August 15, 2012. Available at <http://www.dos.ny.gov/opd/programs/consistency/Habitats/HudsonRiver/Hudson_Highlands_FINAL.pdf> (accessed 14 March 2016).

Appendix A

- O'Connor MP, Juanes F, McGarigal K. 2012. Findings on American shad and striped bass in the Hudson River estuary: A fish community study of the long-term effects of local hydrology and regional climate change. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science* 4(1):327–336.
- Pimm SL, Jones HL, Diamond J. 1988. On the risk of extinction. *The American Naturalist* 132(6):757-785.
- Rogers SG, Van Den Avyle MJ. 1983. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (South Atlantic)—Atlantic Menhaden. U.S. Fish and Wildlife Service, Division of Biological Services, FWS/OBS-82/11.11. U.S. Army Corps of Engineers, TR EL-82-4. Available at http://www.nwrc.usgs.gov/wdb/pub/species_profiles/82_11-108.pdf (accessed 7 August 2015).
- Schnute JT, Richards LJ. 2001. Use and abuse of fisheries models. *Canadian Journal of Fisheries and Aquatic Sciences* 58:10–17.
- Secor DH, Houde ED. 1995. Temperature effects on the timing of striped bass egg production, larval viability, and recruitment potential in the Patuxent River (Chesapeake Bay). *Estuaries* 18:527–533.
- [SEDAR] Southeast Data, Assessment and Review. 2015. SEDAR 40—Atlantic Menhaden Stock Assessment Report. SEDAR, North Charleston, SC. 643 p. Available at http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=40 (accessed 3 August 2015).
- Stanley JG, Danie DS. 1983. Species profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (North Atlantic—White Perch). U.S. Fish and Wildlife Service, Division of Biological Sciences, FWS/OBS-82/11.7. U.S. Army Corps of Engineers, TR EL-82-4. Available at http://www.nwrc.usgs.gov/wdb/pub/species_profiles/82_11-007.pdf (accessed 7 August 2015).
- Stewart LL, Auster PJ. 1987. Species profiles: Life History and Environmental Requirements of Coastal Fishes and Invertebrates (North Atlantic): Atlantic Tomcod. U.S. Fish and Wildlife Service Biological Report 82(11.76). U.S. Army Corps of Engineers, RT EL-82-4, Washington DC; Vicksburg, MS. Available at http://www.nwrc.usgs.gov/wdb/pub/species_profiles/82_11-076.pdf (accessed 30 July 2015).
- Strayer DL, Hattala KA, Kahnle AW, Adams RD. 2014. Has the Hudson River fish community recovered from the zebra mussel invasion along with its forage base? *Canadian Journal of Fisheries and Aquatic Sciences* 71(8):1146–1157.
- Strayer DL, Smith LC, and Hunter DC. 1998. Effects of the zebra mussel (*Dreissena polymorpha*) invasion on the macrobenthos of the freshwater tidal Hudson River. *Canadian Journal of Zoology* 76(3):419–425.
- Sunitha L, BalRaju M, Sasikiran J, Venkat Ramana E. 2014. Automatic outlier identification in data mining using IQR in real-time data. *International Journal of Advanced Research in Computer and Communication Engineering* 3:7255–7257.
- Vouglitois JJ, Able KW, Kurtz RL, Tighe K. 1987. Life history and population dynamics of the bay anchovy in New Jersey. *Transactions of the American Fisheries Society* 116(2):141-153.

Waldman JR, Lake TR, Schmidt RE. 2006. "Biodiversity and Zoogeography of the Fishes of the Hudson River Watershed and Estuary." In: Waldman JR, Limburg KE, Strayer DL, editors. *Hudson River Fish and Their Environment*. American Fisheries Society Symposium 51, Bethesda, MD. p 129–150.

Wilk S.J. 1979. Biological and Fisheries Data on Weakfish, *Cynoscion regalis* (Bloch and Schneider). U.S. Department of Commerce, National Marine Fisheries Service Technical Series Report No. 21:1–49. Available at <<http://www.nefsc.noaa.gov/publications/series/shltsr/shltsr21.pdf>> (accessed 30 July 2015).

Young JC. 2016. Appendix 2C: Biological Examination of Spatial and Temporal Distribution and Abundance of Early Life Stages of River Herring With Respect to IPEC Entrainment Impacts. Prepared for Entergy Nuclear Operations, Inc. March 2016. Submitted as an attachment to Entergy 2016a.

Addendum A–1: Linear Analysis of Population Trends

This addendum presents supporting plots and tables for the trend analysis presented in Appendix A and summarized in Chapter 4 of this supplement. The analysis uses the LRS, FSS, and BSS years 1985 through 2011, which have relatively consistent sampling design and no change in the FSS sampling gear. The trend analysis for the abundance index incorporates the years 1974 through 2011. Data are standardized by subtracting the mean and dividing by the standard deviation over years 1985 through 2011. Trend analyses are calculated with and without extreme observations defined as absolute standardized observations >3 .

Figures A1 through C1 present the smoothed and standardized River Segment 4 annual YOY density measure of abundance (75th percentile of the weekly density) and the fitted simple linear trends for the LRS, FSS, and BSS 1985 through 2011 data. Regression lines associated with slopes that are significantly different from zero are represented with solid lines and dashed 95 percent confidence intervals about the fitted line. Regression lines associated with slopes that are not significantly different from zero are represented by a dashed line and without a 95 percent confidence interval.

Figures D1 and E1 present the standardized River Segment 4 annual YOY catch-per-unit-effort (CPUE) measure of abundance (75th percentile of the weekly CPUE). The fitted regressions are for the LRS and FSS 1985 through 2011 only. White catfish had a maximum of five annual observations >0 for the years 1985 through 2011 in River Segment 4 and was not analyzed.

Figures F1 through H1 present the standardized riverwide annual CPUE (annual total YOY catch divided by the volume sampled) for the LRS, FSS, and BSS for 1985 through 2011.

Figures I1 through K1 present the standardized riverwide annual YOY abundance index (provided by Entergy) for the LRS, FSS, and BSS 1974 through 2011 data.

Figures L1 and M1 present River Segment 4 and riverwide annual YOY CPUE measures of abundance for the LRS, FSS, and BSS for Atlantic menhaden from 1985 through 2011 based on new information received from Entergy following the issuance of the draft of this supplement.

Tables A through K present the regression statistics including the mean squared error (MSE), the estimated linear slope (S) plus or minus the standard error of the estimated slope, the p-value associated with the null hypothesis H_0 : slope equals zero, the conclusion about the linear trend ($S=0$, $S < 0$, and $S > 0$), and the decision score (1 or 4). Tables A through E are the River Segment 4 regression result, presented in the same order as the figures, and Tables F through K are the riverwide regression results. Table L is the River Segment 4 and riverwide regression results for Atlantic menhaden. Decision scores for each River Segment 4 and riverwide measure of abundance are for the most protective result (e.g., if a negative significant slope is statistically significant with the extreme value but not with the extreme value removed from the regression, the decision for the trend is a 4).

Figure A1. River Segment 4 LRS YOY Density (May–July Sampling Events, 1985–2011, with 3 yr. Moving Average Smoothing)

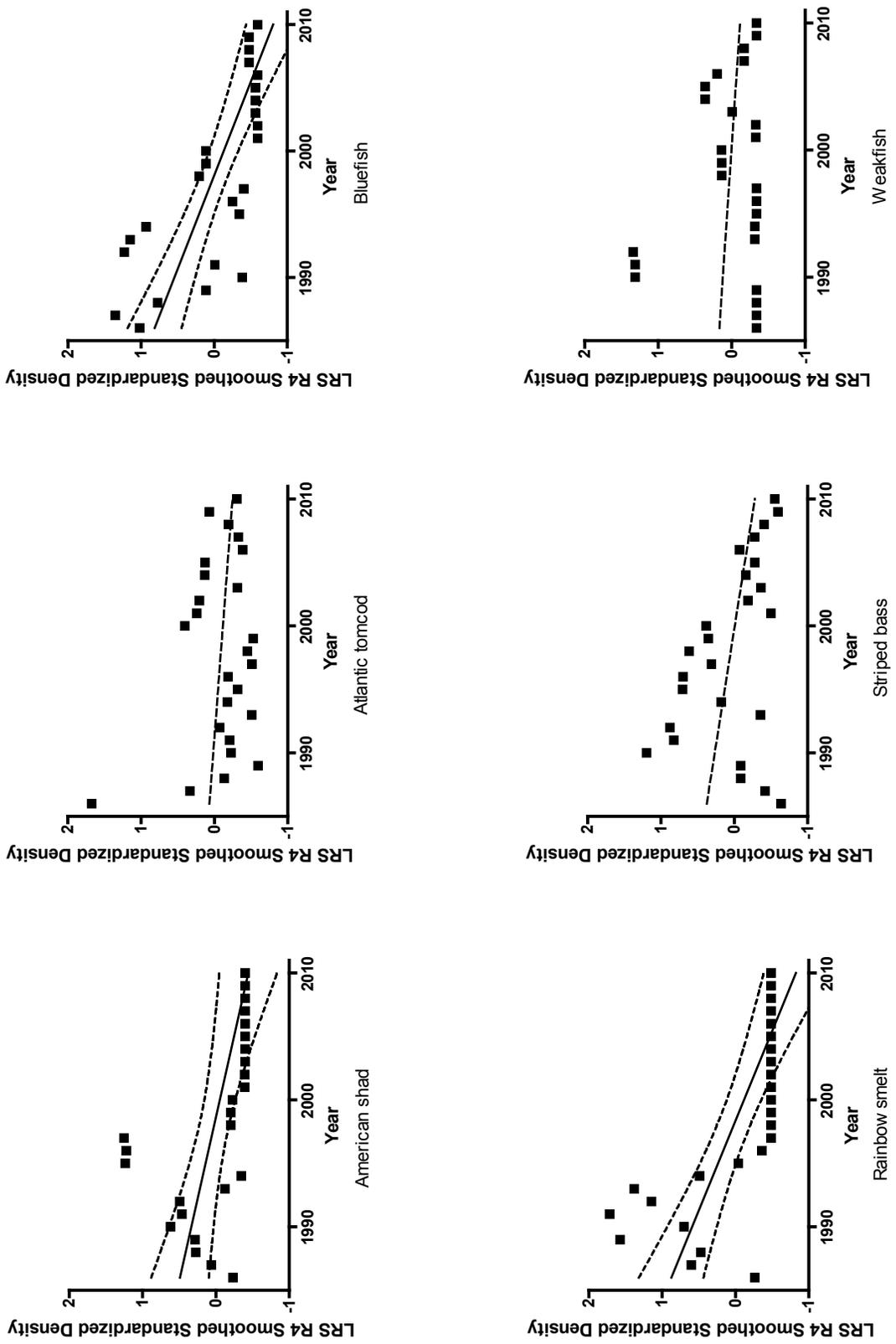


Figure B1. River Segment 4 FSS YOY Density (July–Oct Sampling Events, 1985–2011, with 3 yr. Moving Average Smoothing)

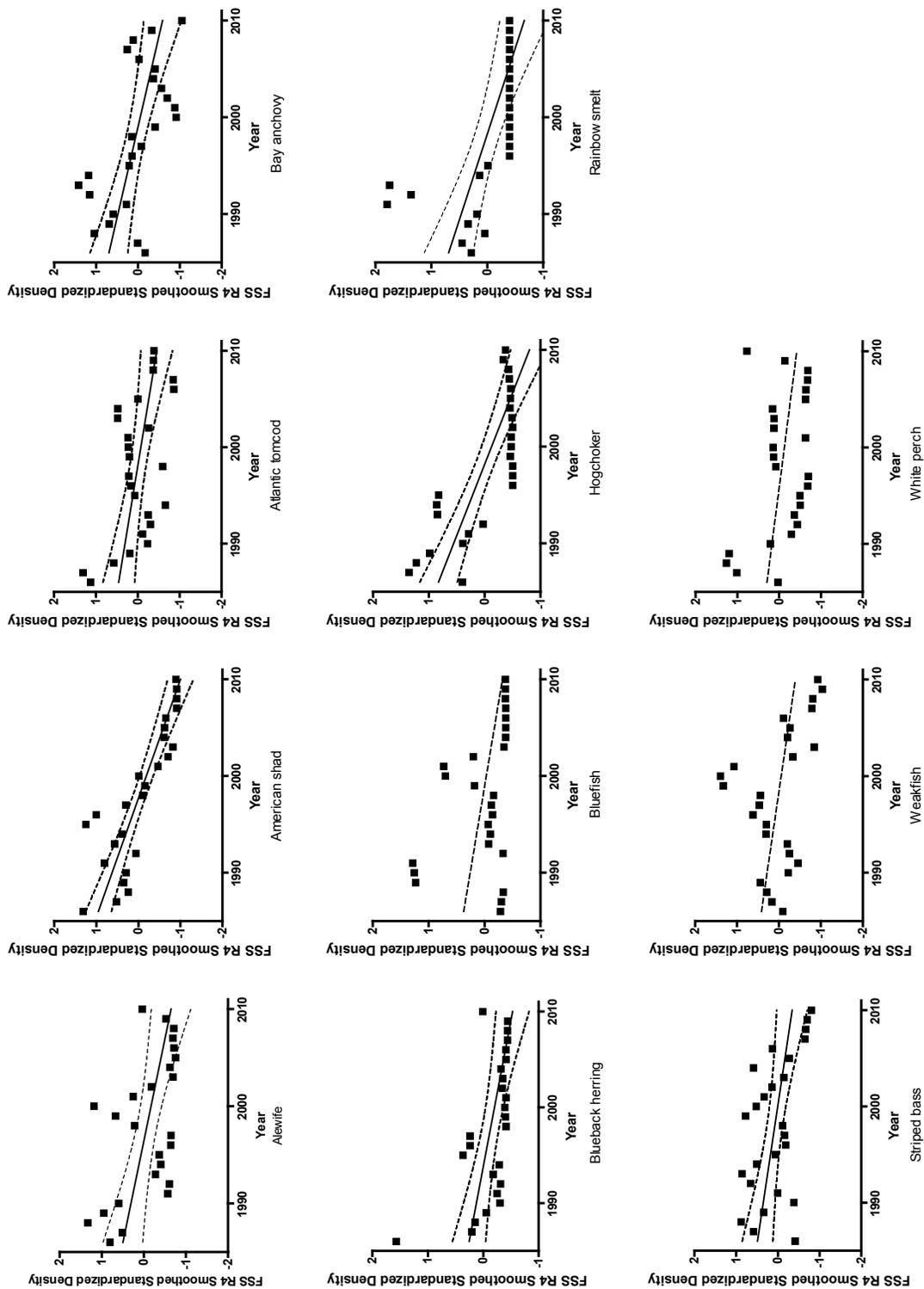


Figure C1. River Segment 4 BSS YOY Density (July–Oct Sampling Events, 1985–2011, with 3 yr. Moving Average Smoothing)

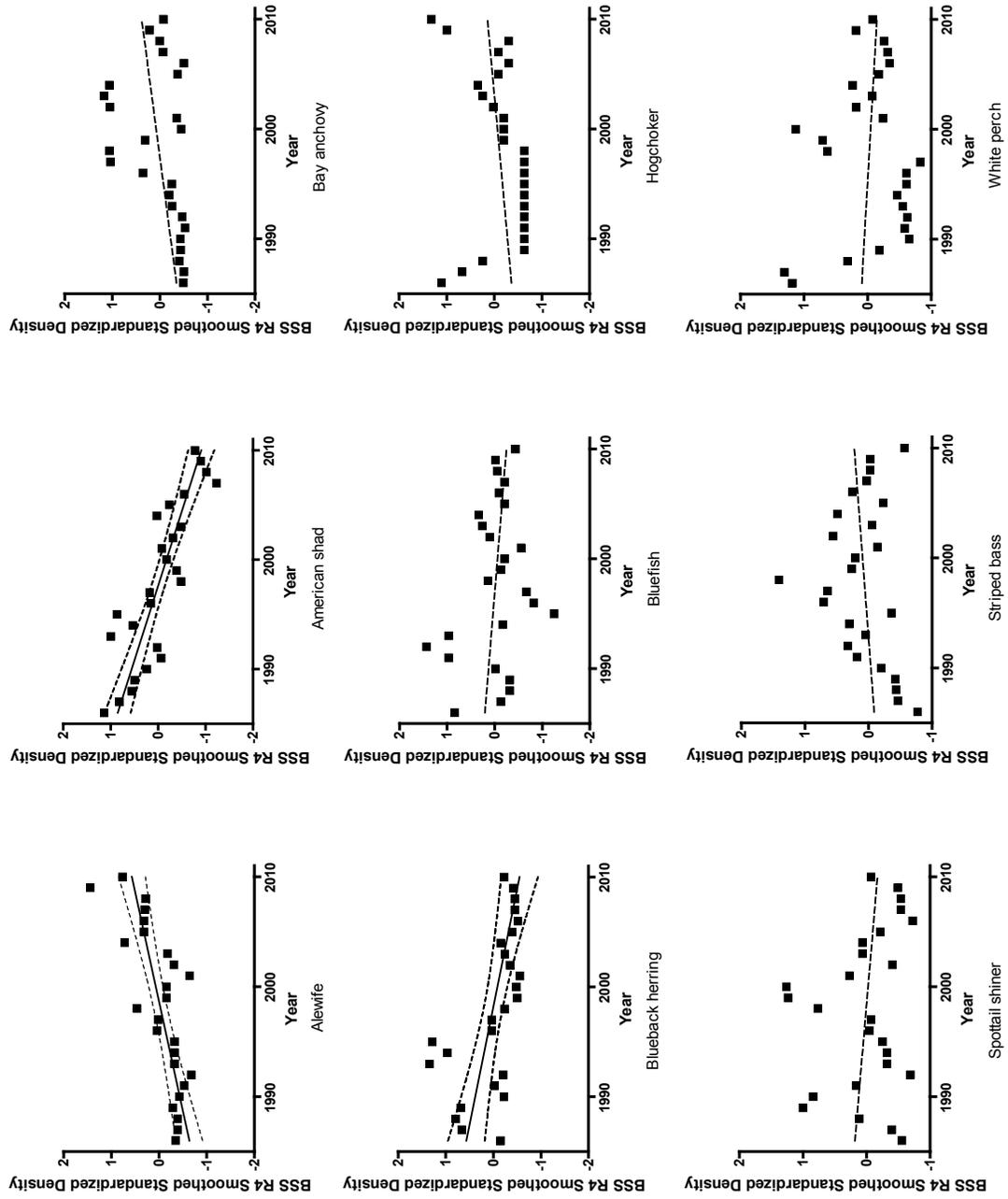


Figure D1. River Segment 4 LRS YOY CPUE (May–July Sampling Events, 1985–2011)

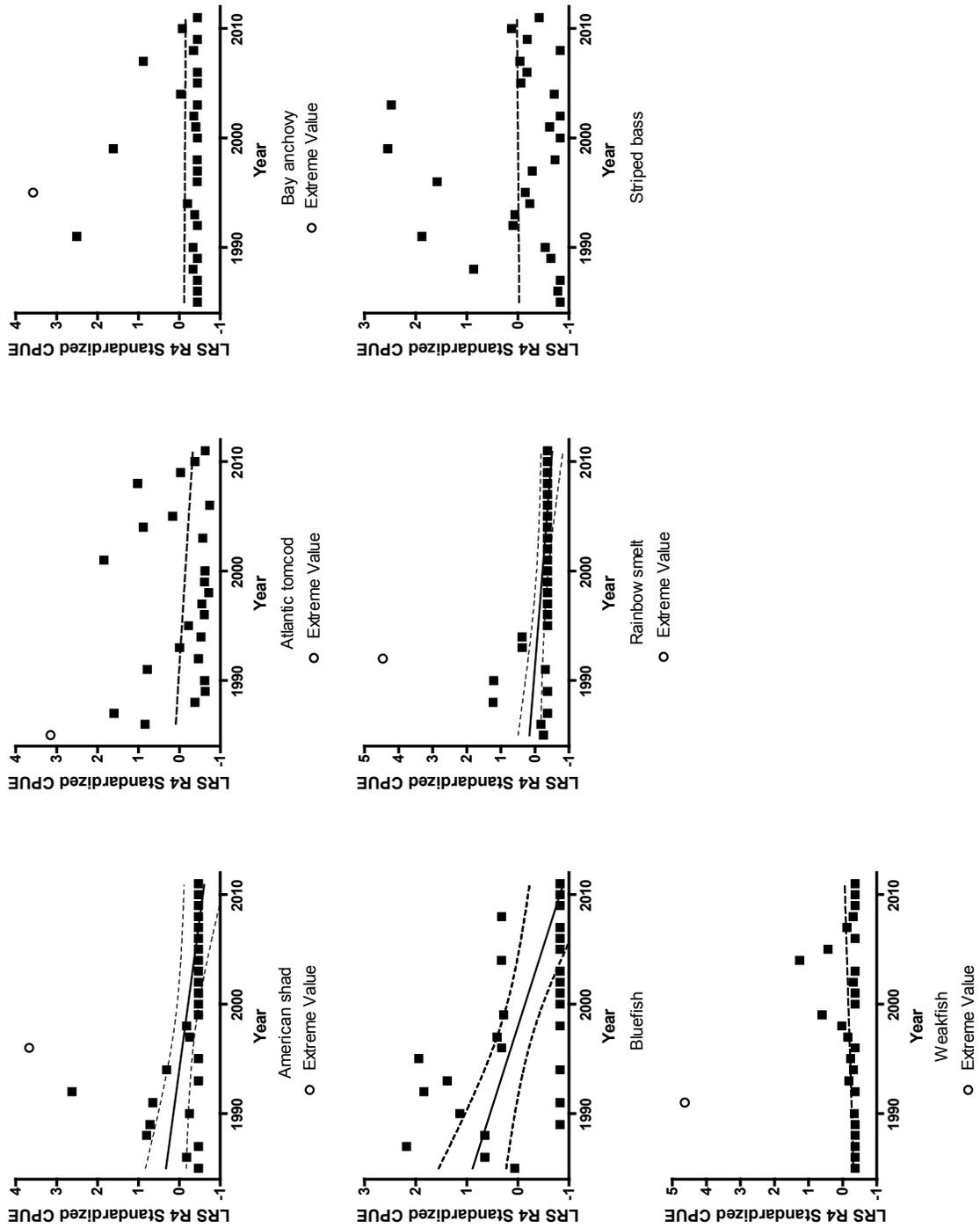


Figure F1. Riverwide LRS YOY CPUE (May–July Sampling Events, 1985–2011)

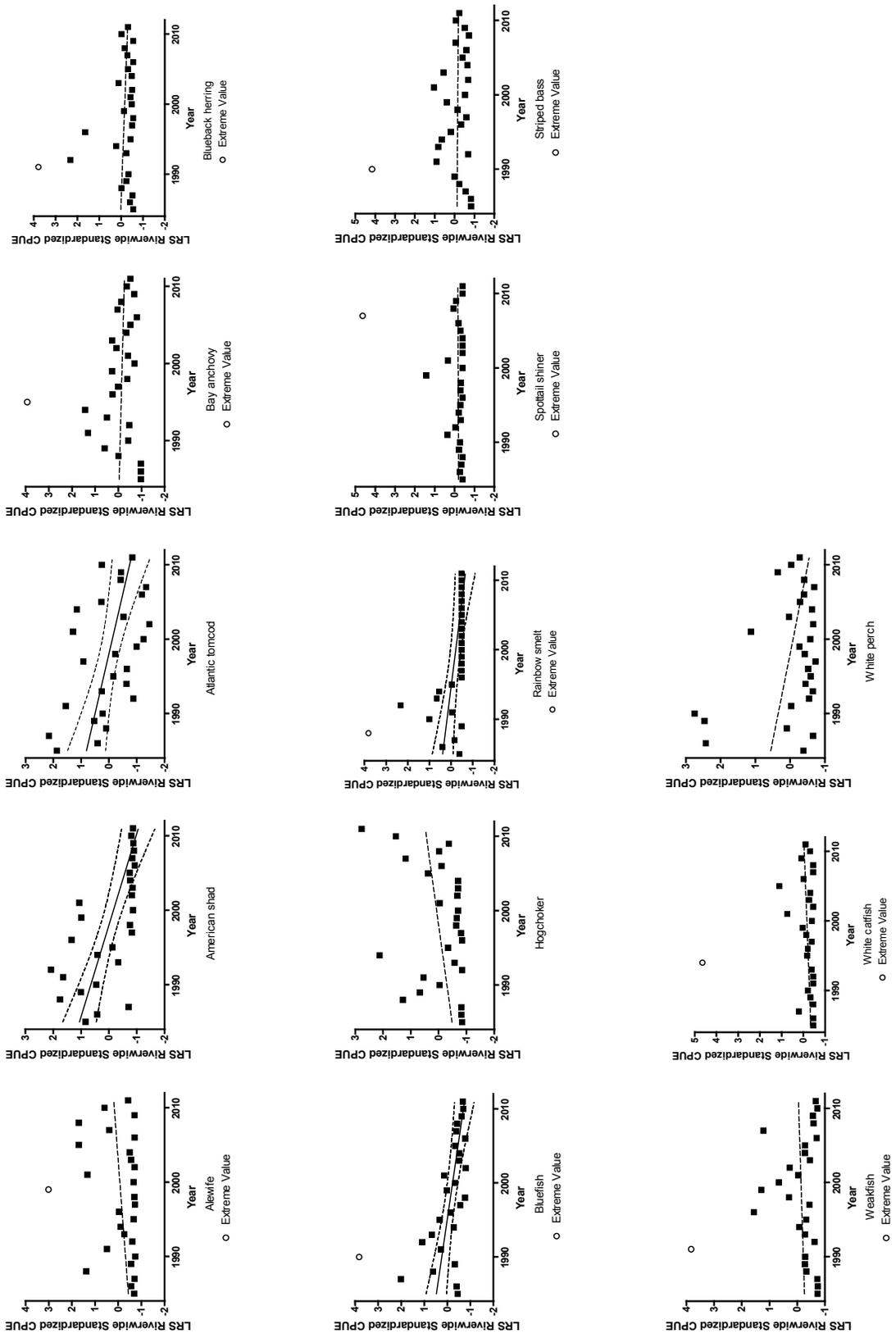
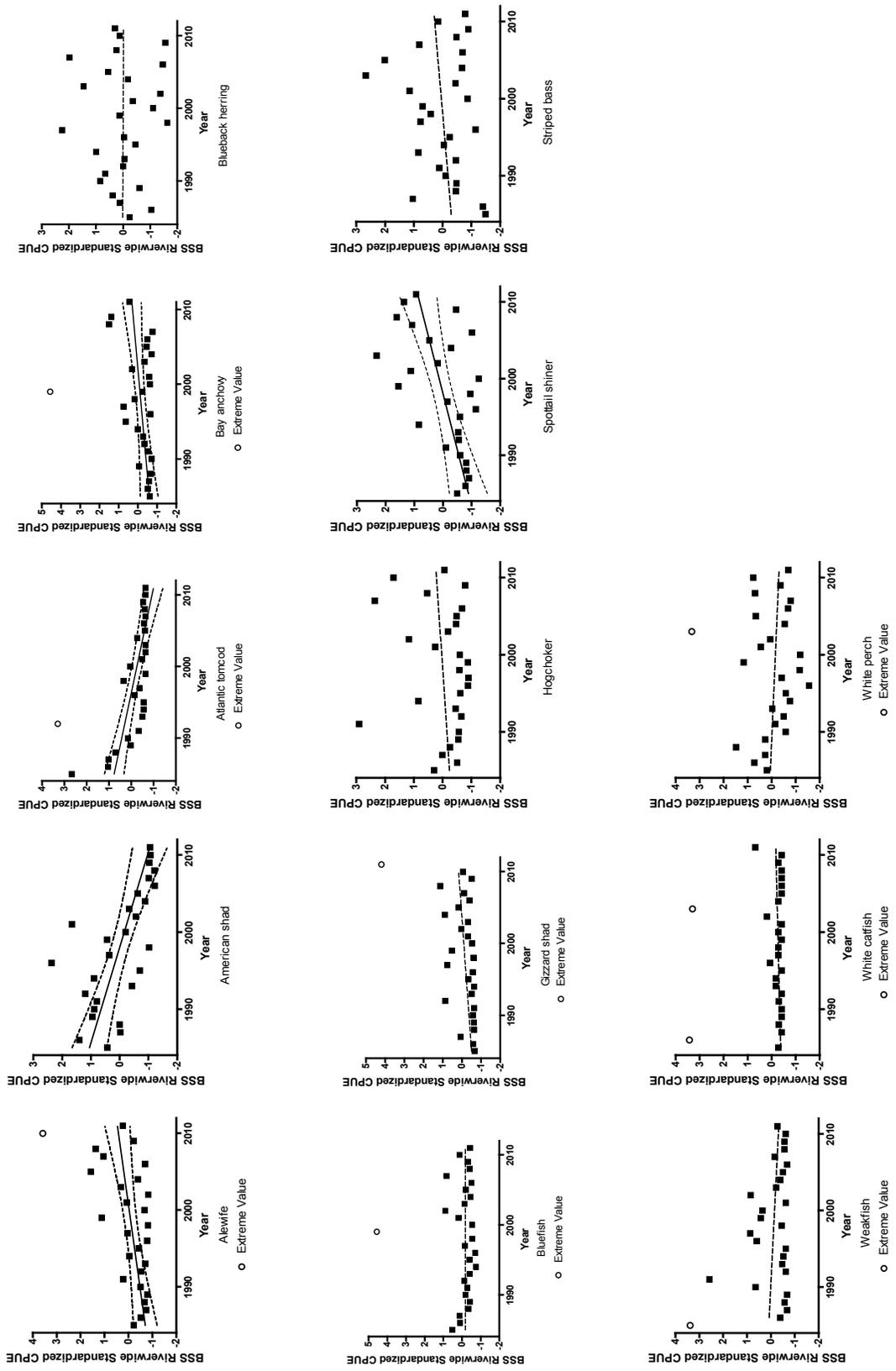


Figure H1. Riverwide BSS YOY CPUE (July–Oct Sampling Events, 1985–2011)



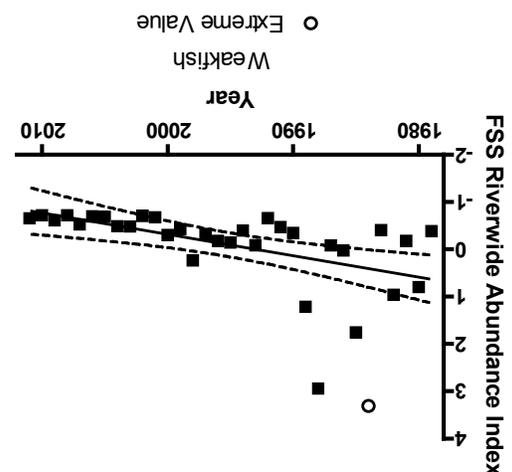
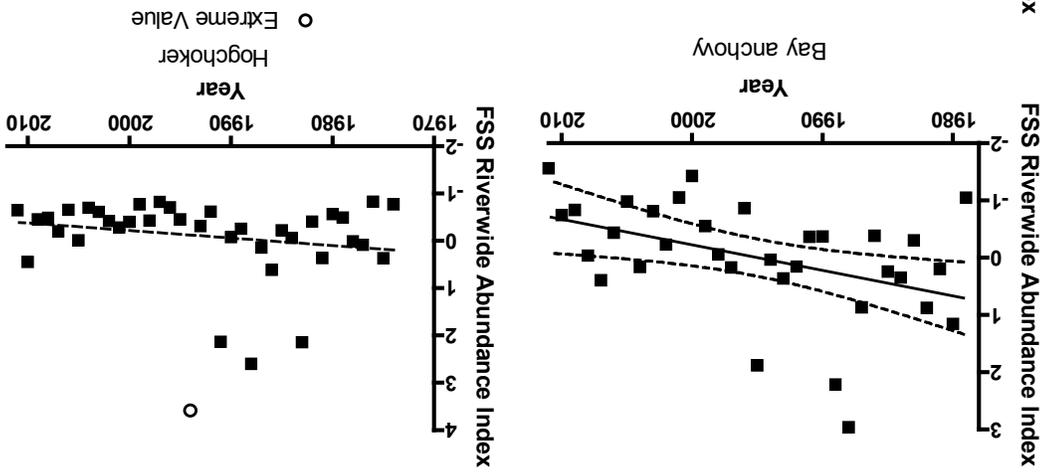
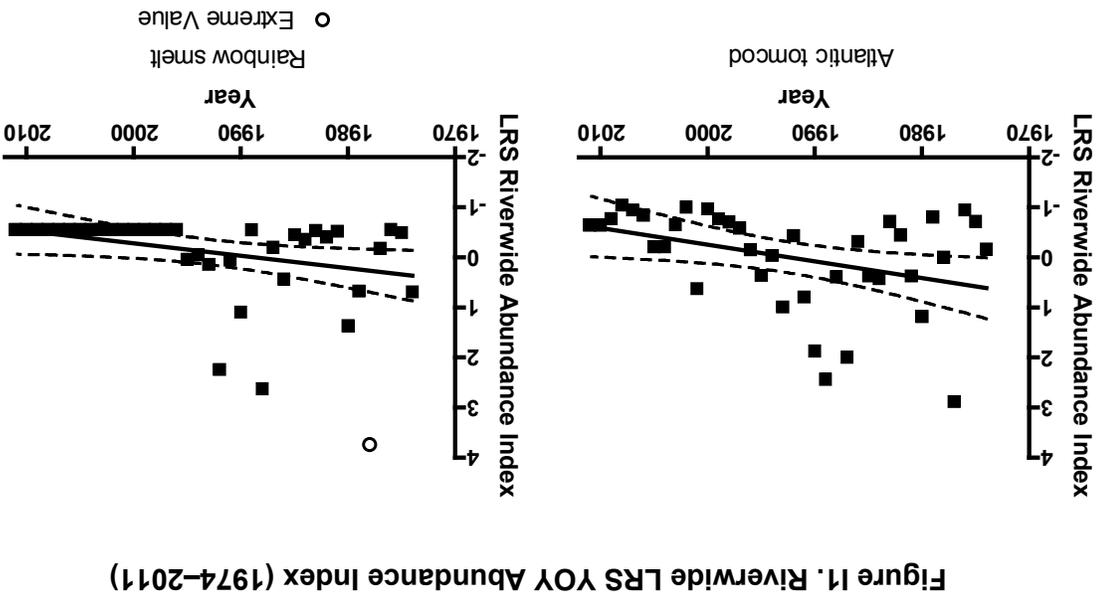


Figure K1. Riverwide BSS YOY Abundance Index (1974–2011)

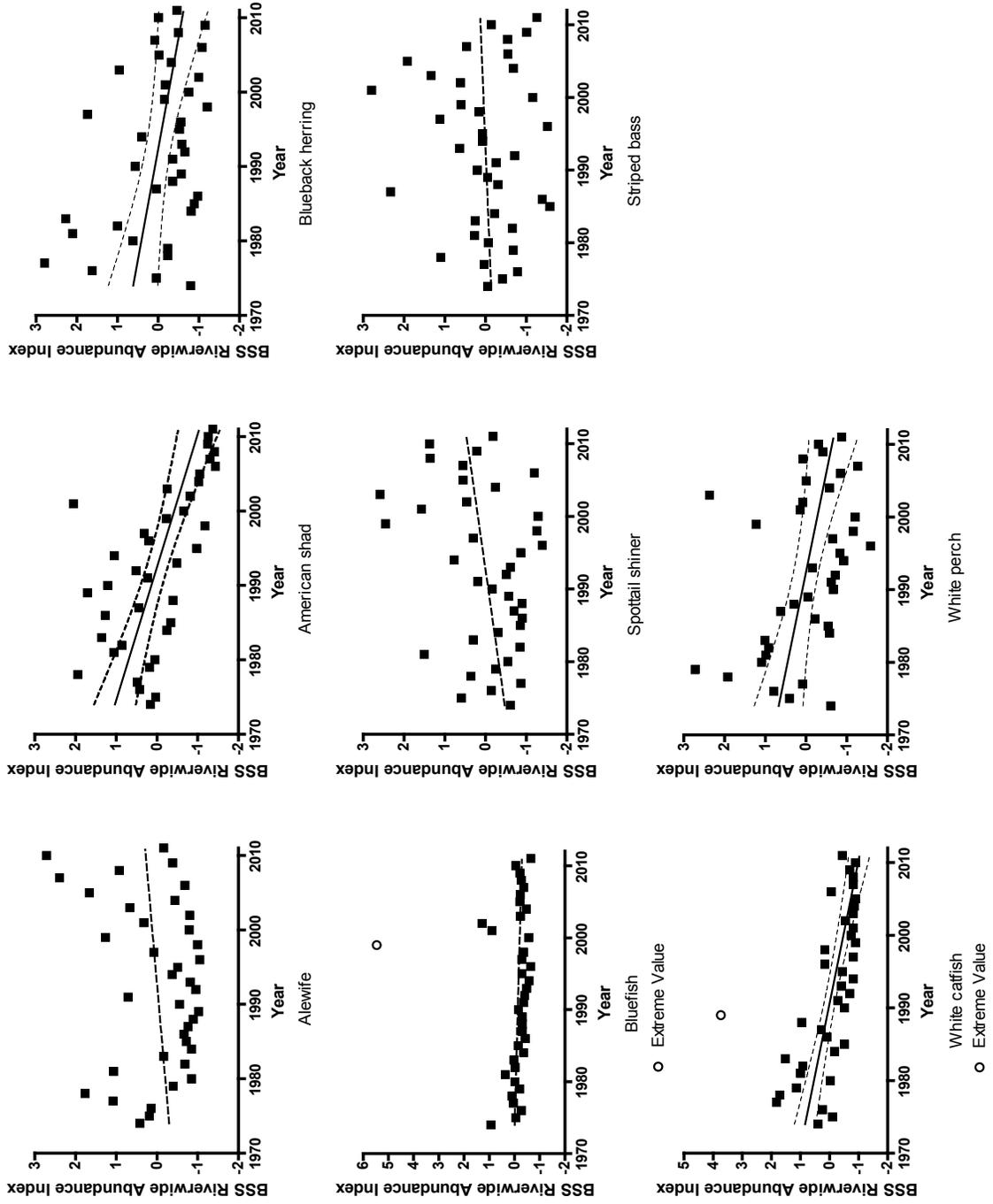


Figure L1. River Segment 4 YOY CPUE for Atlantic Menhaden (July-Oct Sampling Events, 1985–2011)

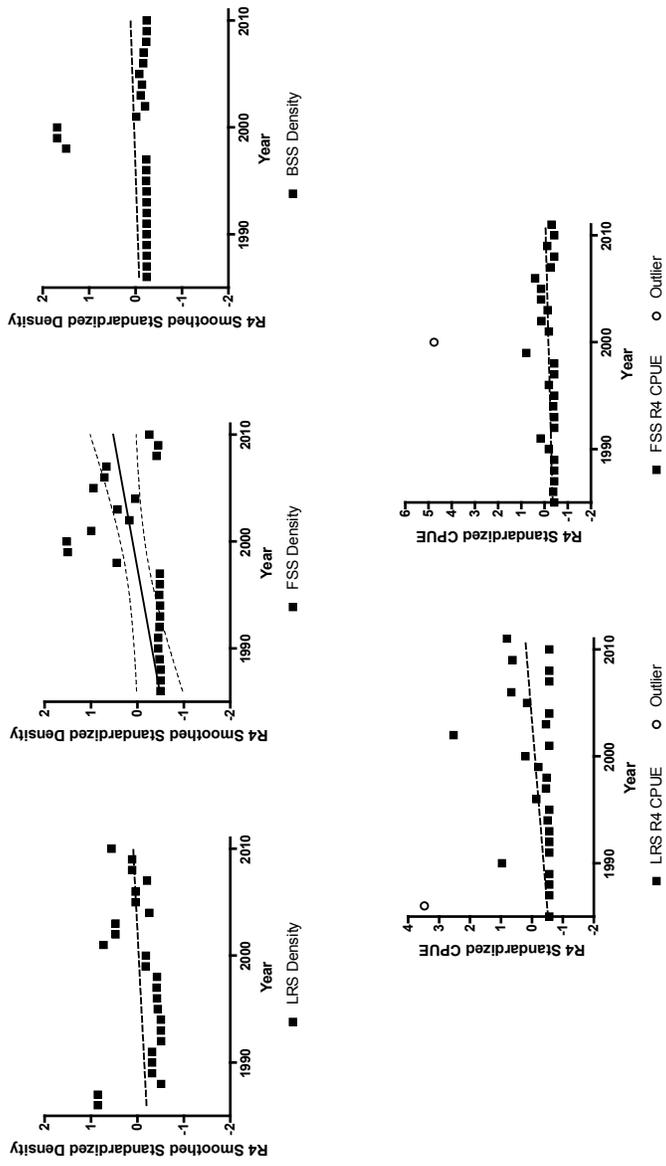
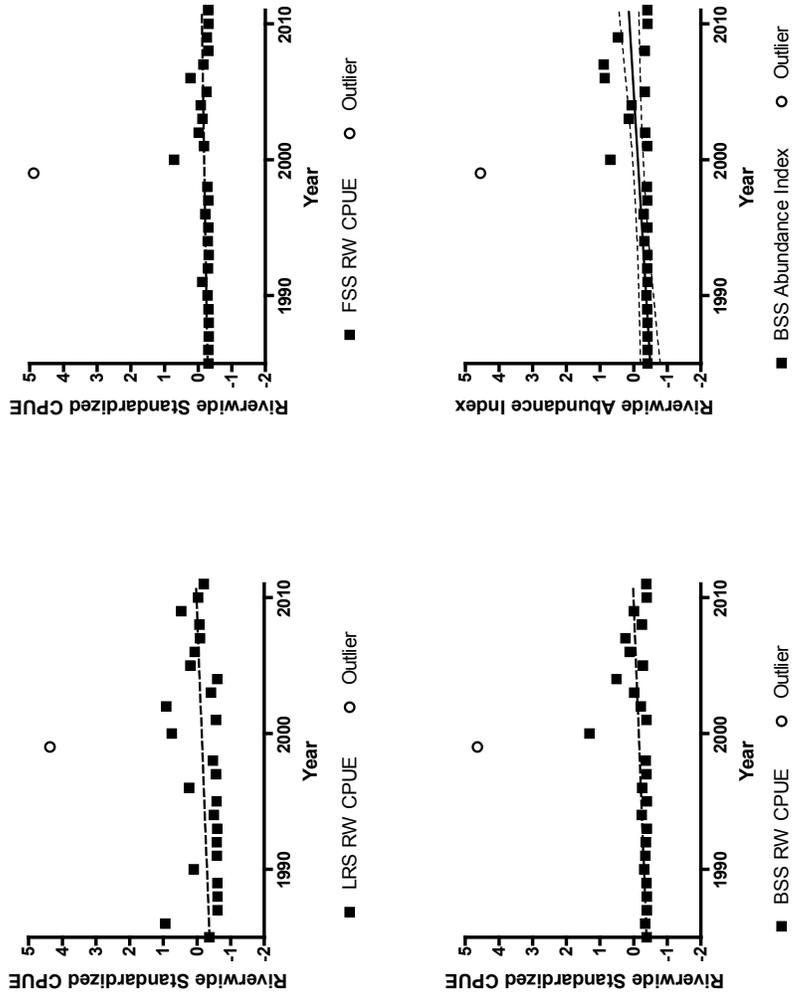


Figure M1. Riverwide YOY CPUE for Atlantic Menhaden (July-Oct Sampling Events, 1985–2011)



River Segment 4 Tables

Table A. Linear Analysis of LRS Region 4 YOY Density*(May–July Sampling Events, 1985–2011, with 3 yr. Moving Average Smoothing)*

Linear Regression LRS River Segment 4 Density						
RIS	MSE	Slope ± 1 Standard		P value	Slope	Decision
		Error of Slope				
American Shad	0.241	-0.039±0.014		0.009	S<0	4
Atlantic Tomcod	0.213	-0.013±0.013		0.316	S=0	1
Bluefish	0.212	-0.068±0.013		<0.001	S<0	4
Rainbow Smelt*	0.300	-0.071±0.015		<0.001	S<0	4
Striped Bass	0.251	-0.027±0.014		0.061	S=0	1
Weakfish*	0.300	-0.012±0.015		0.445	S=0	1

* Nine and eight annual non-zero values for smelt and weakfish respectively.

Table B. Linear Analysis of FSS Region 4 YOY Density*(July–Oct Sampling Events, 1985–2011, with 3 yr. Moving Average Smoothing)*

Linear Regression FSS River Segment 4 Density						
RIS	MSE	Slope ± 1 Standard		P value	Slope	Decision
		Error of Slope				
Alewife	0.344	-0.048±0.016		0.008	S<0	4
American Shad	0.146	-0.081±0.011		<0.001	S<0	4
Atlantic Tomcod	0.223	-0.038±0.013		0.008	S<0	4
Bay Anchovy	0.314	-0.053±0.016		0.002	S<0	4
Blueback Herring	0.139	-0.033±0.010		0.004	S<0	4
Bluefish	0.275	-0.029±0.015		0.059	S=0	1
Hogchoker	0.175	-0.068±0.012		<0.001	S<0	4
Rainbow Smelt*	0.297	-0.056±0.015		0.001	S<0	4
Striped Bass	0.209	-0.034±0.013		0.013	S<0	4
Weakfish	0.399	-0.034±0.018		0.067	S=0	1
White Perch	0.328	-0.030±0.016		0.075	S=0	1

* Eight annual non-zero values

Table C. Linear Analysis of BSS Region 4 YOY Density*(July–Oct Sampling Events, 1985–2011, with 3 yr. Moving Average Smoothing)*

Linear Regression BSS River Segment 4 Density					
RIS	MSE	Slope \pm 1 Standard Error of Slope	P value	Slope	Decision
Alewife	0.123	0.050 \pm 0.010	<0.001	S>0	1
American Shad	0.117	-0.073 \pm 0.009	<0.001	S<0	4
Bay Anchovy	0.317	0.031 \pm 0.016	0.063	S=0	1
Blueback Herring	0.232	-0.046 \pm 0.013	0.002	S<0	4
Bluefish	0.347	-0.019 \pm 0.016	0.264	S=0	1
Hogchoker	0.350	0.021 \pm 0.016	0.211	S=0	1
Spottail Shiner	0.349	-0.015 \pm 0.016	0.377	S=0	1
Striped Bass	0.229	0.013 \pm 0.013	0.339	S=0	1
White Perch	0.387	-0.010 \pm 0.017	0.571	S=0	1

Table D. Linear Analysis of LRS Region 4 YOY CPUE*(May–July Sampling Events, 1985–2011)*

Linear Regression LRS River Segment 4 CPUE					
RIS	MSE	Slope \pm 1 Standard Error of Slope	P value	Slope	Decision
American Shad	0.931	-0.041 \pm 0.024	0.100	S=0	4
American Shad with 1 value removed	0.411	-0.036 \pm 0.016	0.032	S<0	
Atlantic Tomcod	0.930	-0.041 \pm 0.024	0.098	S=0	1
Atlantic Tomcod with 1 value removed	0.636	-0.017 \pm 0.021	0.429	S=0	
Bay Anchovy	1.036	-0.008 \pm 0.025	0.743	S=0	1
Bay Anchovy with 1 value removed	0.529	-0.002 \pm 0.018	0.932	S=0	
Bluefish	0.733	-0.068 \pm 0.021	0.003	S<0	4
Rainbow Smelt*	0.924	-0.042 \pm 0.024	0.089	S=0	4
Rainbow Smelt* with 1 value removed	0.175	-0.026 \pm 0.010	0.022	S<0	
Striped Bass	1.040	0.002 \pm 0.025	0.950	S=0	1
Weakfish	1.032	-0.011 \pm 0.025	0.671	S=0	1
Weakfish with 1 value removed	0.146	0.010 \pm 0.010	0.302	S=0	

* Eight annual non-zero values

Table E. Linear Analysis of FSS Region 4 YOY CPUE
(July–Oct Sampling Events, 1985–2011)

Linear Regression FSS River Segment 4 CPUE					
RIS	MSE	Slope \pm 1 Standard Error of Slope	P value	Slope	Decision
Alewife	1.022	-0.017 \pm 0.025	0.509	S=0	1
Alewife with 1 value removed	0.346	-0.019 \pm 0.015	0.196	S=0	1
American Shad	0.798	-0.061 \pm 0.022	0.011	S<0	4
Atlantic Tomcod	0.762	-0.065 \pm 0.022	0.006	S<0	4
Bay Anchovy	1.036	0.008 \pm 0.025	0.765	S=0	1
Blueback Herring	0.876	-0.050 \pm 0.023	0.041	S<0	4
Blueback Herring with 1 value removed	0.187	-0.014 \pm 0.011	0.220	S=0	4
Bluefish	0.852	-0.054 \pm 0.023	0.027	S<0	4
Hogchoker	0.810	-0.059 \pm 0.022	0.013	S<0	4
Hogchoker with 1 value removed	0.467	-0.052 \pm 0.017	0.006	S<0	4
Rainbow Smelt*	0.907	-0.045 \pm 0.024	0.067	S=0	4
Rainbow Smelt* with 1 value removed	0.125	-0.028 \pm 0.009	0.004	S<0	4
Striped Bass	0.803	-0.060 \pm 0.022	0.012	S<0	4
Weakfish	1.008	-0.022 \pm 0.025	0.380	S=0	1
White Perch	0.939	-0.039 \pm 0.024	0.114	S=0	1
White Perch with 1 value removed	0.357	-0.014 \pm 0.015	0.353	S=0	1

* Eight annual non-zero values

Riverwide Tables

Table F. Linear Analysis of LRS Riverwide YOY CPUE
(May–July Sampling Events, 1985–2011)

Linear Regression LRS Riverwide CPUE					
RIS	MSE	Slope \pm 1 Standard Error of Slope	P value	Slope	Decision
Alewife	0.995	0.026 \pm 0.025	0.297	S=0	1
Alewife with 1 value removed	0.650	0.024 \pm 0.020	0.233	S=0	1
American Shad	0.606	-0.081 \pm 0.019	<0.001	S<0	4
Atlantic Tomcod	0.787	-0.062 \pm 0.022	0.009	S<0	4
Bay Anchovy	1.024	-0.016 \pm 0.025	0.529	S=0	1
Bay Anchovy with 1 value removed	0.409	-0.009 \pm 0.016	0.595	S=0	1
Blueback Herring	0.987	-0.028 \pm 0.025	0.257	S=0	1
Blueback Herring with 1 value removed	0.454	-0.012 \pm 0.017	0.484	S=0	1
Bluefish	0.768	-0.064 \pm 0.022	0.006	S<0	4
Bluefish with 1 value removed	0.306	-0.047 \pm 0.014	0.003	S<0	4
Hogchoker	0.950	0.037 \pm 0.024	0.137	S=0	1
Rainbow Smelt	0.790	-0.062 \pm 0.022	0.009	S<0	4
Rainbow Smelt with 1 value removed	0.349	-0.040 \pm 0.015	0.014	S<0	4
Spottail Shiner	0.989	0.028 \pm 0.025	0.267	S=0	1
Spottail Shiner with 1 value removed	0.157	0.002 \pm 0.010	0.875	S=0	1
Striped Bass	1.004	-0.024 \pm 0.025	0.348	S=0	1
Striped Bass with 1 value removed	0.335	-0.003 \pm 0.015	0.855	S=0	1
Weakfish	1.034	-0.009 \pm 0.025	0.718	S=0	1
Weakfish with 1 value removed	0.445	0.008 \pm 0.017	0.635	S=0	1
White Catfish	1.040	0.000 \pm 0.025	0.998	S=0	1
White Catfish with 1 value removed	0.140	0.012 \pm 0.009	0.210	S=0	1
White Perch	0.921	-0.043 \pm 0.024	0.084	S=0	1

Table G. Linear Analysis of FSS Riverwide YOY CPUE
(July–Oct Sampling Events, 1985–2011)

Linear Regression FSS Riverwide CPUE					
RIS	MSE	Slope \pm 1 Standard Error of Slope	P value	Slope	Decision
Alewife	1.014	0.020 \pm 0.025	0.440	S=0	1
Alewife with 1 value removed	0.453	0.017 \pm 0.017	0.313	S=0	1
American Shad	0.561	-0.086 \pm 0.019	<0.001	S<0	4
Atlantic Tomcod	0.666	-0.076 \pm 0.020	0.001	S<0	4
Atlantic Tomcod with 1 value removed	0.434	-0.061 \pm 0.017	0.001	S<0	4
Bay Anchovy	1.040	-0.002 \pm 0.025	0.952	S=0	1
Blueback Herring	0.678	-0.074 \pm 0.020	0.001	S<0	4
Blueback Herring with 1 value removed	0.431	-0.063 \pm 0.016	0.001	S<0	4
Bluefish	0.706	-0.071 \pm 0.021	0.002	S<0	4
Bluefish with 1 value removed	0.293	-0.073 \pm 0.013	<0.001	S<0	4
Gizzard Shad	1.040	-0.001 \pm 0.025	0.960	S=0	1
Gizzard Shad with 1 value removed	0.165	-0.010 \pm 0.010	0.327	S=0	1
Hogchoker	0.954	-0.036 \pm 0.024	0.146	S=0	1
Hogchoker with 1 value removed	0.667	-0.018 \pm 0.021	0.391	S=0	1
Rainbow Smelt	0.917	-0.043 \pm 0.024	0.079	S=0	4
Rainbow Smelt with 1 value removed	0.066	-0.026 \pm 0.006	0.001	S<0	4
Spottail Shiner	0.832	-0.056 \pm 0.023	0.019	S<0	4
Spottail Shiner with 1 value removed	0.415	-0.042 \pm 0.016	0.016	S<0	4
Striped Bass	0.857	-0.053 \pm 0.023	0.030	S<0	4
Striped Bass with 1 value removed	0.599	-0.036 \pm 0.020	0.083	S=0	4
Weakfish	0.950	-0.037 \pm 0.024	0.137	S=0	1
White Catfish	0.859	-0.053 \pm 0.023	0.031	S<0	4
White Perch	1.018	-0.019 \pm 0.025	0.461	S=0	1

Table H. Linear Analysis of BSS Riverwide YOY CPUE*(July–Oct Sampling Events, 1985–2011)*

Linear Regression BSS Riverwide CPUE					
RIS	MSE	Slope ± 1 Standard Error of Slope	P value	Slope	Decision
Alewife	0.737	0.068±0.021	0.004	S>0	
Alewife with 1 value removed	0.403	0.045±0.016	0.012	S>0	1
American Shad	0.613	-0.081±0.019	<0.001	S<0	4
Atlantic Tomcod	0.634	-0.079±0.020	0.001	S<0	
Atlantic Tomcod with 1 value removed	0.307	-0.068±0.014	<0.0001	S<0	4
Bay Anchovy	0.794	0.061±0.022	0.010	S>0	
Bay Anchovy with 1 value removed	0.347	0.035±0.015	0.033	S>0	1
Blueback Herring	1.040	-0.001±0.025	0.962	S=0	1
Bluefish	1.040	0.003±0.025	0.916	S=0	
Bluefish with 1 value removed	0.184	0.000±0.011	0.985	S=0	1
Gizzard Shad	0.814	0.059±0.022	0.014	S>0	
Gizzard Shad with 1 value removed	0.277	0.027±0.014	0.061	S=0	1
Hogchoker	1.018	0.018±0.025	0.476	S=0	1
Spottail Shiner	0.737	0.068±0.021	0.004	S>0	1
Striped Bass	1.006	0.023±0.025	0.362	S=0	1
Weakfish	0.923	-0.042±0.024	0.087	S=0	
Weakfish with 1 value removed	0.572	-0.016±0.020	0.423	S=0	1
White Catfish	1.034	-0.009±0.025	0.710	S=0	
White Catfish with 2 values removed	0.063	0.008±0.007	0.257	S=0	1
White Perch	1.038	-0.003±0.025	0.902	S=0	
White Perch with 1 value removed	0.590	-0.014±0.019	0.473	S=0	1

Table I. Linear Analysis of LRS Abundance Index*Standardized Data (1974–2011)*

Linear Regression LRS Riverwide Abundance Index					
RIS	MSE	Slope ± 1 Standard Error of Slope	P value	Slope	Decision
Atlantic Tomcod	0.886	-0.033±0.014	0.022	S<0	4
Rainbow Smelt	0.864	-0.036±0.014	0.013	S<0	
Rainbow Smelt with 1 value removed	0.569	-0.025± 0.011	0.037	S<0	4

Table J. Linear Analysis of FSS Abundance Index
Standardized Data (1979–2011; Hogchoker 1974–2011)

Linear Regression FSS Riverwide Abundance Index					
RIS	MSE	Slope \pm 1 Standard Error of Slope	P value	Slope	Decision
Bay Anchovy	0.839	-0.045 \pm 0.017	0.012	S<0	4
Hogchoker	1.000	-0.015 \pm 0.015	0.328	S=0	1
Hogchoker with 1 value removed	0.646	-0.016 \pm 0.012	0.190	S=0	
Weakfish	0.732	-0.056 \pm 0.016	0.001	S<0	
Weakfish with 1 value removed	0.495	-0.045 \pm 0.013	0.002	S<0	4

Table K. Linear Analysis of BSS Abundance Index
Standardized Data (1974–2011)

Linear Regression BSS Riverwide Abundance Index					
RIS	MSE	Slope \pm 1 Standard Error of Slope	P value	Slope	Decision
Alewife	0.995	0.016 \pm 0.015	0.287	S=0	1
American Shad	0.631	-0.056 \pm 0.012	<0.001	S<0	4
Blueback Herring	0.885	-0.034 \pm 0.014	0.021	S<0	4
Bluefish	1.028	0.000 \pm 0.015	0.988	S=0	1
Bluefish with 1 value removed	0.173	-0.008 \pm 0.006	0.213	S=0	
Spottail Shiner	0.946	0.025 \pm 0.014	0.086	S=0	1
Striped Bass	1.022	0.007 \pm 0.015	0.634	S=0	1
White Catfish	0.668	-0.053 \pm 0.012	<0.001	S<0	4
White Catfish with 1 value removed	0.317	-0.050 \pm 0.008	<0.001	S<0	
White Perch	0.859	-0.036 \pm 0.014	0.012	S<0	4

Table L. Linear Analysis of Atlantic Menhaden

Metric	MSE	Slope \pm 1 Standard Error of Slope	P value	Slope	Decision
River Segment 4 Abundance Metrics					
LRS Density	0.207	0.012 \pm 0.013	0.355	S=0	1
FSS Density	0.379	0.042 \pm 0.017	0.023	S>0	1
BSS Density	0.384	0.008 \pm 0.017	0.653	S=0	1
LRS CPUE*	0.511	0.028 \pm 0.019	0.141	S=0	1
FSS CPUE*	0.092	0.012 \pm 0.008	0.134	S=0	1
Riverwide Abundance Metrics					
LRS CPUE*	0.242	0.016 \pm 0.012	0.211	S=0	1

Appendix A

Metric	MSE	Slope \pm 1 Standard Error of Slope	P value	Slope	Decision
FSS CPUE*	0.048	0.007 \pm 0.005	0.230	S=0	1
BSS CPUE*	0.135	0.016 \pm 0.009	0.100	S=0	1
BSS Abundance Index*	0.144	0.025 \pm 0.009	0.015	S>0	1

*One outlier removed

Addendum A–2: Summary of Population Trends by RIS

This addendum presents supporting plots for the trend analysis presented in Appendix A and summarized in Chapter 4 of this supplement. Each plot provides a visual summary of the results of each measure of abundance for a given RIS. The bar for each measure of abundance indicates the estimated linear slope, and the thick circle is the associated p-value for the test of the null hypothesis H_0 : the linear slope $S=0$. RIS appear in alphabetical order. As a result of new information received from Entergy following the issuance of the draft of this supplement, the NRC staff added a supporting plot (Figure C2) for Atlantic menhaden to this addendum.

Figure A2. Alewife Estimated Slope (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance

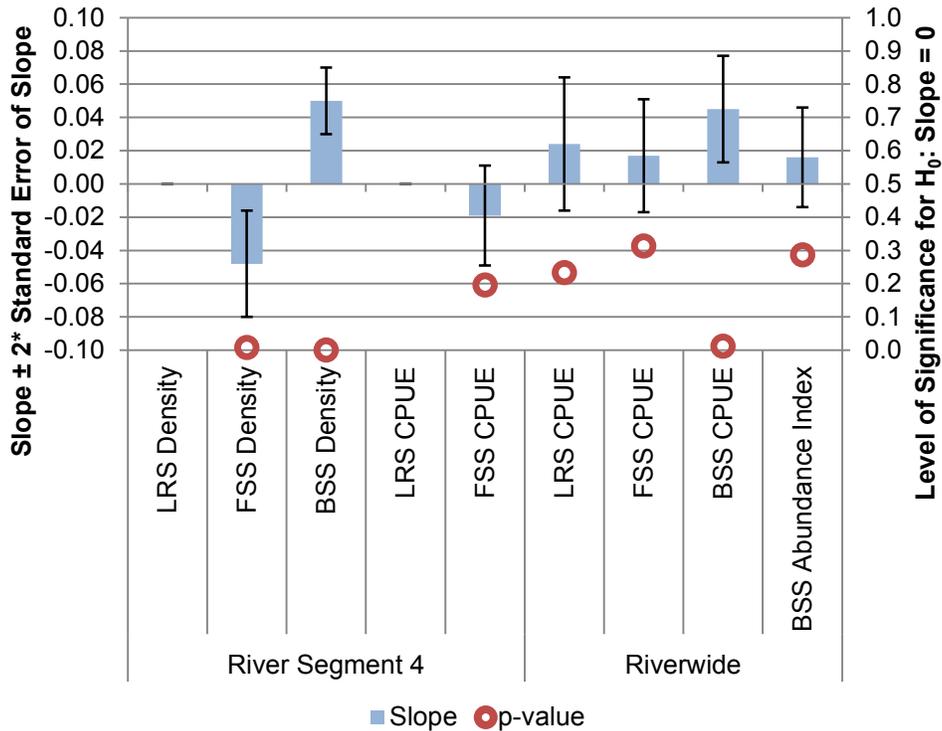


Figure B2. American Shad Estimated Slope (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance

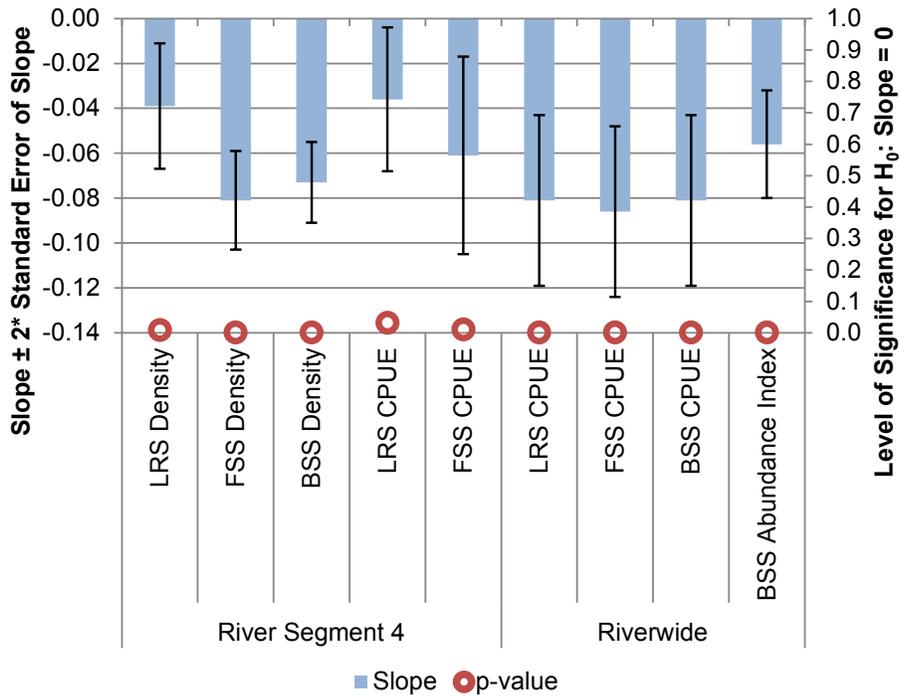


Figure C2. Atlantic Menhaden Estimated Slope (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance

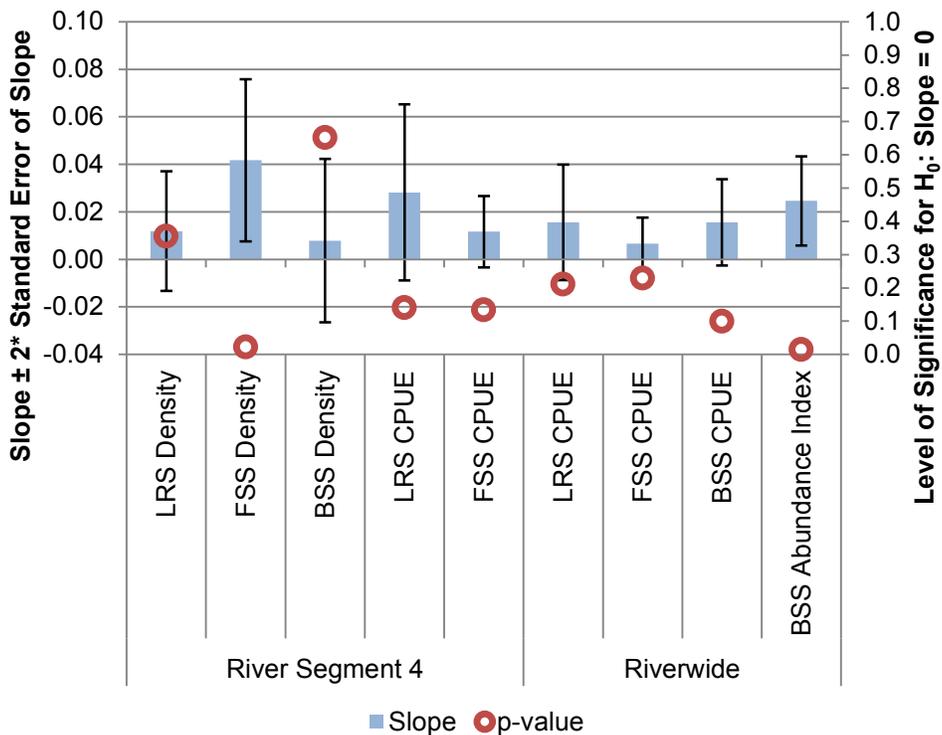


Figure D2. Atlantic Tomcod Estimated Slope (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance

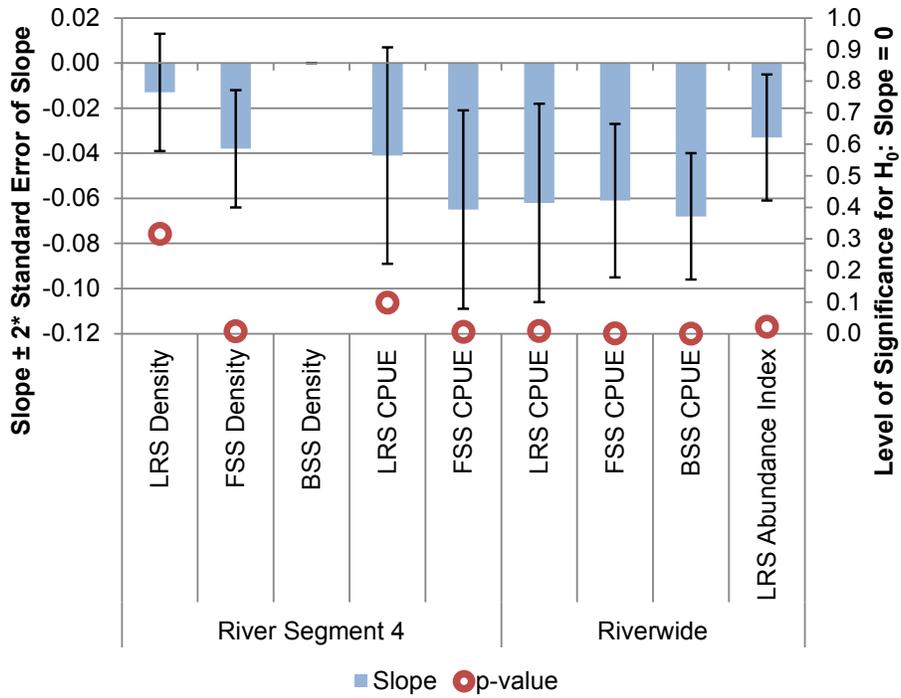


Figure E2. Bay Anchovy Estimated Slope (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance

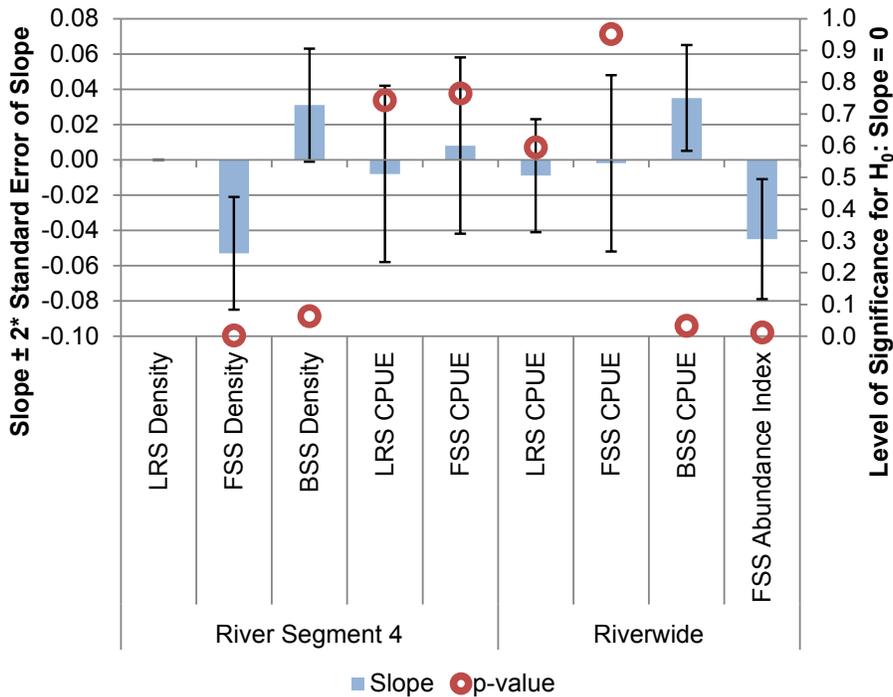


Figure F2. Blueback Herring Estimated Slope (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance

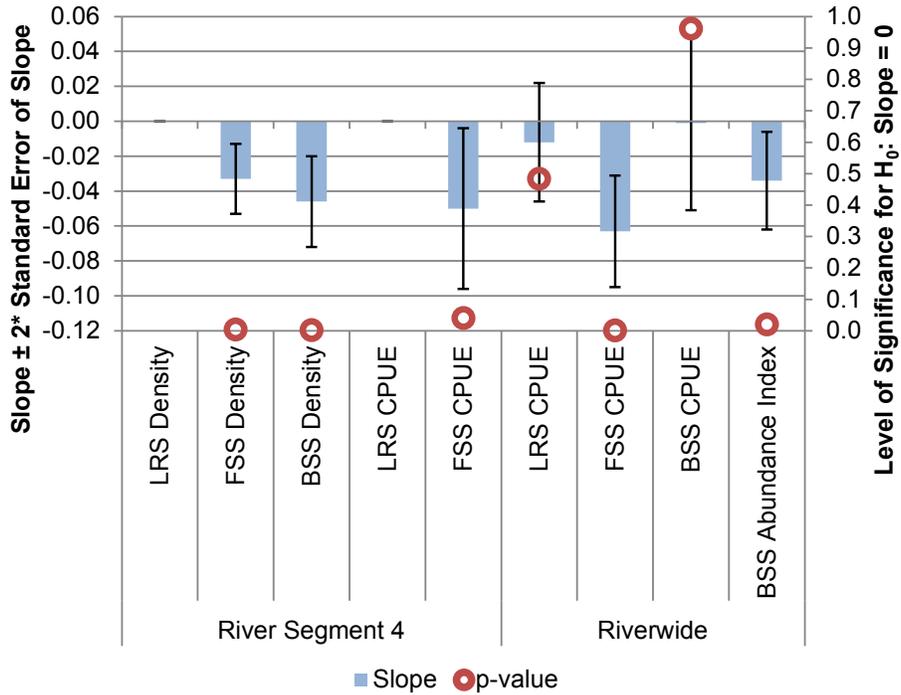


Figure G2. Bluefish Estimated Slope (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance

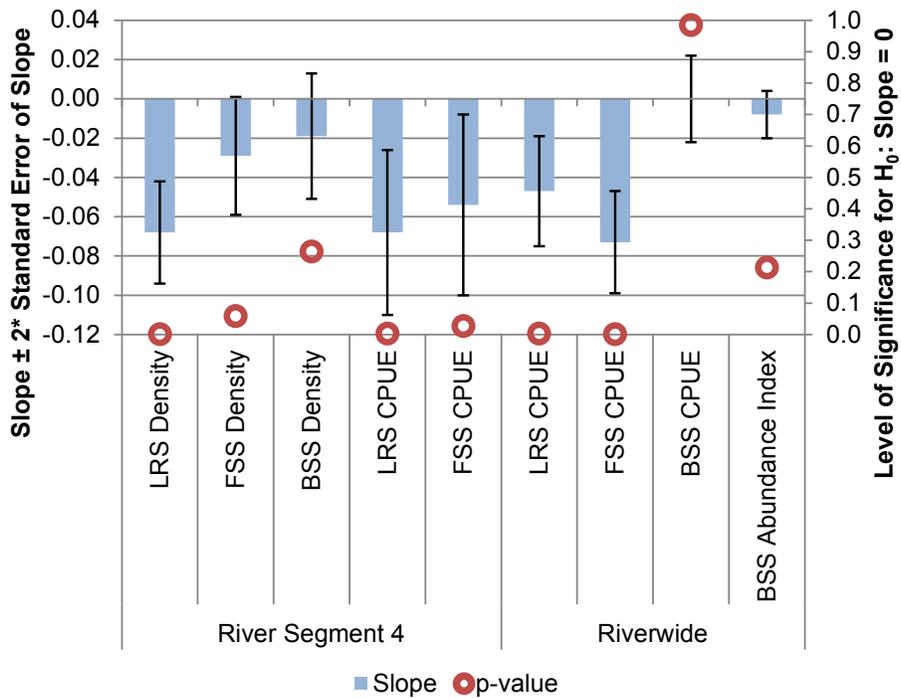


Figure H2. Gizzard Shad Estimated Slope (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance

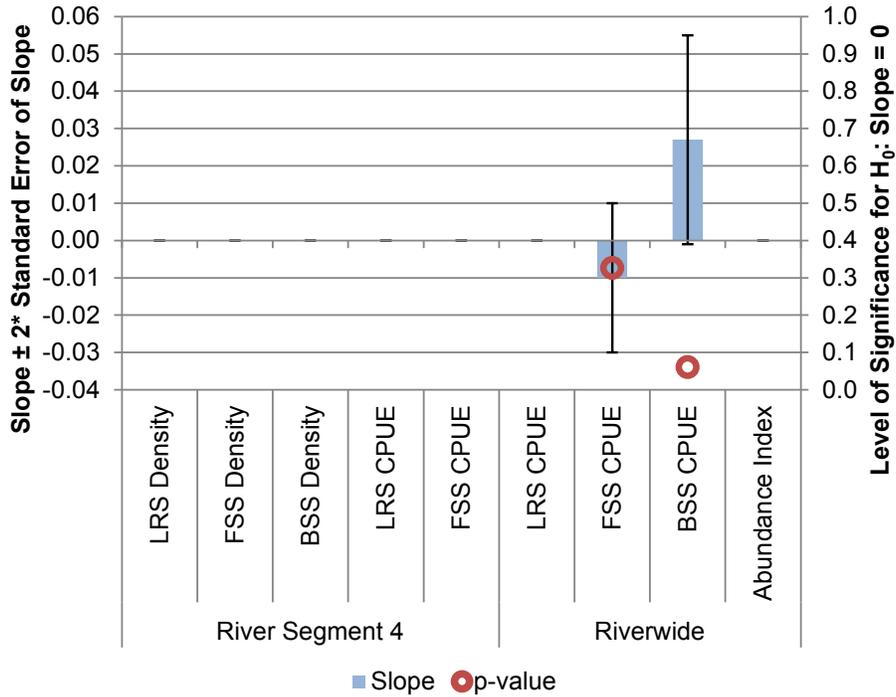


Figure I2. Hogchoker Estimated Slope (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance

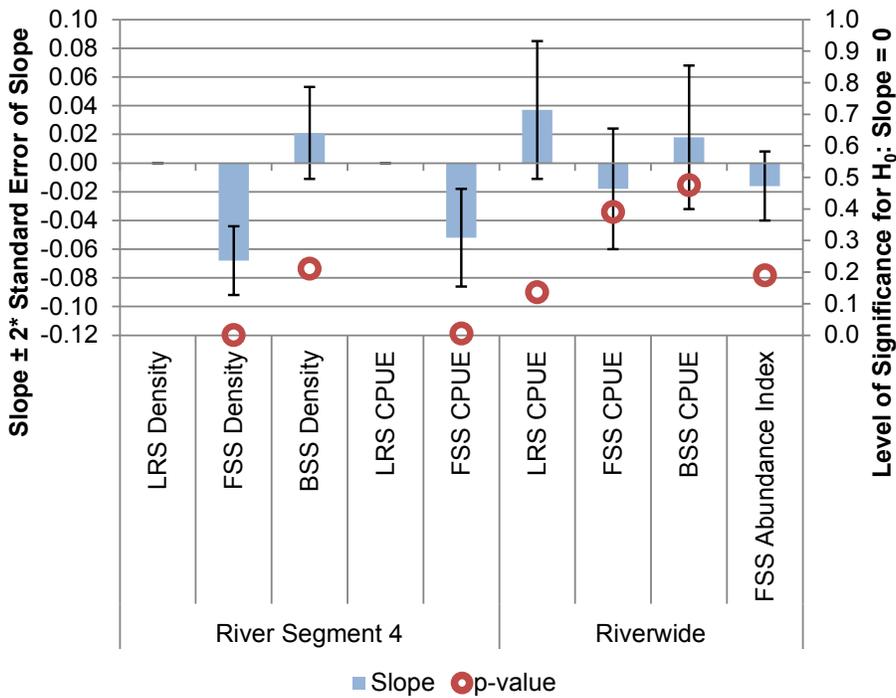


Figure J2. Rainbow Smelt Estimated Slope (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance

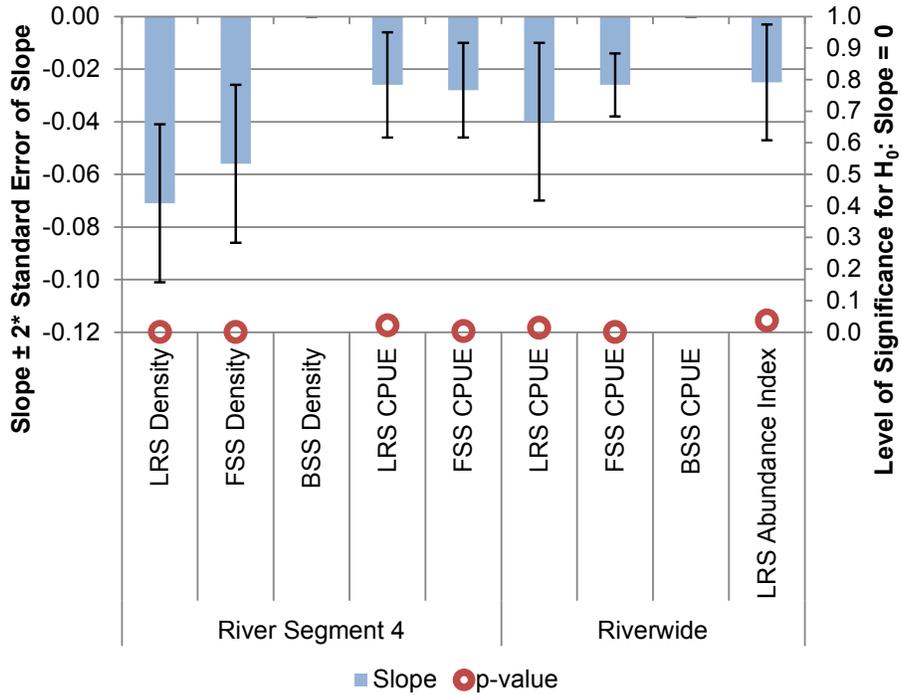


Figure K2. Spottail Shiner Estimated Slope (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance

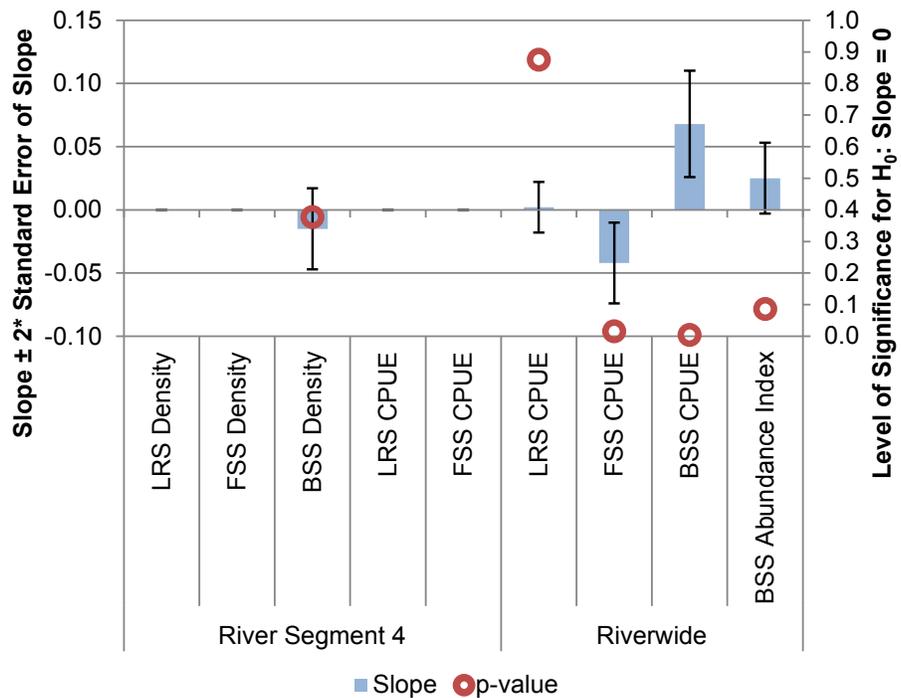


Figure L2. Striped Bass Estimated Slope (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance

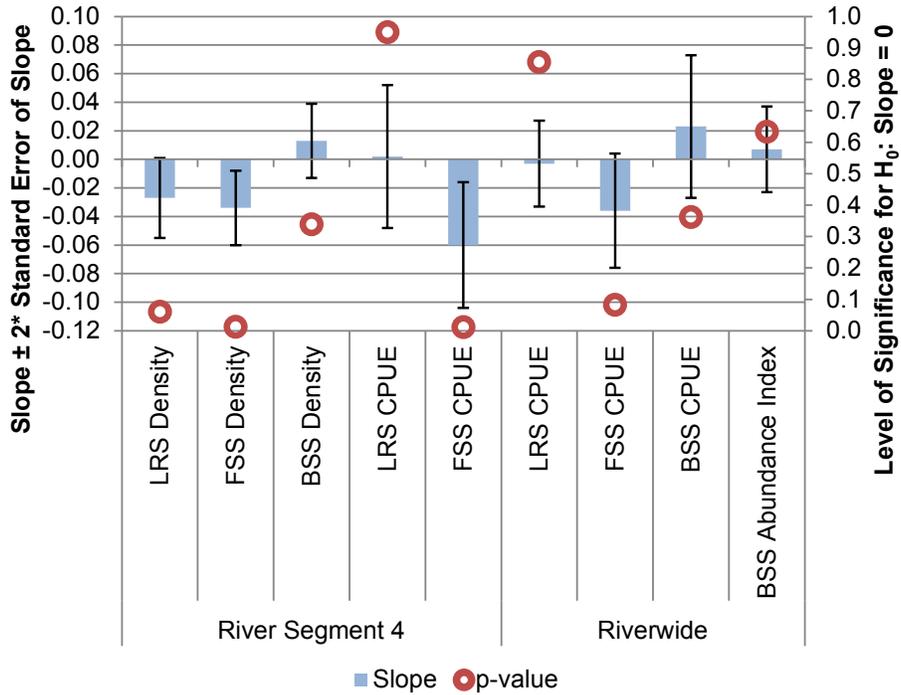


Figure M2. Weakfish Estimated Slope (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance

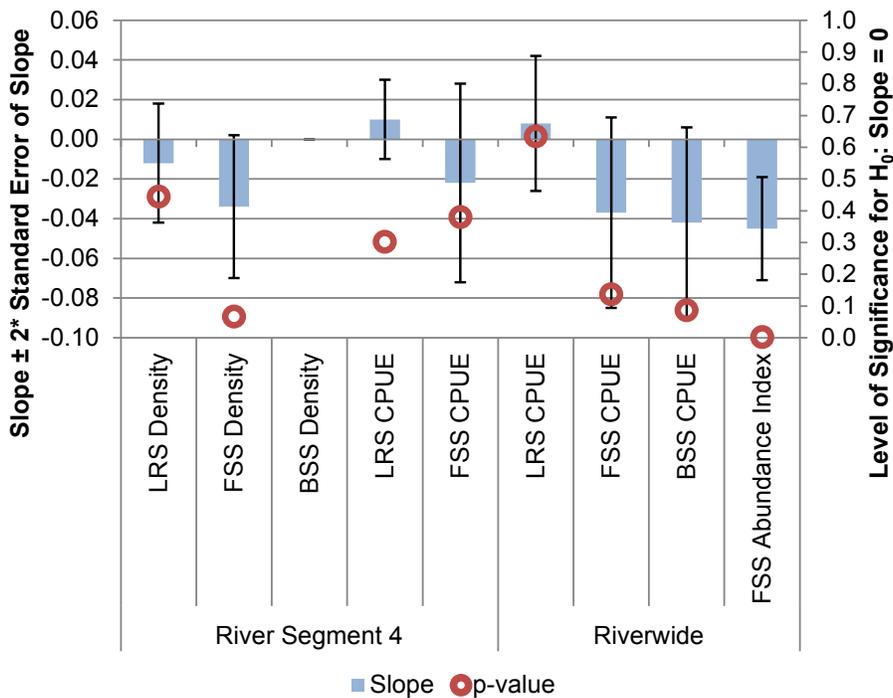


Figure N2. White Catfish Estimated Slope (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance

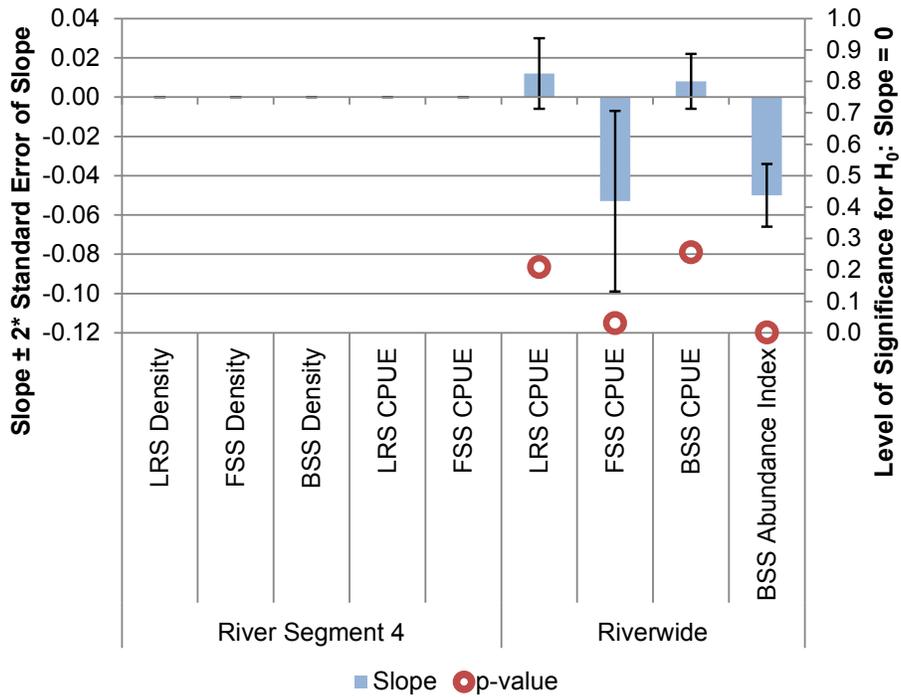
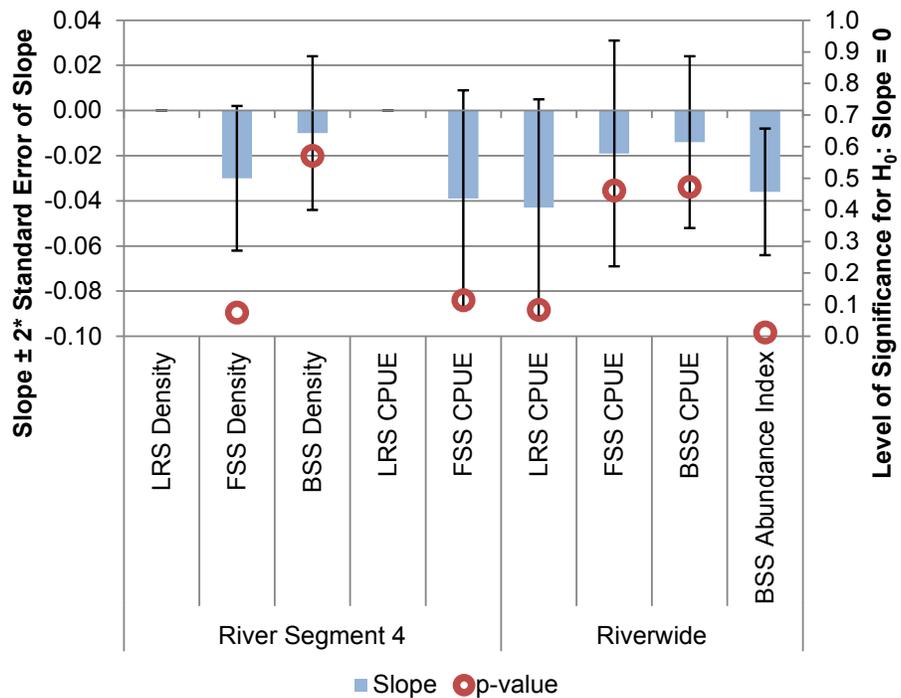


Figure O2. White Perch Estimated Slope (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance



APPENDIX B
COMMENTS RECEIVED ON THE DRAFT SUPPLEMENT

B. Comments Received on the Draft Supplement

On December 22, 2015, the U.S. Nuclear Regulatory Commission (NRC) staff issued the draft second supplement to the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3, Final Report* (NUREG–1437, Supplement 38, Volume 5; referred to as the draft supplement to the FSEIS) to Federal, Tribal, State, and local government agencies and interested members of the public for comment in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) 51.92(f)(1). The U.S. Environmental Protection Agency (EPA) issued its Notice of Availability on December 31, 2015 in the *Federal Register* (FR) (80 FR 81818). The public comment period ended on March 4, 2016. As part of the process to solicit public comments on the draft supplement to the FSEIS, the NRC staff did the following:

- placed a copy of the draft supplement to the FSEIS at the Field Library in Peekskill, New York; the White Plains Public Library in White Plains, New York; and the Henrick Hudson Free Library in Montrose, New York;
- made the draft supplement to the FSEIS available in the NRC's Public Document Room in Rockville, Maryland;
- placed a copy of the draft supplement to the FSEIS on the NRC web site at <http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/supplement38/v5/>;
- provided a copy of the draft supplement to the FSEIS to any member of the public that requested one;
- sent copies of the draft supplement to the FSEIS to certain Federal, Tribal, State, and local government agencies;
- filed the draft supplement to the FSEIS with the EPA; and
- published a notice of availability of the draft supplement to the FSEIS on December 29, 2015 (80 FR 81377).

During the public comment period, the NRC staff received comments from 22 individuals or groups. Each comment letter is part of the docket file for the Indian Point (IP) 2 and IP3 license renewal application, all of which are accessible in the NRC's Agencywide Documents Access Management System (ADAMS). ADAMS is accessible at <http://www.nrc.gov/reading-rm/adams.html>. Table B–1 lists each person who provided a comment during the comment period. The NRC staff reviewed each comment letter and assigned individual comments a unique identifier consisting of the Commenter ID (specified in Table B–1), an alphanumeric code corresponding to the source document (also specified in Table B–1), and a number associated with the sequential order of the comment within the specific document. Comment letters, with the individual comments delineated, can be found in the documents titled *Public Comments Received on the Draft Second Supplement to the Final Supplemental Environmental Impact Statement for the License Renewal of Indian Point Nuclear Generating Unit Nos. 2 and 3*, which can be found at ADAMS Accession number (No.) ML17188A200.

Table B–1. Individuals Providing Comments During the Comment Period

Commenter	Affiliation (if stated)	Commenter ID	Comment Source
Valerie Alcena	None given	1	Letter (L02)
Anonymous	None given	2	Letter (L01)
James Bacon	Riverkeeper, Inc.	3	Letter (L20)
Lonnie Clark	None given	4	Letter (L12)
Fred Dacimo	Entergy Nuclear Operations, Inc.	5	Letter (L17) Letter (L22)
Tom Gurdziel	None given	22	Email (L23)
Jerry Kremer	New York Affordable Reliable Energy Alliance	6	Letter (L19)
Michel Lee	Indian Point Safe Energy Coalition	7	Letter (L18)
Eileen Mahood-Jose	None given	8	Letter (L07)
Norris McDonald	African American Environmentalist Association	9	Letter (L16)
Brian Melton	None given	10	Letter (L09)
Judy-Ann Mitchell	U.S. Environmental Protection Agency	11	Letter (L21)
Kathleen Moser	New York State Department of Environmental Conservation	12	Letter (L15)
Sharon Nolting	None given	13	Letter (L06)
Andrew Raddant	U.S. Department of the Interior	14	Letter (L11)
Laurie Rieman	None given	15	Letter (L05)
Dr. Michael Shank	None given	16	Letter (L03)
Susan Shapiro	Public Health and Sustainable Energy	17	Letter (L14)
John Sipos	Asst. Attorney General, State of New York	18	Email (L13)
Rudy Stefanel	Thorium Energy Alliance	19	Letter (L08)
Kathleen Talbot	None given	20	Letter (L04)
Martin Wallace	None given	21	Letter (L10)

Specific comments were categorized and consolidated by topic. Comments with similar specific objectives were combined to capture the common essential issues raised by commenters. Comments received during the comment period were placed into categories based on topics. These categories are as follows:

- Air Quality and Meteorology,
- Alternatives to License Renewal,
- Aquatic Resources,
- Climate Change,

- Cumulative Impacts,
- Environmental Justice,
- Groundwater Resources,
- Human Health,
- NRC's License Renewal and National Environmental Policy Act (NEPA) Processes,
- Opposition to License Renewal or Nuclear Power,
- Out of Scope,
- Postulated Accidents, including Severe Accident Mitigation Alternatives (SAMAs),
- Special Status Species and Habitats,
- Support for License Renewal,
- Surface Water Resources,
- Terrestrial Resources, and
- Waste Management.

The following pages present the comments, reproduced directly from the comment source documents, followed by the NRC staff response. In most cases, the entire comment has been reproduced. In some cases, voluminous comments have been summarized by reproducing substantial excerpts from the individual comment. Each comment is identified by its unique comment identifier (as described in Table B-1) and grouped by comment issue category (as identified above). Similar comments are grouped together with a single response. Section B.1 below addresses comments concerning all matters other than aquatic resource impacts; Section B.2 below addresses comments concerning aquatic resource impacts.

B.1 Public Comments Received on the Draft Supplement (Excluding Aquatic Resources) and NRC Staff Responses

B.1.1 Air Quality and Meteorology

Comment 9-L16-3: In regards to the Category 1 issue, The Draft Report states,

"Air quality impacts (all plants)," considers air quality impacts from continued operation and refurbishment associated with license renewal and has an impact level of SMALL. The 2010 FSEIS (NRC 2010) considered the air quality impacts during refurbishment, but the air quality impacts from continued operation were not discussed. The discussion is revised below [in the Draft Report] to address air quality impacts from continued operation during the license renewal term."²

We agree with this revision. This air quality area is also where environmental justice issues are usually relevant in evaluating impacts. In regards to the impact level being 'SMALL,' perhaps some consideration should be given to the great clean air benefits that nuclear power plants provide to nonattainment areas. So although the negative impact level is SMALL, the positive impact is LARGE.

The revised language (in red) on Page 44, Lines 2-8 should be supplemented with language that describes the major air benefits of IP2 and IP3. Some language should reflect the fact that

Indian Point provides 25 percent of the electricity for New York City and Westchester County and does this with virtually zero carbon dioxide emissions.

This is more than 2,000 megawatts of virtually no carbon dioxide, nitrogen oxides, sulfur dioxide, and particulates. Indian Point Energy Center reduces carbon dioxide emissions by 8.5 million metric tons on an annual basis - or the equivalent of 1.6 million cars on the road. These are very significant considerations and some sort of language that describes these benefits should be included.

² 5.1 Air Quality Impacts (All Plants), Lines 12-19.

Comment 6-L19-1: Regarding air quality impact (all plants), the revised supplement takes into consideration air quality impact from continued operation of IPEC, as opposed to the previous version of the GEIS, which only considered the air quality impact during refurbishment. In the revision, the adverse air quality impact from continued operation of IPEC is adjudged to be small.

However, in addition to supporting this benign assessment of the potential harm to air quality posed by IPEC's continued operation, we urge that the revised language be supplemented with language that in fact describes the major benefits that accrue to our air from the continued operation of IP2 and IP3. The further revision we propose should reflect the fact that IPEC provides 25 percent of the electricity for New York City and Westchester County, more than 2000 megawatts, with virtually zero emissions of carbon dioxide, nitrogen oxides, sulfur dioxide, or particulates. IPEC reduces carbon dioxide emissions by 8.5 million metric tons annually, the equivalent of taking 1.6 million cars off the road.

These are substantive considerations, because by so significantly eliminating emissions that would otherwise be made by fossil fuel generation which is the only feasible current substitute for IPEC's baseload power in the event of its closure. IPEC's continued operation prevents significant numbers of hospitalizations and deaths from asthma and other respiratory and pulmonary disorders. These benefits are of direct relevance and importance to the decision regarding renewal of IPEC's license, and the NRC should include consideration of these benefits in its EIS.

Response: *The commenters recommend that the NRC consider the benefits of continued operation of IP2 and IP3 on air quality and revise Section 5.1 of this supplement to discuss greenhouse gas (GHG) and criteria air emissions that are avoided and the overall positive air quality benefits from continued operation.*

While the NRC staff does not disagree with the commenter's point that operation of IP2 and IP3 may have a beneficial impact on cumulative GHG emission, the NRC staff disagrees that Section 5.1 of this supplement should be revised as suggested in the comments. Section 5.0 of this supplement discusses the NRC's 2013 publication of a final rule (78 FR 37282), which revised the agency's environmental protection regulations in Title 10 of the Code of Federal Regulations (10 CFR) Part 51, and Revision 1 to NUREG-1437, Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants (2013 GEIS), that provides the technical basis for the final rule. The 2013 GEIS (NRC 2013a) evaluated continued plant operations on air quality because of the potential for air quality to be affected by the operations of fossil-fuel-fired equipment (e.g., diesel generators, boilers) needed for normal operations. With respect to air quality, the final rule amended Table B-1 in Appendix B to Subpart A of the revised 10 CFR Part 51 by changing the issue, "Air quality during refurbishment (nonattainment and maintenance areas)," from a Category 2 (site-specific) issue to a Category 1 (generic) issue and renamed the issue, "Air quality impacts (all plants)," which considers the air quality impacts from continued operation and refurbishment associated with license renewal and has an impact

level of SMALL. Section 5.1 of this supplement considers this Category 1 issue. Category 1 issues do not require a plant-specific assessment unless new and significant information is found that would change the conclusions in the GEIS.

Based on the above, Section 5.1 of this supplement appropriately considers the impacts from continued operation of fossil-fuel-fired equipment needed for IP2 and IP3 operation and refurbishment activities in accordance with the scope of the Category 1 issue, "Air quality impacts (all plants)." As discussed in Section 5.1.3 of this supplement, the NRC staff did not identify any new and significant information related to this Category 1 air quality issue and concludes that the air quality impacts associated with IP2 and IP3 operation are SMALL, consistent with the 2013 GEIS. The 2010 FSEIS examines the potential air quality impacts of replacing IP2 and IP3 with alternative electric-generation sources or energy conservation. Table 9-1 of this supplement summarizes the air quality impacts of license renewal and alternatives. Given that the NRC staff did not identify any new and significant information related to the Category 1 issue, "Air quality impacts (all plants)," the NRC staff's air quality impacts analysis conforms to the scope of the issue as described above. The 2010 FSEIS examines air quality impacts from alternative technologies if the IP2 and IP3 licenses are not renewed. Therefore, the NRC staff does not believe that Section 5.1 of this supplement needs to be revised to discuss avoided criteria pollutant emissions or the air quality benefits from continued operation of IP2 and IP3.

However, the NRC staff has revised Section 5.14.12, Global Climate Change, of this supplement to provide additional information describing GHG emissions from the proposed action relative to State-level GHG emission reduction goals and to discuss the net beneficial effect of the proposed action on GHG emissions when compared to replacement power alternative technologies (i.e., NGCC [natural gas combined-cycle] Alternative and Combination Alternatives).

Comment 5-L17-4:

IV. The IP2 and IP3 Generators and Diesel Fire Pumps Are Not Included in the New Combined Air Permit for IP2 and IP3 Issued by the NYSDEC, but Are Subject to the Requirements of the EPA's Reciprocating Internal Combustion Engine Rule

In response to an NRC Staff request for additional information issued Sept 14, 2014, Entergy provided updated information regarding the status of the station air permits and compliance history, and also responded to requests concerning all emission sources relevant to calculations of potential GHG emissions. In two locations in the Draft Supplement (page 43, lines 7-24, and page 45, lines 27-40), there are descriptions of air emission sources regulated under the new combined IP2/IP3 air permit that require clarification. Although the previous individual IP2 and IP3 air permits included generators and diesel fire pumps, the new combined permit regulates emissions from gas turbines and boilers. It does not include the generators and fire pumps, which are exempt from NYSDEC permitting. However, generators and fire pumps are subject to the US EPA's Reciprocating Internal Combustion Engine ("RICE") Rule requirements, as set forth in 40 C.F.R. Part 63, Subpart ZZ:ZZ. Therefore, their run times are tracked and recorded to ensure that they do not exceed the limits set for emergency reciprocating internal combustion engines.

Response: The comment recommends that Sections 5.1.1 and 5.1.3 of this supplement be revised to clarify that diesel generators and fire pumps are exempt from the IP2 and IP3 air permit issued by the New York State Department of Environmental Conservation (NYSDEC). The NRC staff agrees with the comments and has revised Sections 5.1.1 and 5.1.3 of this supplement to clarify that IP2 and IP3 have internal combustion engines that provide emergency

power, and these are exempt sources, as stated in the December 2014 IP2 and IP3 combined air permit (Air State Facility Permit No. 3-5522-00011/00026) issued by NYSDEC.

Comment 5-L17-3 (due to the length of the comment, the NRC staff has reproduced relevant quotations from the comment to convey its intended meaning):

These comments address the Nuclear Regulatory Commission ("NRC") Staff's consideration of the air-quality and climate-change impacts associated with the proposed action to issue renewed operating licenses to Entergy Nuclear Operations, Inc. ("Entergy") for Indian Point Units 2 and 3 ("IP2" and "IP3"). The relevant NRC Staff discussion of these issues is contained in Sections 5.1, 5.13, and 5.14.1 of the Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 38, Volume 5, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3 ("Draft Supplement"). In the Draft Supplement, the NRC Staff found that the incremental impacts of IP2's and IP3's continued operation on air quality during the proposed 20-year license renewal term (*i.e.*, the period of extended operation), would be "SMALL," and that the cumulative impacts would range from "SMALL to MODERATE," depending on the extent to which future climate change influences other air quality issues that benefit from Indian Point's continued operations. It also found that the incremental impacts of IP2's and IP3's continued operation on climate change during the period of extended operation "would be SMALL," and that the cumulative impacts "would be MODERATE."

The NRC Staff's findings should be viewed in the context of the potential impacts to air quality and climate change should the operating licenses not be renewed. In its December 2010 final supplemental environmental impact statement for IP2 and IP3 license renewal ("FSEIS"), the NRC Staff acknowledged that "[p]lant shutdown will result in a net loss of power generating capacity," which "would likely be replaced by (1) power supplied by other producers (either existing or new units) using generating technologies that may differ from that employed at IP2 and IP3, (2) demand-side management and energy conservation, or (3) some combination of these options." The FSEIS therefore considered potential air-quality impacts from a new gas-fired combined cycle generating facility located either at the Indian Point site or at a different site, perhaps as part of an existing-facility repowering. The NRC Staff found that the air-quality impacts of a new or repowered unit would range from "SMALL to MODERATE," conclusions that Table 9-1 ("Summary of Environmental Significance of License Renewal and Alternatives" Draft Supplement repeats without further comment.

The finding that a new or repowered unit would result in "SMALL to MODERATE" impacts must be reconciled with the portion of Table 9-1 that addresses air-quality impacts of the "no action" alternative-the denial of operating licenses without a new or repowered unit coming online to replace IP2 and IP3's generation. In such a situation, existing electric generation units-which consist largely of relatively older fossil-fuel units, including some coal units-will necessarily increase their generation to replace IP2 and IP3's lost generation. Yet, in revised Table 9-1 of the Draft Supplement, the NRC Staff repeats its conclusion in the 2010 FSEIS that a decision not to renew the licenses for IP2 and IP3 would have only "SMALL" air quality impacts-no greater than those expected from the proposed license-renewal action" because emissions related to plant operation and worker transportation will decrease." No analysis is performed of increased emissions from replacement generation facilities; instead, in footnote (b) to revised Table 9-1, the Draft Supplement merely indicates that the "no action" alternative does not meet the need for increased electric generation that will result if the Indian Point units are retired, and therefore does not analyze the air-quality impacts of such increased generation. It further states that "[n]o action would necessitate other generation or conservation actions which may include-but are not limited to-the alternatives addressed in this table," but Table 9-1 leaves the impression that this would not change the "SMALL" finding.

As detailed below and consistent with the requirements of the National Environmental Policy Act ("NEPA") and 10 C.F.R. Part 51, Entergy respectfully submits that the NRC Staff should include in the Draft Supplement additional substantive discussion of the potential air quality and climate-change impacts that would result from *not* renewing the IP2 and IP3 operating licenses in the "no action" alternative, and revise the findings of Table 9–1 for that scenario to reflect a "MODERATE" or greater impact. To assist the NRC Staff in that assessment, Entergy summarizes below the substantial evidence concerning the air quality impacts of a "no action" scenario that recently has been developed in the pending adjudicatory proceedings before the New York State Department of Environmental Conservation ("NYSDEC") concerning the CWA water quality certification and state pollution discharge elimination system ("SPDES") permit for IP2 and IP3. That evidence substantiates the expected magnitude of air-pollutant and greenhouse gas emissions that would result if IP2 and IP3 cease generating electricity due to the lack of renewed operating licenses, and their generation is replaced by a mix of resources, including increased generation by fossil-fueled units. As this evidence shows, the potential air quality and climate change impacts of the "no action" alternative properly should be considered MODERATE or greater."

"II. NEPA Requires That the NRC Compare the Environmental Impacts of License Renewal, Including Impacts Related to Air Quality and Climate Change, With Those of the No-Action Alternative"

"III. Denying Renewal Licenses to IP2 and IP3 Would Result in Large Increases in Emissions of Criteria Air Pollutants and Greenhouse Gas Emissions ("GHGs")"

"A. Increases in Criteria Air Pollutants and the Adverse Environmental and Human-Health Consequences of Such Increases"

"B. Indian Point Units 2 and 3 Are *De Minimis* Contributors to GHG Emissions and Potentially-Related Climate Change"

"C. Increases in Carbon Dioxide Emissions Likely Resulting From the Cessation of IP2 and IP3 Operations and their Implications for Climate Change"

"In conclusion, there is every reason to believe that serious environmental and human-health consequences will result from not renewing the IP2 and IP3 operating licenses, due to increases in both criteria air pollutants and GHGs from fossil-fuel based replacement sources of power. Expert testimony and evidence already submitted in the pending adjudicatory proceedings before NYSDEC demonstrates that to be the case. Accordingly, Entergy requests that the NRC Staff fully consider and evaluate those impacts in the final version of its Draft Supplement to the 2010 FSEIS."

Response: *This comment recommends that the NRC staff re-evaluate the air quality impacts of the No-Action Alternative (i.e., NRC decision to not renew the IP2 and IP3 operating licenses) in the context of increased criteria pollutants and GHG emissions and climate change impacts from replacement power alternative technologies, provide an evaluation of the environmental consequences of replacement baseload power generation, and recommends that the air quality impacts from the No-Action Alternative be MODERATE or greater. The commenter provides an analysis for NRC's consideration concerning the air quality consequences associated with the cessation of IP2 and IP3 operations.*

The NRC disagrees that the No-Action Alternative should be re-evaluated in the context of increased emissions from replacement power alternative technologies. Section 8.2, No-Action Alternative, of the 2010 FSEIS clarifies that neither the 2002 NUREG–0586, Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities, nor its supplement, considered the impacts from the decision to permanently cease operations; therefore, the

2010 FSEIS considers the immediate impacts that would occur between plant shutdown and the beginning of decommissioning. Furthermore, Section 8.2 of the 2010 FSEIS explains that:

- (1) an IP2 and IP3 shutdown will result in a net loss of power generating capacity that would likely be replaced by different generating technologies or other options,
- (2) Section 8.3 of the 2010 FSEIS discusses the environmental impacts from replacement power alternatives, and
- (3) that, while the alternatives to license renewal also constitute potential consequences of the No-Action Alternative, the “[i]mpacts from these options will [be] addressed in their respective portions” of Section 8.3 of the 2010 FSEIS.

The NRC staff’s analysis of air quality impacts from the No-Action Alternative considers the impacts in the context of the activities and actions necessary to cease operation of IP2 and IP3. Further, the No-Action Alternative does acknowledge that plant shutdown will result in a loss of power generating capacity, and the 2010 FSEIS considers the environmental consequences of replacement baseload power generation. Air quality impacts from replacement power alternative energy sources (NGCC generation, purchased electrical power) and energy conservation and efficiency are considered, assessed, and disclosed in Section 8.3 of the 2010 FSEIS.

No changes were made to the supplement as a result of this comment.

B.1.2 Alternatives to License Renewal

Comment 3-L20-6:

E. The [Draft FSEIS Supplement] Does Not Address New and Significant Information Regarding the Benefits of the No-Action Alternative

A robust alternatives’ analysis is the linchpin of any federal agency’s permitting review. The comparative evaluation of alternatives to the proposed action “is the heart of the environmental impact statement” because it “sharply defin[es] the issues and provid[es] a clear basis for choice among options by the decisionmaker and the public.” 40 C.F.R. §1502.14. Therefore, agencies must “[r]igorously explore and objectively evaluate all reasonable alternatives[.]” Id. §1502.14(a). The assessment of the environmental impacts is the “scientific and analytic basis for the comparison[.]” of alternatives. 40 C.F.R. §1502.16. *Defenders of Wildlife v. North Carolina Department of Transportation*. 44 ELR 20181. No. 13-2215, (4th Cir. 08/06/2014).

Riverkeeper has consistently called upon the NRC to fully assess alternatives including examining alternate sources of energy to replace IPEC’s power generation.

Recent developments, not evaluated in the [draft FSEIS supplement], demonstrate that closing IPEC is a viable option that would avoid or mitigate potential impacts because New Yorkers’ energy needs can be met today, with full reliability, without IPEC, even in peak demand Summer months. These developments include:

- Recent increases in downstate NY area generating capacity [1,047 mW];
- Recent transmission improvements in the power grid to allow downstate NY access to more capacity from outside the downstate NY area [400 mW];
- Increases in energy efficiency made by Con Edison under order of the Public Service Commission [109–142 mW];

- Reductions in downstate peak demand forecasted for 2016 thanks to better-than-expected results on distributed renewable energy, increased energy efficiency, and general shifts in peak consumption patterns [549 mW] and;
- Reduction in demand for centralized power sources like IPEC due to increases in distributed renewable energy

As discussed below, these four critical electricity resource factors total between 2,105 and 2,138 mW (greater than Indian Point's capacity of 2,040 mW), allowing for overall sufficient "resource adequacy" for the region to maintain energy reliability if Indian Point is taken permanently offline.

1. Recent increases in downstate NY generating capacity

Recently restored supply includes the restoration of the Danskammer power plant [493 mW], which was shut down after Hurricane Sandy, the restoration of capacity that had been damaged at the Bowline power plant [net increase of 377 mW], (Danskammer and Bowline are both located in the Hudson Valley), and the reactivation of the Astoria No. 2 power plant in Queens [177 mW]. *Total recent increases in generating capacity-1,047 mW.*

2. Recent transmission improvements in the grid allowing access to more energy outside the metro area

Transmission improvements allow more power to flow from upstate to downstate, allowing for less energy from Indian Point. Con Edison and other transmission owners in New York State are in the process of completing – by June 2016 – major reinforcements and additions to part of the high-voltage power grid in and around the region stretching from central New York down to the Ramapo-Rock Tavern area in Orange and Rockland counties. Also, Con Edison has completed improvements to transmission facilities on Staten Island that allow for more power flow to the other boroughs from Staten Island. Together, these improvements were made under an Order by the New York Public Service Commission (PSC) to consider reliability impacts of Indian Point Energy Center retirement. The key Order associated with these improvements was made in November of 2013 and is available on the PSC website:

<http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={5AFE13E9-181F-40CF-A91C-5AEC0E066AC9}>

The total increased capacity due to grid improvements is roughly 400 mW.

Therefore, if IPEC closed this Spring, economically-competitive replacement energy would come through the regional power grid, as enhanced above, and from the varied mix of resources that currently supply the wholesale energy requirements in the New York, Pennsylvania-New Jersey-Maryland (PJM) and New England competitive electricity markets. That includes energy from the newer, cleanest combined-cycle gas-fired resources in the region. By the early to mid-2020s, the vast majority, if not all of the energy sources replacing Indian Point will be solar photovoltaic resources, wind energy, hydropower and lower demand due to energy efficiency and demand management.

3. Recent energy efficiency improvements

Targeted energy efficiency improvements are upgrades made at many buildings throughout the Con Edison service territory that reduce the amount of electricity they use. This includes more efficient lighting, air conditioning, and refrigeration equipment. As part of the NY PSC order noted above on transmission, ConEd was required to develop additional energy efficiency plans to obtain 125 megawatts (MW) of power savings. They are on track to complete this request by

June 2016, as indicated in this recently filed status report, "Third Quarter 2015 Demand Management Status Report"

<http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={1E3E3728-7E41-4F88-A82C-2CBB2EE47048}>.

Significantly, Con Ed's most recent projected savings through these improvements are between 109 and 142 mW.

4. Reduction in downstate peak energy demand forecasts for Summer 2016

The New York Independent System Operator (NYISO), a no-profit organization formed in 1997 to manage New York's bulk energy grid and oversee the state's wholesale electricity markets, is New York's source for electricity supply and demand information, such as the annual NYS "Comprehensive Reliability Plan."

NYISO's 2014 Comprehensive Reliability Plan concluded that 500 MW of "compensatory MW" would be needed in downstate New York ("SENY", or southeast New York) if Indian Point were to be shut down by the summer of 2016, to meet summer peak needs.

However, NYISO 's most recent forecast, issued in December 2015, shows a 549 MW drop in peak demand forecasted for Southeast New York in summer 2016 -- that drop is from 22,337 mW to 21,788 mW -- compared to the earlier demand forecast on which the 2014 Comprehensive Reliability Plan was based.

Importantly, the 2014 prediction of additional need should IPEC close was based on the then-available peak demand forecast for 2016 for the key downstate New York region, which are NYISO zones G through J (essentially, lower Hudson Valley through and including New York City), and Long Island (zone K). That forecast came from the NYISO document known as the 2014 "Load and Capacity" report, commonly known as the NYISO "Gold Book."

The 2014 Gold Book shows on page 14, in "Table I-2b-2: Baseline Forecast of Non-Coincident Peak Demand – G to J Locality" a forecast peak demand in the summer of 2016 of 16,749 MW for downstate zones G to J (lower Hudson Valley to New York City); and at the top of page 13, a summer 2016 peak load forecast for Long Island (zone K) of 5,588 MW. *In total, the 2014 forecast of peak downstate demand in the summer 2016 was 22,337 mW.*

The 2014 Gold Book forecast of peak Summer 2016 demand *has been superseded* by a December 2015 forecast of peak demand in summer 2016, amounting to 21,788 *for these regions, or 549 MW less than the earlier forecast.* The newest draft load forecast for 2016, which will become a formal forecast in the 2016 Gold Book, to be released by the NYISO in April 2016 forecasts a total of 21,788, for zones G-J (16,310 MW) and zone K, Long Island (5,478 MW).

5. Reduction in demand for centralized power sources like IPEC due to increases in distributed renewable energy

Localized renewable power sources, in particular solar PV installed in downstate New York, are an alternate means of meeting demand for consumption of energy at residences and commercial buildings. This alternative supply allows reduction in demand for centralized power sources transmitted to homes over the wires of the state's power grid. These localized renewable power sources are one of the reasons that the latest forecast of peak summer demand in 2016 is 549 mW less than what was forecast back in 2014. Another reason is the significant increase, beyond 2014 projections, in installed energy efficiency resources (e.g., more efficient lighting (such as LED), air conditioning equipment, motors, and refrigeration), that has been achieved throughout the downstate region.

[A graph provided by the commenter] shows NYISO's current forecast as to how energy efficiency and distributed power generation will reduce grid-based electricity demand in New York by 8%, over the next ten years, essentially allowing New York to grow without adding capacity demands to our power grid.

Comment 5-L22-5:

III. Entergy's Corrections to Comments Concerning the No-Action Alternative and Other Potential Sources of Baseload Power Generation Capability

In its March 4, 2016 Comments, Riverkeeper contends that the Draft Supplement does not address new and significant information regarding the benefits of the no-action alternative. Specifically, it asserts that "[r]ecent developments, not evaluated in the [Draft Supplement], demonstrate that closing IPEC is a viable option that would avoid or mitigate potential impacts because New Yorkers' energy needs can be met today, with full reliability, without IPEC, even in peak demand Summer months." More specifically, Riverkeeper cites the following "[r]ecent developments" as supporting its position that Indian Point is not needed for the New York State electric system to operate reliably:

1. Increases in downstate generation totaling 1047 MW, including the return of the Danskammer, Astoria, and Bowline power plants;
2. Increases in downstate transmission capability totaling 400 MW, represented by the so-called "Transmission Owner Transmission Solutions" ("TOTS") projects mandated by order of the New York State Public Service Commission ("NYSPSC");
3. Increases in energy efficiency achieved through Consolidated Edison's so-called "DR/EE/CHP" program; and
4. Reductions in forecasted load (*i.e.*, demand for electricity), including reductions that are due to increases in distributed renewable energy (e.g., residential solar panels).

The evidence Riverkeeper cites does not support its conclusion. To the contrary, New York State regulators have looked at the very same evidence and concluded that Indian Point remains necessary to the New York electric system. In particular, the New York Independent System Operator ("NYISO"), the regulatory body responsible for ensuring the present and future reliability of the New York electric system, recently studied the reliability implications of Indian Point's hypothetical retirement in its 2014 Comprehensive Reliability Plan ("CRP"). NYISO found that, "[i]f the Indian Point Plant becomes unavailable in 2016, even with the additional resources modeled in the 2014 CRP, reliability violations would still occur immediately in 2016...requiring approximately 500 MW in compensatory MW in SENY [southeast New York, comprising the Lower Hudson Valley, New York City and Long Island] to satisfy resource adequacy criteria."

In pointing to potential resources to bridge the 500 MW gap for 2016, Riverkeeper does not acknowledge NYISO already took into account most [of] the very same "[r]ecent developments" that Riverkeeper points to, yet still found a resource gap. NYISO's 2014 CRP reliability study already assumed, for example, that the Danskammer, Bowline and Astoria plants would return to service by the summer of 2016. NYISO likewise factored in for 2016 the transmission improvements represented by the TOTS projects, as well as full achievement of the energy efficiency goals established as part of the DR/EE/CHP program. Even with those additional resources, however, NYISO's study still concludes that Indian Point's unavailability in 2016 would cause "immediate[]" violations of system-reliability criteria. Riverkeeper therefore cannot rely on these "[r]ecent developments" to establish that the electric system no longer needs Indian Point's generating capacity; NYISO's analysis demonstrates that to be untrue.

Riverkeeper's focus on 2016 is also entirely myopic, as NYISO projects that reliability violations in the absence of Indian Point would increase in severity over time. The 2014 CRP predicts an increasing loss of load expectation ("LOLE"), indicative of a worsening resource adequacy and system reliability picture over time, through the year 2024 for both for southeastern New York ("SENY," represented by zones G-K) and on a statewide basis, as shown in Table 6 of the CRP below, where a result over 0.10 equals a violation of mandated system reliability criteria.

The 2014 CRP's modeling analysis likewise predicts that capacity margins, *i.e.*, the number of MW of generation that can be removed from service without a LOLE violation, in SENY and statewide will decrease every year until 2024, as reflected in Table 5 of the CRP below. "Zonal capacity at risk" represents the amount of capacity that is needed in order to avoid a violation of NYISO's reliability criteria. Put differently, the -1500 MW figure reported in SENY for the year 2016 means that NYISO expects there to be a 1500 MW surplus of excess capacity beyond what is needed to assure system reliability in that year. Removing Indian Point's approximately 2,000 MW of capacity in SENY, however, turns that 1,500 MW surplus into the 500 MW shortfall in 2016 that the CRP reported. In 2020, when the expected surplus in SENY is projected to be only 800 MW, removing Indian Point produces a shortfall in SENY of 1,200 MW. By the year 2024, the expected surplus in SENY would be only 10 MW, it would be necessary to bring in 1,990 MW of replacement capacity to keep the electric system functioning reliably in the absence of Indian Point.

Riverkeeper's reliance on reduced load forecasts to protect electric system reliability in the absence of Indian Point is equally inconsistent with the available evidence. The best evidence, including testimony provided by members of the New York State Department of Public Service ("NYS DPS") Staff in the NYSDEC SPDES/WQC proceeding, refutes Riverkeeper's reliance on reduced load forecasts. While the 2015 NYISO "Gold Book" forecast that Riverkeeper cites may ameliorate the future outlook somewhat, it contains no finding that the New York electric system will satisfy electric system reliability criteria in Indian Point's absence over any time horizon. In fact, the 2015 Gold Book predicts that peak loads in SENY and statewide will continue to increase, even if by less than NYISO previously anticipated. Moreover, Riverkeeper does not acknowledge the possibility that projected load forecasts may increase in the future, as has happened previously.

Recent testimony in the NYSDEC proceeding from NYSDPS Staff witnesses who have extensive experience in electric-system reliability matters confirms that, despite the reduced load forecast in the 2015 Gold Book, one still can expect "a worsening reliability picture over time." As a NYSDPS Staff witness explained, "as you march through time, load is growing," meaning that less capacity can be lost in future years without violating system-reliability criteria. That witness further testified that, "[c]apacity coming on the system is necessary" in order "to address the reliability issues" that would be created by Indian Point's retirement.

Riverkeeper's comments also incorrectly assume a perfectly linear relationship between forecasted load reductions and the need for compensatory MW—in other words, that a 500 MW reduction in projected peak load allows a 50 MW reduction in generation capacity while maintaining electric system reliability. The NYSDPS Staff witness explained in the NYSDEC proceeding that the relationship between load and generation needs is "not necessarily linear, [or] one for one." He further testified that, while the reductions in the load forecast likely have reduced the need for compensatory MW if Indian Point were to retire, the amount of compensatory MW needed still "would probably be something above zero."

Riverkeeper's Comments completely fail to address other, important aspects of electric-system reliability that might be adversely affected in the event that Indian Point retires. These include voltage support and transmission security. The undisputed evidence in the NYSDEC

proceeding demonstrates that Indian Point supplies voltage support at a critical location within the New York State electric system, in "very close" proximity to the transmission interface between upstate and southeast New York. That voltage support helps other generating units operate "in a coherent manner" and reduces the risk of problems that could lead to system failures or even blackouts. Importantly, voltage support is location-dependent, meaning that voltage support currently provided by Indian Point cannot be entirely replaced by generation units in different locations. With respect to the related issue of transmission security, NYISO's most recent study found that "[s]ignificant violations of transmission security...criteria would occur in 2016 if the Indian Point Plant were to be retired as of that time."

Finally, Riverkeeper's Comments fail to address the adverse air quality and climate change impacts that Indian Point's retirement would cause, as its generation is replaced by generation from other, largely fossil-fuel powered units including those identified by Riverkeeper in its Comments. As Entergy explained in its own Comments, these adverse impacts would likely include large, ongoing increases in greenhouse gas emissions, as well as significant, ongoing increases in the emissions of criteria air pollutants such as NO_x and SO_x, with concomitant, persistent adverse consequences for the human health and mortality of those affected.

Response: *These comments address the need for the power generated by IP2 and IP3. The need for power is considered to be outside the scope of license renewal, and the FSEIS supplement need not address it (see 10 CFR 51.95(c)(2)). The purpose and need for the proposed action (issuance of a renewed license) is to provide an option that allows for power generation capability beyond the term of a current nuclear power plant operating license to meet future system generating needs. Such needs may be determined by State, utility, and where authorized, Federal (other than NRC) decisionmakers. This definition of purpose and need reflects the NRC's recognition that, unless there are findings in the safety review required by the Atomic Energy Act or findings in the NEPA environmental analysis that would cause the NRC to reject a license renewal application, the NRC does not have a role in energy-planning decisions or deciding whether a particular nuclear power plant is needed to meet system generating needs. The 2010 FSEIS provides the NRC staff's evaluation of the environmental impacts from a range of reasonable replacement power alternatives.*

No changes were made to the supplement as a result of these comments.

B.1.3 Climate Change

Comment 17-L14-2: CLIMATE CHANGE

SEIS 5.13. Greenhouse Gas Emissions and Climate Change, correctly concludes that, "the effects from climate change could have negative implications for industrial cooling and potable water use." (SEIS p.104) Yet it does not provide any mitigation measures to address these significant issues.

The SEIS fails to consider the impact of increased levels of the Hudson River during larger storm systems associated with climate change and rising sea levels. Super Storm Sandy was approximately only a foot away from breaching the banks of the Hudson and flooding Indian Point, which would result enormous releases of radiation into the Hudson and Hudson Valley air.

Comment 17-L14-6: Nor does the SEIS consider climate change impacts which, over the next 20 years, storms will increase in size and intensity, which will result in increased storms surges, flooding and will raise Hudson River water levels.

During Super Storm Sandy, the Hudson River rose swiftly and nearly breached Indian Point's storm surge barrier. Yet, this important matter has not been addressed in the SEIS.

Response: *These comments express concern that the FSEIS supplement did not appropriately consider the potential impacts from and mitigation of climate change on surface water use; specifically, impacts from postulated increases in storm intensities, including the effects from storm surge associated with the October 2012 extratropical storm known as “Superstorm Sandy.”*

The NRC staff agrees in part and disagrees in part with the comments. The NRC staff agrees that consideration of climate change impacts is warranted. Accordingly, the NRC staff considered the environmental impacts to water resources that could occur from climate change in Section 5.13.2.2 of this supplement. Section 5.14.3 of this supplement further discusses the potential climate change impacts to surface water resources within the context of the NRC’s cumulative impacts analysis for the license renewal of IP2 and IP3.

The NRC staff disagrees that this supplement should have more explicitly addressed climate change mitigation with respect to cooling water sources for IP2 and IP3 or industrial cooling and water use. In Section 5.14.3 of this supplement, the NRC staff concludes that the incremental impacts on water use and quality from the continued operation of IP2 and IP3 during the license renewal term will continue to be SMALL, while other actions and trends, including climate change, could result in SMALL to MODERATE impacts on water resources. In general, the NRC does not consider mitigation measures for climate change and associated impacts on environmental resources, which are global in scope and beyond the NRC’s control and influence. The NRC considers the potential impacts on plant safety caused by external hazards, such as potential breaches of Indian Point’s storm surge barrier, as part of its ongoing assessment of plant safety through the Reactor Oversight Process; the Reactor Oversight Process applies to both initial licenses and any renewed licenses. Furthermore, as related to the proposed action, the NRC cannot impose mitigation measures or standards on its nuclear power plant licensees that are not within the scope of license renewal, as defined in 10 CFR Part 54. Nonetheless, Section 5.14.3 of this supplement does state that, while the effects from climate change could have negative implications for industrial cooling and potable water uses, entities could take action by providing additional water treatment to address any climate-related degradation in water quality, enacting operational changes at affected facilities, and providing for additional infrastructure investment to cope with climate change effects.

The NRC staff disagrees with the comments that the staff did not address the hydrologic considerations associated with climate change. As part of describing the water resources and associated hydrologic conditions that could be affected by climate change, Section 5.14.3 of this supplement discusses the potential for increases in storm intensity, sea level rise, heavy precipitation events, and flooding in the Northeast region where IP2 and IP3 are located. Specific to IP2 and IP3, Section 5.14.3 states that the plant site has not experienced tidal flooding and that storm surge would have to exceed 15 ft (4.6 m) to challenge the critical elevation of IP2 and IP3 facilities. Section 5.14.3 also states that Entergy, as the licensee for IP2 and IP3, has taken additional actions to protect plant structures, systems, and components from flooding up to a height of 17 ft (5.2 m). These actions were taken to protect IP2 and IP3 against storms that could result in flooding levels in excess of those observed with Superstorm Sandy. Entergy’s protective actions and updated analysis of flooding hazards at the IP site are detailed in Entergy’s December 2013 flooding hazard re-evaluation for IP2 and IP3 (Entergy 2013), which was considered and is referenced in Section 5.14.3 of this supplement.

In addition, as documented in Revision 25 of the updated final safety analysis report for IP2 (Entergy 2014b), the highest water elevation recorded at the IP site during Superstorm Sandy was 9.7 ft (2.96 m). This observed water elevation resulting from storm inundation was lower than the critical water level elevation (15 ft (4.6m)) referenced above and cited in this supplement. Further, water levels were not in danger of breaching any storm surge barrier, as

implied by the comment. Therefore, the NRC staff does not consider the information in the comments to be new, or to call into question the information discussed in Section 5.14.3 of this supplement.

Finally, the NRC staff disagrees that it should have specifically addressed the safety impacts and implications from the storm surge associated with Superstorm Sandy. As stated above, the impacts of climate change on nuclear power plant operations and safety are addressed as part of the NRC's ongoing Reactor Oversight Process rather than during the license renewal environmental review process, which is the focus of this supplement. The NRC evaluates new information that could affect the safety of operating nuclear power plants, such as changes in the operating environment, on an ongoing basis to determine if any changes are needed at existing plants. This ongoing Reactor Oversight Process is separate and distinct from the license renewal process, which is focused on managing the effects of aging on systems, structures, and components during the period of extended operation.

No changes were made to the supplement as a result of these comments.

Comment 17-L14-3: SEIS Table 5–6 Comparison of GHG Emission Inventories, is inaccurate and incomplete and does not include the new carbon atoms, Carbon 14, produced by Indian Point every day from fission. Every day nuclear fission occurs, new carbon atoms, Carbon 14 atoms, are created and released as radioactive CO₂ and methane emission from IP2 and 3. Unlike fossil fuels which release sequestered carbon during energy production, fission actually creates new carbon atoms, which changes the Earth's carbon balance.

Thus the newly created carbon emissions from nuclear fission are not monitored, but only estimated since 2010, therefore Table 5–4 cannot be accepted by this Board as being factually accurate or complete. Without actual data and measurements the statement "that GHG emissions resulting from operations at IP2 and IP3 are below the EPA's reporting threshold of 25,000 MT (27,558 tons) of CO₂." is without factual basis.

Please refer to the EPRI 2010 Technical Report, Estimation of Carbon-14 in Nuclear Power Plant Gaseous Effluents which references a study which found that "people living 1 km from the site could potentially double their carbon body burden if all of the gaseous releases were as CO₂ (EPRI 2010 report 4-11).

Thus Indian Point's impacts on climate change have not been fully considered and the SEIS cannot be relied upon.

Response: *This comment expresses the concern that Table 5–4 of this supplement does not consider carbon-14 (C-14) releases from IP2 and IP3 and that the supplement does not provide a factual basis as to why IP2 and IP3 GHG emissions are below 25,000 metric tons (MT). The NRC staff disagrees with the comment's characterization of the findings from the 2010 EPRI report and its assertion that Table 5–4 is incomplete. The NRC staff believes Table 5–4 of this supplement is complete and correctly does not include C-14 releases from IP2 and IP3 for the reasons discussed below.*

In 2014, IP2 and IP3 released 21.5 curies of C-14 (Entergy 2015), which is equivalent to 4.8 grams (5.3x10⁻⁶ tons) a year. This quantity, when compared to the GHG inventory presented in Table 5–4, is insignificant and orders of magnitude lower than emissions presented in Table 5–4, and would not change the quantified emissions. Section 5.13.2.1 of this supplement states that GHG emissions resulting from operations at IP2 and IP3 are below EPA's reporting threshold of 25,000 MT. Table 5–4 contains the GHG sources and estimated emissions; these emissions are from combustion-related sources at IP2 and IP3, worker vehicle emissions, and electrical equipment-related sources.

The comment quotes a statement made in a 2010 EPRI Technical Report, “Estimation of Carbon-14 in Nuclear Power Plant Gaseous Effluents” (EPRI 2010), regarding the potential carbon body burden to members of the public but fails to provide the context of the statement. The statement cited by the commenter pertains to a 1974 study discussed within the EPRI study that measured the chemical form of C-14 in the decay tank gas and containment air from three operating pressurized water reactors and which found that less than 5 percent of the releases were in a CO₂ or CO form: “Over 80% of the total gaseous ¹⁴C release was in the form of low molecular weight hydrocarbons (CH₄ and C₂H₆). The CO₂ and CO fraction was less than 5%. From the above data and concentration measurements, Kunz, et al., (1974) calculated a gaseous release of ~6 Ci/GWe-yr. They further commented that people living 1 km from the [nuclear plant] site could potentially double their ¹⁴C body burden if all of the gaseous releases were as CO₂. Since less than 5% of the releases were as CO₂ or CO, and the releases were not at ground level, the actual increase in the ¹⁴C body burden would be considerably less” (EPRI 2010). Therefore, as concluded in the EPRI study, the increase in the C-14 body burden is small (EPRI 2010).

No changes were made to the supplement as a result of this comment.

Comment 17-L14-5: Nor does the SEIS consider the climate change impacts ozone production released from Indian Point.

Response: *This comment expresses concern that the supplement does not consider climate change impacts from ozone generated as a result of operation of IP2 and IP3. The NRC staff disagrees with the comment. Table 5-4 of this supplement presents estimated GHG emissions as a single common unit, carbon dioxide equivalents, from operations at IP2 and IP3 for quantifiable and long-lived GHGs. As discussed in Section 5.13.2 of this supplement, long-lived GHGs (carbon dioxide, methane, nitrous oxide, water vapor, and fluorinated gases) are well mixed throughout the Earth’s atmosphere and their impact on climate change is long lasting as a result of their long atmospheric lifetimes (decades to centuries). Ozone is a GHG that is formed and destroyed by chemical reactions in the atmosphere and its atmospheric lifetime is on the order of hours to days. Thus, ozone is a very a short-lived GHG ([IPCC 2007b](#)). Ozone precursors (gases that influence the formation or destruction of ozone) include carbon monoxide, nitrogen oxides, and volatile organic compounds. The 2010 FSEIS explains that in accordance with the 1996 license renewal GEIS and Rule, production of ozone and oxides of nitrogen is insignificant and does not contribute measurably to ambient levels of these gases (see Section 4.2 of the 2010 FSEIS) and that, new and significant information about the Category 1 issue, “Air quality effects of transmission lines,” was not identified. Section 5.1.3 of this supplement explains that air emission sources at IP2 and IP3 are operated infrequently and are considered minor emission sources, since emissions (including ozone precursors such as carbon monoxide and nitrogen oxides) are below 100 tons per year. Therefore, ozone emissions as a result of continued operation of IP2 and IP3 are not significant. Accordingly, the NRC staff considers that this FSEIS supplement has addressed ozone production appropriately.*

No changes were made to the supplement as a result of this comment.

Comment 9-L16-5: The GHG Emissions and Climate Change section (5.13.2) is inadequate because, as in the case of environmental justice, the benefits of the facility are not listed. At a very minimum, Supplement 38 should include the fact that the Indian Point Energy Center prevents (versus fossil fuel plant replacements) carbon dioxide emissions of 8.5 million metric tons on an annual basis - or the equivalent of adding 1.6 million cars on the road. Although it represents a small percentage in the grand scheme of things, carbon dioxide emission reductions are important to the State of New York, to the United States and to many other nations. It is an acknowledged global problem that needs to be mitigated. IP2 and IP3 are part

of the solution to that problem. The general information is important but limiting impacts to extremely small on-site emissions is inadequate.

Response: *This comment recommends that Section 5.13.2 of this supplement be revised to discuss GHG emissions that would be avoided as a result of continued operation of IP2 and IP3. The NRC staff agrees with the comment and has included this discussion under Section 5.14.12, Global Climate Change.*

Comment 11-L21-4: In addition, Section 5.14.12 compares total expected greenhouse gas emissions with projected state, U.S. and global greenhouse gas emissions. EPA does not recommend comparing project-level greenhouse gas emissions to total emissions in this way, as the comparison is not meaningful for decision makers. Climate change is a global problem resulting from the emissions of many individual sources that generate a large cumulative impact. These environmental impacts are best considered by using emissions as a proxy when comparing the proposal, alternatives and potential mitigation. EPA would also recommend adaptation and mitigation plans for any water level rise issues, particularly the storage of nuclear waste in casks on site.

Response: *This comment recommends that the NRC staff not compare project level GHGs to total U.S. and global GHG emissions but rather compare the emissions from the proposed action, alternatives, and potential mitigation. The commenter also recommends that adaptation and mitigation plans for potential sea level rise be developed for onsite storage of spent nuclear fuel in dry casks.*

The NRC staff agrees in part and disagrees in part with the comment. The NRC staff agrees that additional context is warranted for the presentation of project-level GHG emissions. Table 5–6 of this supplement presents GHG emission inventories on a State and County level in addition to global and national emissions to provide context for GHG emissions for the proposed action (continued operation of IP2 and IP3). While Table 5–6 was not changed, the NRC staff revised Section 5.14.12 to include a frame of reference for the GHG emissions from the proposed action relative to state-level GHG emission reduction goals. The NRC staff also revised Section 5.14.12 to include a discussion of the net beneficial effect of the proposed action when compared to the alternative replacement power generation sources.

The NRC staff disagrees that this supplement should have considered and discussed climate change adaptation and mitigation plans for the onsite storage of spent nuclear fuel in dry casks. Climate change adaptation and mitigation plans are separately and independently considered outside the scope of the NRC’s license renewal environmental review, and the NRC did not specifically evaluate them in the development of this supplement. On an ongoing basis, the NRC’s oversight authority over NRC-licensed facilities is the mechanism that is used to address the impact of natural hazards on plant safety. Under current NRC regulations applicable to dry cask storage facilities, the NRC requires that the vendor or licensee include design parameters to ensure that the storage casks and spent fuel storage facilities are able to withstand severe weather conditions, such as hurricanes, tornadoes, and floods. NRC-licensed spent fuel storage facilities are designed to be robust. They are evaluated to ensure that performance of their safety systems, structures, and components is maintained upon the occurrence of natural phenomena hazards. In the event of impacts induced by climate change, such as sea level rise, which occurs gradually over long periods of time, NRC regulations (e.g., 10 CFR 72.172, “Corrective action”) require licensees to implement actions to identify and correct conditions adverse to safety. Such requirements apply and are subject to NRC enforcement, for initial as well as any renewed licenses, outside the scope of license renewal.

B.1.4 Cumulative Impacts

Comment 3-L20-4:

D. The [Draft FSEIS Supplement] Violates NEPA by Failing to Address the Environmental Impacts of the AIM Project

In violation of NEPA, the [draft FSEIS supplement] briefly mentions the AIM project but fails to provide any specific information about the project or discuss its potentially significant environmental impacts. As above, the amended 10 CFR Part 51 specifically requires examination of cumulative impacts at IPEC.

The AIM project proposes to re-site and expand the diameter of a natural gas pipeline by tunneling beneath the Hudson River and onto and across the IPEC site. The 2GEIS does not address the AIM and IPEC cumulative impacts to water quality and aquatic species impacts in the Hudson.

As above, New York State has launched a multi-agency investigation into potential impacts relating to placing the AIM pipeline on IPEC property. The state's February 29, 2016 letter identifies potentially synergistic impacts relating to the construction, operation and potential accidents involving the proposed pipeline. Specifically, the state advised:

The AIM Project's path will require horizontal directional drilling under the Hudson River and adjacent to Indian Point. While the applicant has committed to build the pipeline to a more stringent standard on the Indian Point grounds, including laying two concrete liners above the pipeline to prevent excavation damage, burying the pipeline deeper than required, and using a stronger grade of steel than is required even in high consequence areas, it is imperative to determine if this is enough in light of the recent significant tritium leak and other operational difficulties at the nuclear facility. An independent safety risk analysis will address the adequacy of those mitigation efforts. We will share the results with you immediately upon receiving them.

Until this independent safety risk analysis is completed, we ask the FERC stay and reconsider its prior determination to grant a certificate of public convenience and necessity to ensure that the health and safety of all New Yorkers is adequately protected. Specifically, FERC must reconsider whether the proximity to Indian Point and the construction methods required to install the Project would have an impact on the recent increasing leaks of tritium into ground water or otherwise increase the potential for serious operational problems at Indian Point.

Response: *This comment expresses concern that the NRC staff did not address the cumulative impacts of the Algonquin Incremental Market (AIM) Project with respect to water quality and aquatic species. The comment also expresses concern regarding the Federal Energy Regulatory Commission's (FERC's) prior determination to grant a certificate of public convenience and necessity to construct the AIM Project, and references the NYSDEC's 2016 request for reconsideration and stay of that determination.*

The NRC staff disagrees that it has not addressed cumulative impacts to water quality and aquatic species associated with the AIM Project and the continued operation of IP2 and IP3. As described in Section 5.14 of this supplement, the NRC staff updated its analysis of cumulative impacts to include the review of additional projects and actions identified subsequent to the issuance of the 2010 FSEIS. This review included the proposed AIM Project, as listed in Table 5-5. The potential cumulative impacts associated with the AIM Project and the other listed actions were collectively considered and discussed for each resource area commensurate with their anticipated contribution to cumulative impacts. Although each action or project was

considered and addressed collectively, not all actions or projects listed in the table were specifically mentioned under each resource area. As stated in Section 5.14.13 of this supplement, the NRC staff concluded that the potential cumulative impacts associated with these additional projects and actions would continue to be bounded by the 2010 FSEIS.

Regarding the proposed AIM project, the NRC staff, separate from the license renewal process, performed an independent confirmatory analysis of Entergy's site hazards analysis and confirmed that the proposed pipeline does not introduce significant additional risk to safety-related structures, systems, and components at IP2 and IP3 (NRC 2014e). Based upon these analyses and other factors (FERC 2016), FERC denied the NYSDEC's request for the reconsideration and stay of FERC's prior determination.

No changes were made to this supplement as a result of this comment.

B.1.5 Environmental Justice

Comment 9-L16-2: The Draft Report states that,

"The GEIS established 92 separate issues for the NRC staff to consider. Of these issues, the NRC staff determined that 69 are generic to all plants (Category 1), whereas 21 issues do not lend themselves to generic consideration (Category 2). Two other issues remained uncategorized: (1) environmental justice and (2) chronic effects of electromagnetic fields. These two issues must be evaluated on a site-specific basis. A list of all 92 issues can be found in Appendix B to 10 CFR Part 51."

We question why environmental justice is uncategorized. We have raised similar concerns in regards to NRC's GEIS in the past. The Draft Report gives no reasons for why environmental justice must be evaluated on a site-specific basis. Without guidance as a Category 1 GEIS issue, site specific environmental justice evaluations are usually given short shrift in EISs.

Comment 9-L16-4: Section 5.12, Minority and Low Income Populations is woefully inadequate in addressing environmental justice as it relates to IP2 and IP3. According to 2010 Census data, 53 percent of the U.S. population residing within a 50-miles radius of IP2 and IP3 (approximately 17,231,000 individuals) identified themselves as minority. With such a large minority population within this 50-mile radius of IP2 and IP3, environmental justice merits more scrutiny. AAEA has provided such information for more than a decade. The short version is that the major benefits of the plant should be included in the impact analysis. We do not understand the NRC's seeming reluctance to include these benefits in its environmental assessments. IP2 and IP3 prevent significant numbers of hospitalizations and deaths from asthma and other respiratory and pulmonary problems. Such benefits speak directly to the importance or renewing the operating license for the facility.

Supplement 38 should comprehensively examine these environmental justice benefits. The agency might even consider altering their conclusions about impacts to reflect these benefits. The SMALL impact designation is accurate in the context it is used, but does not address the LARGE benefits provided by a virtually emissions free electricity generating station. If the NRC insists on keeping the environmental justice issue as a site-specific category, then the NRC should provide the sort of zip code and Census Block information needed that the New York State Department of Environmental Conservation (DEC) provided for the 2000 Census but is having trouble with resources in producing Potential Environmental Justice Area information for the 2010 Census. In fact, AAEA has been producing, with extremely meager resources, the environmental justice record in the New York State water permit adjudications.

The NRC based most of its conclusion on the fact that:

"The Commission upheld the NRC staff's analysis, finding, in pertinent part, that the FSEIS appropriately considered the reasonably foreseeable impacts of license renewal to minority and low-income populations and that supplementation of the FSEIS was not required (NRC 2015c)."

This conclusion was reached based on the fact that an:

"...intervenor filed a contention challenging the adequacy of the NRC staff's analysis of the environmental impacts to minority and low-income populations in the 2010 FSEIS, largely focusing on the consequences of a radiological emergency requiring sheltering-in-place or an evacuation."

This narrow consideration missed the larger need as described above in addressing how IP2 and IP3 mitigate environmental injustice. The NRC needs to expand its impact analysis.

Comment 9-L16-6: This Supplement again does not adequately address the environmental justice benefits of IP2 and IP3 in 5.14.11 Environmental Justice. The cumulative environmental justice impacts are enormous in terms of mitigating negative air and health issues. Again, the Supplement should address these specific benefits.

Response: *These comments express concern about how the NRC staff categorizes and addresses the issue of environmental justice in the context of an environmental review and assert that the NRC staff did not appropriately consider the positive impacts on environmental justice from the continued operation of IP2 and IP3. The environmental justice issue was not evaluated in the 1996 GEIS because guidance for implementing Executive Order (EO) 12898 (59 FR 7629) was not yet available, and it was listed in Table B-1 of 10 CFR Part 51 as an uncategorized issue. As such, the finding in Table B-1 stated that "[t]he need for and the content of an analysis of environmental justice will be addressed in plant-specific reviews." The 2010 FSEIS (NRC 2010) addressed environmental justice as a plant-specific issue, along with other Category 2 license renewal NEPA issues. Subsequently, the 2013 final rule and revised license renewal GEIS (78 FR 37282) added "minority and low-income populations" as a Category 2 site-specific issue within the context of environmental justice.*

Section 4.4.6 of the 2010 FSEIS (NRC 2010) describes potential human health and environmental effects of license renewal on minority and low-income populations living near IP2 and IP3. The analysis uses the current human health and environmental effects of IP2 and IP3 as a "baseline" for assessing potential impacts to minority and low-income populations during the period of extended operation. Because current human health and environmental effects to minority and low-income populations are SMALL and because those effects are expected to remain unchanged during the period of extended operation, minority and low-income populations are not expected to experience disproportionately high and adverse impacts during the period of extended operation.

The NRC staff is guided in its consideration of environmental justice in plant-specific environmental reviews by Office of Nuclear Reactor Regulation (NRR), Office Instruction LIC-203, Appendix C, "Environmental Justice in NRR NEPA Documents" (NRC 2013d). The environmental justice review involves identifying minority and low-income populations in the vicinity of the plant that may be affected by license renewal, any concerns and potential environmental impacts that may affect these populations, including their geographic locations, the significance of such concerns and effects and whether they would be disproportionately high and adverse when compared to the general population, and if so, the mitigation measures available to reduce and/or eliminate these impacts. The NRC performs the environmental justice review to determine whether there would be disproportionately high and adverse human health and environmental effects on minority and low-income populations and reports the results

of this review in the SEIS. The potential benefits of IP2/IP3 operation, addressed in this comment, do not constitute “adverse” impacts and therefore are not addressed as an environmental justice issue in Section 5.4.11. However, Chapter 8 in the 2010 FSEIS discusses air quality impacts from alternative energy power generation, including environmental justice concerns.

No changes were made to this supplement as a result of these comments.

B.1.6 Groundwater Resources

Because of the length of comments 5-L17-5, 5-L22-8, and 17-L14-1, the NRC staff has reproduced relevant quotations from the comments to convey their intended meaning.

Comment 5-L17-5:

IV. Consistent With the Approach Used in the 2010 FSEIS, the NRC Staff Should Base Its Impact Assessment of Radionuclides in Groundwater at Indian Point on a Comparison to NRC Dose Limits, Not to EPA's MCL-Derived Concentration Limits

“Radiological releases, doses to members of the public, and the associated environmental impacts are summarized annually in two reports for IP2 and IP3: (1) the Annual Radioactive Effluent Release Report (“ARERR”) and (2) the Annual Radiological Environmental Operating Report (“AREOR”). The ARERR describes the quantities of liquid and gaseous radioactive materials released to the environment during the calendar year, and must be consistent with the objectives outlined in Appendix I, Section IV.8.1. It also assesses the dose impact of radiological effluent releases into the environment, as calculated using radiation monitoring data and NRC approved methods. The AREOR provides the means to verify the radiological concentrations in the environment resulting from plant operations, consistent with projections based on plant effluent releases, and essentially describes the results of the REMP for the previous year. It also serves to verify the calculated dose impacts from plant effluent releases.”

“In Entergy's view, the impact of radionuclide releases to groundwater at the Indian Point site should be evaluated within the context of the above-described regulatory framework. NRC regulations do not preclude releases to site groundwater, but instead require that licensees account for such releases, evaluate them relative to NRC regulatory requirements, and report the quantity of radioactivity released and the dose to the hypothetical maximally exposed member of the public. Thus, the NRC Staff's impact assessment in the Draft Supplement should focus on whether radionuclide releases to groundwater and associated doses exceed the permissible levels in NRC regulations.”

Response: *This comment states that the NRC staff's evaluation of the issue titled “Radionuclides Released to Groundwater” should be based on NRC regulations that evaluate the dose to workers and members of the public, rather than impacts on the environment. The NRC staff disagrees with this comment.*

The evaluation of dose to workers and the public is performed in the context of impacts on “Human Health” in NRC license renewal environmental impact statements. This is also where the dose to the public from groundwater releases was evaluated in the 2010 FSEIS (NRC 2010).

In contrast, the NRC staff's evaluation of the issue titled “Radionuclides Released to Groundwater” does not evaluate the dose to the public. Rather, it evaluates the impact on groundwater quality as a resource. By way of analogy, one may consider a scenario where birds are considered to be both a resource and a pathway (vehicle) for contamination to be transported from a facility to the public. In this scenario, the “Human Health” evaluation would contain a description of dose to the public from the bird pathway (i.e., birds). However, it would

not contain a description of the impact of the contamination on the bird population. In this scenario, the bird population is both a pathway and a resource. At the Indian Point site, the groundwater is also both a pathway and a resource. The issue titled "Radionuclides Released to Groundwater" is where the impact of radiological contamination on the groundwater as a resource is evaluated. The evaluation encompasses such resource attributes as the intrinsic quality of the resource and considers other site-specific characteristics, including current and potential future uses of the resource.

The 2010 FSEIS was prepared before the June 2013 final rule that amended Table B–1 in Appendix B to 10 CFR Part 51. The final rule added a new paragraph at 10 CFR 51.53(c)(3)(ii)(P) to address "Radionuclides Released to Groundwater" as a Category 2 issue. This new Category 2 issue was added to Table B–1 to "evaluate the potential combined impact of inadvertent discharges of radioactive liquids from all plant systems into groundwater" (78 FR 37282, page 37295). The NRC staff prepared this FSEIS supplement in accordance with the 2013 revision of 10 CFR Part 51.

The 2010 FSEIS was also prepared before the 2013 GEIS, which provides the technical basis for the June 2013 final rule (NRC 2013a). The 2013 GEIS identifies groundwater as a resource (NRC 2013a, pages S-1, S-10, and S-11). As described in the 2013 GEIS, the purpose of the new issue titled "Radionuclides Released to Groundwater" is to evaluate the potential contamination and degradation of groundwater resources resulting from the release of radioactive liquids into the groundwater from nuclear power plants. (NRC 2013a, pages S-10, S-11, 1-24, 4-51, 4-54, A-71, A-72, and A-405; 78 FR 37282, page 37031)

As previously illustrated, while 10 CFR Part 20 and 10 CFR Part 50 are used to evaluate the dose to workers and public via various pathways, they are not used to evaluate or characterize the impact on the pathway (i.e., groundwater and the degradation of groundwater quality). Further, "[w]hile the NRC's regulations in 10 CFR part 20 and in 10 CFR part 50 limit the amount of radioactive material released (i.e., from routine and inadvertent sources) from a nuclear power plant into the environment, the regulations are focused on protecting the public, not the quality of the groundwater. Therefore, as required by NEPA, the NRC must consider the potential impacts to the groundwater from radioactive liquids released into groundwater" (78 FR 37282).

Accordingly, the NRC staff's evaluation of this Category 2 issue is separate from its assessment of the potential impact on human health. This approach is consistent with the resource-based and focused approach to evaluating the environmental impacts of license renewal, as referenced in the 2013 final rule and revised GEIS.

No changes were made to the supplement as a result of this comment.

Comment 5-L17-5: "Second, instead of applying SDWA MCLs for drinking water to Indian Point site groundwater, the NRC Staff should adhere to the approach used in the 2010 FSEIS, and evaluate whether previous radionuclide releases and associated doses exceed the permissible levels specified in NRC regulations. The Draft Supplement deviates from this well-established practice. NRC regulations explicitly state that "[f]or the purposes of assessing radiological impacts, the Commission has concluded that those impacts that do not exceed permissible levels in the Commission's regulations are considered small," as the term is used in 10 C.F.R. Part 51. Application of the relevant dose limits in 10 C.F.R. Part 50, in lieu of SDWA MCLs for drinking water, to Indian Point site groundwater does not support a finding of "MODERATE" impacts. As discussed further below, it instead supports a finding of "SMALL" impacts with respect to releases of radionuclides from the IP1 and IP2 spent fuel pools to onsite groundwater."

“Significantly, the NRC Staff used this approach in its 2010 FSEIS, wherein it concluded that the radiological impacts to human health resulting from radioactive effluent releases (including releases to groundwater) at Indian Point are “SMALL.” In brief, in evaluating the radiological impacts of effluent releases to groundwater, the NRC Staff considered the results of Entergy’s groundwater investigations and groundwater monitoring program as well as data from the REMP and Annual Radioactive Effluent Release Reports. The Staff noted that “calculated doses to maximally exposed individuals in the vicinity of IP2 and IP3 were a small fraction of the limits specified in the IP2 and IP3 ODCM to meet the dose design objectives in Appendix I to 10 CFR Part 50, as well as the dose limits in 10 CFR Part 20 and EPA’s 40 CFR Part 190.” Consistent with the evaluation in FSEIS Section 2.2.7, the NRC Staff concluded that impacts to human health resulting from radionuclide releases to groundwater during the license renewal term are “SMALL.” That same conclusion-“SMALL”-should be reiterated in the Draft Supplement because the subsequent releases do not exceed NRC’s permissible dose limits, as explained below.”

Response: *This comment indicates that, for assessing radiological impacts on groundwater resources, those impacts that do not exceed permissible levels in the Commission’s regulations should be considered SMALL. The NRC staff disagrees with the commenter.*

As explained in the previous response, radiological impacts are evaluated under “Human Health” issues (Table B–1 in Appendix B to Subpart A of 10 CFR Part 51). To evaluate these issues, the NRC staff may rely on the Commission’s ongoing radiological safety program to protect the health of the worker and the public. The NRC staff may also rely on the Commission’s ongoing radiological safety program to address some of the issues under Waste Management in Table B–1. The radiological impacts criterion cited in the comment relative to the impact significance level of SMALL applies only to those license renewal issues in Table B–1 that have a nexus to human health.

The NRC and EPA have both established radiological dose criteria. The NRC’s dose criteria are set out in 10 CFR Part 20, while the EPA’s dose criteria are set out in 40 CFR Part 190. In its 40 CFR Part 141 regulations (National Primary Drinking Water Regulations), EPA has also established dose criteria that are specific to drinking water and can readily be related to water quality data.

The responsibility for setting air emission and drinking water standards for radioisotopes belongs to EPA, which has limits for drinking water, called MCLs, for four groupings of radionuclides. One of these groups is made up of 179 man-made beta and photon emitters. The radionuclides released into the groundwater at Indian Point belong to this group.

The MCLs address the health effects from radiation inside the body from the consumption of water that contains radionuclides. As explained in the text, the MCL for these radionuclides sets a standard that seeks to achieve a 4 millirem (mrem) per year dose limit. The MCL represents the sum of all radionuclides, so that taken together, the annual dose from all of the applicable radionuclides will not exceed 4 mrem per year (EPA 2002).

The NRC sets dose limits for radiation workers and members of the public. This is an all-pathways dose analysis, in which groundwater is only one of the pathways that are summed to derive a dose to workers or members of the public. The NRC has not established standards that are specific to drinking water quality; EPA’s drinking water standards address that subject.

To apply dose-based criteria to the many environmental issues in Table B–1 would rank all issues in the table as SMALL, even when NRC regulations relative to radiation protection do not apply to the issue. For example, impacts on land use, visual resources, air quality, noise, geology, historic and cultural resources, and many other issues listed in Table B–1 do not rely

on the Commission's radiation protection regulations and standards. To do so would create a situation where the NRC's impact-ranking system would not properly reflect the NRC's required NEPA analysis.

This is also true for three issues that contain "radionuclide" in their title: (1) Exposure of terrestrial organisms to radionuclides, (2) Exposure of aquatic organisms to radionuclides, and (3) Radionuclides released to groundwater. All three could be potential pathways of radionuclides to workers and the public, but the NEPA analysis for those impacts actually describes the impact of continued operations on each respective resource from radionuclides. Radiological doses to workers and members of the public (from all pathways) are considered separately (see Sections 2.2.7, 4.3 and 4.8.3 of the 2010 FSEIS).

To describe and rank impacts for those resources, the evaluations in the 2013 GEIS (NRC 2013a) for these three resource areas did not rely on the Commission's radiological safety program and associated regulations and dose limits. The NRC staff's evaluation of dose to terrestrial organisms and aquatic organisms (NRC 2013a, pages 4-61 to 4-64 and pages 105 and 107) reference a U.S. Department of Energy guideline for radiation dose rates from environmental sources that contains numerical recommendations to limit the radiation dose to aquatic biota, to riparian and terrestrial mammals, and to plants. For the issue of "Radionuclides Released to Groundwater," the 2013 GEIS does mention that "NRC regulations in 10 CFR Part 20 and in 10 CFR Part 50 limit the amount of radioactive material, from all sources at a nuclear power plant, released into the environment to levels that are as low as is reasonably achievable (ALARA)." Further, in the 2013 GEIS, the evaluations of the impacts on groundwater quality from radionuclides and the ranking of this issue rely on background water quality concentrations and on EPA maximum contaminant levels (MCLs) (NRC 2013b, pages 4-51 to 4-54).

No changes were made to the supplement as a result of this comment.

Comment 5-L17-5: "Furthermore, the groundwater of concern at Indian Point cannot be extracted in sufficient volumes, e.g., without the risk of salt water intrusion, to be considered a viable drinking water resource."

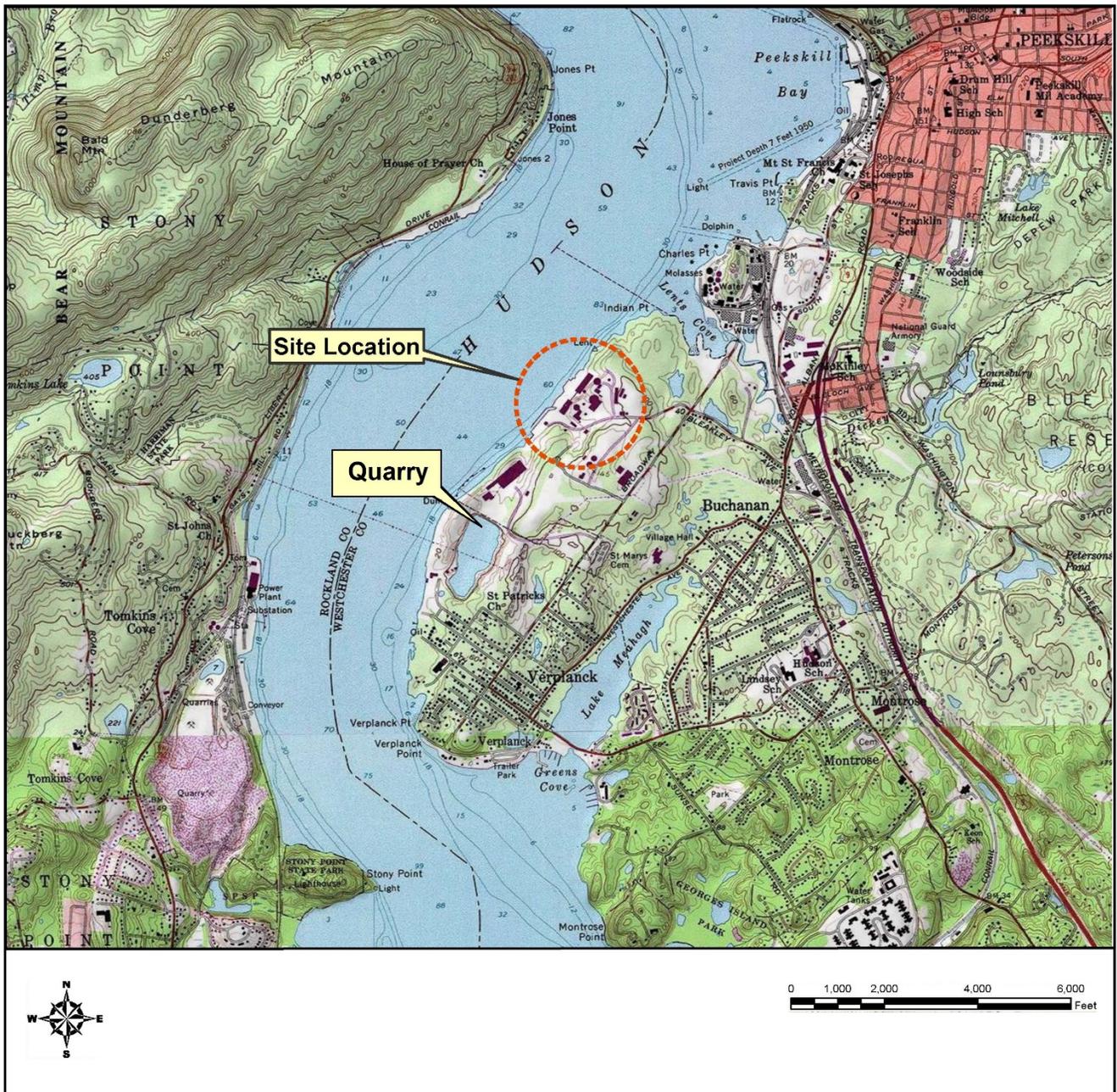
Response: The comment expresses the view that the Inwood Marble cannot yield sufficient volumes to be used as a source of water and that pumping water from the Inwood Marble beneath the site might cause brackish water to move inland from the Hudson River and into the Inwood Marble. The NRC staff generally disagrees with the comments.

Section 5.4.1 of this supplement states that the Inwood Marble contains fresh water, but it then becomes brackish in quality near the river. On site, the hydraulic properties of the Inwood Marble will not support large yields of water to wells. The low hydraulic conductivities and porosities of the fractures are insufficient to supply a public water system. However, wells drilled with conventional techniques might be able to produce enough water to supply an individual household (NRC 2015c, page 56). In its analysis, the NRC staff considered that, in fractured media, it is not uncommon for wells extracting groundwater at a low rate to be used to supply a household. Usually, in this situation, the well pumps water into a holding tank, from which it is later removed at the rate required for in-home uses.

The Inwood Marble beneath the site runs approximately north-south. Just south of the site, a former quarry (the Verplanck Quarry) was excavated into the Inwood Marble to supply marble rock for various local uses. The quarry is approximately 33 acres in size and is now filled with water (Figure B-1). The excavation is located along the southern boundary of the site and 350 ft from the Hudson River. The quarry is flooded to a depth of 176 ft (UMA 1974, page 17). Operations in the quarry ceased when a significant quantity of groundwater was encountered

within the Inwood Marble. The inflow of groundwater flooded the quarry in 1943 (Applebome 2009).

Figure B-1. Verplanck Quarry and Site Location



Modified from Entergy 2016d

In 1974, the Verplanck Quarry was evaluated as a proposed site for a striped bass fish hatchery (UMA 1974). Fresh water for the proposed fishery was obtained from the quarry. Water samples taken from the quarry in February 1974 showed the water to be fresh (UMA 1974 pages 15 and 16). A fish hatchery was built and successfully operated at the quarry starting sometime around 1983 (DeChillo 1986a, 1986b).

As would be expected in a carbonate aquifer, hardness levels were high enough in the quarry that, without treatment, it would not be desirable for many domestic uses, as it would leave a scaly deposit on the inside of pipes, boilers, and tanks. However, hard water can be softened at a fairly reasonable cost, such as via water softeners (USGS 2016b). Sulfate levels in the water were also high enough that it might affect the taste of the water. This might require some treatment for domestic use. However, treatment for this type of groundwater condition is commonly practiced by well owners and is readily available (MDH 2015).

Even though the quarry is located near the Hudson River, its water quality is fresh and has remained fresh for many years. Furthermore, the water has remained fresh even though water has been removed from the quarry by evaporation and has been used to supply a former fish hatchery. Therefore, for the purpose of evaluating environmental impacts, it is reasonable to assume that wells drilled with conventional techniques into the Inwood Marble might be able to produce enough water to supply potable water to an individual household. Wells using conventional drilling techniques would have a larger diameter and would be drilled to a greater depth than the current onsite monitoring wells. This would also give them the ability to extract a greater volume of water. Given the experience in the nearby quarry, it is not unreasonable to assume that sufficient potable water could be extracted on site for general household use. Furthermore, it is reasonable to assume the low rate of water production needed from a well would not necessarily cause brackish water to move into the well from the Hudson River via the Inwood Marble.

No changes were made to the supplement as a result of this comment.

Comment 5-L17-5: “First, the Draft Supplement fails to identify a correct or reasonable “important attribute” of the onsite groundwater impacted by the radionuclide releases in question, given that such groundwater is not being used for drinking water purposes. Indeed, the Draft Supplement confirms the groundwater beneath Indian Point is *not* used for potable purposes today and is highly unlikely to ever be used for that purpose. Therefore, applying MCLs issued under the federal SDWA for the purpose of assessing the radiological impacts of radionuclides released to site groundwater under the National Environmental Policy Act (“NEPA”) is inappropriate as a legal matter.”

“Finally, the SDWA MCL's are end of the tap values. Therefore, implicitly concluding that “drinkability” is an “important attribute” of the onsite groundwater by applying the SDWA MCLs to groundwater wells representing a fraction of on-site groundwater, as the NRC Staff does in the Draft Supplement, is inconsistent with both the relevant facts and law.”

“First, the SDWA does not apply to the groundwater beneath Indian Point. The primary and secondary drinking water regulations developed pursuant to the SDWA apply to “public water systems,” defined by statute to be “a system for the provision to the public of water for human consumption through pipes or other constructed conveyances, if such system has at least fifteen service connections or regularly serves at least twenty-five individuals.” The groundwater beneath Indian Point is not collected for drinking. Moreover, the groundwater at Indian Point does not communicate with any other groundwater-based drinking water source.”

“Additionally, the term “maximum contaminant level” is defined by statute to be “the maximum permissible level of a contaminant in water *which is delivered to* any user of a public water system.” In other words, the SDWA sets MCLs for water “at the tap,” rather than at the source. Accordingly, even if the water beneath Indian Point were (incorrectly) considered a source of drinking water, the MCLs for any contaminant would not apply to the concentration of that contaminant within groundwater as measured in groundwater wells, but to the delivered resource. The Draft Supplement contains no analysis converting concentrations at Indian Point to concentrations for a hypothetical consumer at the tap. Even if such a hypothetical analysis

had been conducted, assumptions about delivered concentrations, which depend on a variety of considerations including source water, dilution and treatment, would be speculative, and therefore are inconsistent with NEPA's requirement that only reasonably foreseeable impacts be considered."

"In this same vein, the Draft Supplement recounts the many facts that support the conclusion that the groundwater beneath Indian Point cannot be extracted in volumes sufficient to constitute a meaningful drinking water resource for a public water system. For example, it notes that "[t]he rock matrix of the Inwood Marble has very low porosity, and groundwater does not easily flow through it," and "although the fracture network forms the groundwater pathways through the rock, it does not hold a large volume of water." Further, "[o]n-site, the hydraulic properties of the Inwood Marble will not support large yields of water to wells. Although wells drilled with conventional techniques might be able to produce enough water to supply an individual household, the low hydraulic conductivities and porosities of the fractures are insufficient to supply a public water system." Finally, the Draft Supplement acknowledges that "[b]ecause municipal water is readily available in the area, it is unlikely that potable or irrigation wells will be installed near the site in the reasonably foreseeable future." Therefore, there is no reasonable basis to conclude that "drinkability" is now, or ever will be, an "important attribute" of the groundwater "resource" beneath Indian Point."

Response: *This comment objects to the use of MCLs to evaluate the impact of radionuclides on the groundwater at the IP2 and IP3 site. While the NRC staff agrees with many of the statements in the comment, the NRC staff disagrees with this commenter's view that MCLs are irrelevant in assessing groundwater impacts. Moreover, it should be noted that the FSEIS supplement does not take a position as to whether state or Federal agencies have the legal right to apply MCL criteria to the groundwater beneath the IP2 and IP3 site.*

As referenced earlier in response to portions of comment 5-L-17-5, the 2013 final rule (78 FR 37282) and the GEIS (NRC 2013a), which provides the technical basis for the final rule, added a new site-specific issue, "Radionuclides Released to Groundwater," to Table B-1 in Appendix B to the revised 10 CFR Part 51. In accordance with NEPA, the issue was added to evaluate the potential impacts of contamination and degradation of groundwater quality resulting from inadvertent discharges of radionuclides from nuclear power plants, with the magnitude of potential impacts dependent on site-specific variables. Therefore, the NRC staff has characterized the affected environment using water quality data and MCLs to evaluate site-specific groundwater resource impacts at the Indian Point site resulting from the inadvertent release of radionuclides, consistent with NEPA and the NRC's regulations in 10 CFR Part 51.

The MCLs under the Safe Drinking Water Act (SDWA) are standards that EPA has set for drinking water quality. An MCL is the legal threshold limit on the amount of a contaminant that is allowed in public water systems under the SDWA. The goal of MCLs is to identify the maximum level of a contaminant that prevents adverse health effects from that contaminant in water. As MCLs are based on concentrations in water, they can readily be used to evaluate the quality of water from measured concentrations.

Although EPA believes that Congress intended MCLs to apply to water at the tap, the Agency has discretion to require monitoring at other locations, as long as such monitoring is representative of levels at the tap (EPA 2016b). This saves having to monitor the many thousands of taps that may be in a public system. Many community water systems depend on groundwater as the source of their water. By protecting the groundwater quality, the water quality at the many taps in the public water supply are protected from groundwater contamination. Therefore, State and Federal programs may reference MCLs to protect the quality of groundwater that supplies public water systems.

State programs as well as local health departments may reference MCLs to evaluate the groundwater quality of private well owners. Also, when State and Federal programs do not legally apply to private wells, individual well owners may use MCLs to determine if the water from their well poses a hazard or needs treatment. State and Federal programs may use MCLs to characterize the quality of groundwater resources that are currently being used or might be used in the future. As MCLs are used across many local, State and Federal programs, their concept is easily understood by the public at large in the characterization of water quality information with respect to its beneficial use.

Before the construction of nuclear power plants at the Indian Point site, the groundwater quality at the site did not contain radionuclides from nuclear power generation. The FSEIS supplement describes the concentrations of radionuclides in groundwater beneath the Indian Point site and how they have changed over time. The FSEIS supplement also describes the concentration of radionuclides relative to relevant MCLs.

In addition to describing the concentrations of chemical constituents in groundwater, the impact on groundwater as a resource can be described with respect to its potential use. In this regard, the Inwood Marble, as also previously discussed, may be able to supply an adequate amount of potable water for a private well. The FSEIS supplement describes the concentration of radiological constituents in the groundwater at the Indian Point site, how they have changed over time, and how they are predicted to change over the period of license renewal. As a way of characterizing how the potential use of the groundwater has been impacted with respect to the current or potential future use of site groundwater resources, the FSEIS supplement also compares groundwater concentrations to MCLs.

Therefore, as was done to evaluate this issue in the 2013 GEIS, using water quality data and MCLs to characterize groundwater resource impacts is considered to be acceptable for a NEPA analysis.

No changes were made to the supplement as a result of this comment.

Comment 5-L17-5: “Further to this point, there is no evidence of any off-site groundwater impacts associated with the inadvertent release of radionuclides at Indian Point. The Draft Supplement properly notes that groundwater beneath Indian Point does not communicate with any other groundwater in the vicinity of the plant or across the Hudson River: “The direction of groundwater flow in the water table prevents contaminated groundwater from migrating off the site property to the north, east or south.” Therefore, groundwater in areas immediately adjacent to the plant has not been impacted by inadvertent releases of radionuclides into groundwater. Moreover, “[t]he size and depth of the Hudson River and the direction of groundwater flow under and on each side of the river mean that it is extremely unlikely that onsite groundwater in the Inwood Marble could flow under the Hudson River to the other side.” Consequently, there is no pathway by which onsite groundwater contamination can spread to any groundwater elsewhere. As a result, there are no impacts—not even “SMALL” impacts—to offsite groundwater. This conclusion should be given substantial weight in any analysis of groundwater impacts in “the environment.”

Response: *The comment suggests that the lack of offsite impacts to groundwater quality should result in a “no impact finding.” The NRC staff disagrees with this approach.*

Again, as referenced earlier in response to portions of comment 5-L-17-5, the NEPA environmental issue of concern here, “Radionuclides Released to Groundwater,” focuses on the attributes of groundwater as a resource. The NRC staff’s analysis considers sources of groundwater degradation as well as current and potential future uses of the resource. The definitions of the significance levels, which are in the footnotes to Table B–1 of 10 CFR Part 51,

Subpart A, Appendix B, define MODERATE as “environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.” Before the construction of nuclear power plants at the Indian Point site, the groundwater quality at the site did not contain radionuclides from such sources but now it does. However, offsite groundwater quality has not been affected by radionuclides from the generation of nuclear power. As a result, the groundwater quality of the onsite groundwater has been noticeably altered, but the groundwater quality in the surrounding aquifers has not been affected.

In the FSEIS supplement, the NRC staff evaluated impacts on offsite groundwater and surface water bodies. The NRC staff concluded that groundwater contamination will either remain on site or be discharged into the Hudson River. Therefore, offsite groundwater supplies should continue to be unaffected by ongoing operations. The NRC staff concluded that onsite impacts on groundwater are MODERATE, but with the elimination of radionuclide leaks to the groundwater and with the use of monitored natural attenuation, the impact on groundwater quality would move to SMALL. Therefore, the overall impacts to groundwater due to the IP2 and IP3 license renewal would be SMALL to MODERATE.

Section 5.14.4 of the supplement evaluates the impact on “regional” offsite groundwater resources under cumulative impacts. The NRC staff concluded that the impact on offsite groundwater resources is SMALL.

The FSEIS supplement has adequately characterized the impact on offsite and onsite groundwater. Leaks of tritium into the groundwater, while not continuous, have occurred near IP2 since 1990. Other radionuclides have also been detected, as discussed in the FSEIS and this supplement. The environmental effects on groundwater resources are sufficient to alter noticeably, but not to destabilize, important attributes of the resource. In summary, the staff decided that offsite and onsite groundwater is a continuous resource within the local aquifer (Inwood Marble). While one area of that resource has been noticeably altered for a long period of time, the groundwater resource has not been destabilized. The NRC staff therefore concludes that the onsite impacts to groundwater are SMALL to MODERATE.

No changes were made to the supplement as a result of this comment.

Comment 5-L17-5: “In conclusion, the Commission has concluded that impacts are of small significance if doses and releases do not exceed permissible levels in NRC regulations. Therefore, in accordance with the preceding discussion, the NRC Staff should revise Section 5.4.3 of the Draft Supplement to incorporate (1) the appropriate comparisons of calculated doses to NRC dose limits, and (2) the consequent conclusion that the current impact of past radionuclide releases on groundwater quality is “SMALL.”

Response: The comment states that the impacts on groundwater quality should be SMALL and that the NRC staff should base its impact determination on NRC dose limits. The NRC staff disagrees with the comment.

As previously discussed, the Inwood Marble may be able to supply an adequate amount of potable water for a private well. Again, the FSEIS supplement evaluates the impact on groundwater as a resource. Impacts from radionuclide leaks into the groundwater have been described from historical and ongoing site activities and have been projected over the license renewal term. The impacts have been described in terms of measured concentrations of radionuclides in the groundwater. The impacts on the potential beneficial use of the groundwater have been described using MCLs.

As discussed in Section 5.4.3, the NRC staff concludes that the impacts caused by radionuclides in groundwater are SMALL to MODERATE. The NRC has established three levels of significance for potential impacts: SMALL, MODERATE, and LARGE. The definitions

of the significance levels, which are in the footnotes to Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, define SMALL and MODERATE as follows:

“SMALL impact: Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource...”

“MODERATE impact: Environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.”

Leaks of tritium into the groundwater, while not continuous, have occurred near IP2 since 1990. As described in this FSEIS supplement, the impacts on groundwater quality at the Indian Point site are detectable and are sufficient to alter noticeably, but not to destabilize, important attributes of the resource. Therefore, the current impact on the groundwater quality is MODERATE. However, with the elimination of radionuclide leaks to the groundwater and with the use of monitored natural attenuation, the impacts on groundwater quality could move to SMALL. As a result, the overall impacts to groundwater caused by IP2 and IP3 license renewal would be SMALL to MODERATE.

No changes were made to the supplement as a result of this comment.

Comment 17-L14-1: “Since the SEIS was written prior to significant “new information” and the change of circumstance as a result of the dramatically increased levels of tritium found in the groundwater in February 2016, the SEIS contains misleading information and cannot be accepted as accurate and complete. Either significant corrections must be made to the SEIS or this Board should require another SEIS be conducted to address the unconsidered significant increase of radionuclides in groundwater.”

“The SEIS incorrectly states that the radioactivity in the leaks is reducing, when in fact the radioactivity has progressively increased from when leaks at Indian Point were first reported in the 1990's yet have never been fully identified or stopped.”

“In March 2014, readings were as high as 660,000 pCi/liter, which is 33 times higher than the safe drinking water limit (20,000 pCi/l).”

“February 2015 readings were as high as 900,000 pCi/l – 45 times higher than the safe drinking water limit.”

“The February 2016 new reading of 8,000,000 pCi/l is not only 400 times above the safe drinking water limit of 20,000 pCi/l, but it is nearly 10 times higher than a year ago.”

“SEIS incorrectly asserts that if the NRC approves a 20 year license for Entergy to continue operations at Indian Point “the mass of a radiological contaminants decreases, the concentration of that radiological contaminants would see a corresponding decrease”. (SEIS p 69).”

“This is utter nonsense. If the plant operates for 20 more years, every day it continues to operate the amount of radiological contaminants correspondingly increase. If amounts of nuclear waste increases, so does the amount of radiological contaminants.”

“Based on the new circumstances of the progressively worsening leaks, the SEIS includes a statement which is patently incorrect, and must be changed, “From 2007 through 2014, tritium concentrations have generally decreased,...[and] concentrations of radionuclides in groundwater entering the river are generally remaining the same or decreasing. Therefore, over the period of license renewal, the Hudson River is unlikely to see higher concentrations of radionuclides flowing into the Hudson River.” (SETS p. 71)

The recent larger leaks are clear evidence that the tritium concentrations have increased, not decreased at Entergy projected. Thus, any references to decreasing concentration of radionuclides of tritium in the SEIS must be removed, otherwise the document is not based in fact, but fiction.”

Comment 5-L22-7: “Specifically, based on the available data, Entergy disagrees with PHASE's characterization of tritium concentrations in Indian Point site groundwater as "progressively increas[ing]." Entergy also disagrees with the claim that the Draft Supplement requires "significant corrections" in light of purportedly new and significant information concerning radionuclide releases to groundwater at Indian Point. In making the foregoing claims, PHASE misleadingly conflates two disparate sources of plant-related radionuclides in site groundwater: (1) historical releases of radionuclides (including tritium) that resulted from since-repaired leaks in the IP1 and IP2 spent fuel pools, and (2) more recent inadvertent releases that resulted from short-lived operational occurrences in April 2014 and January 2016, and which were promptly detected by the Indian Point Radiological Groundwater Monitoring Program.”

“The Draft Supplement was issued on December 22, 2015, and therefore considers the information and data available to the NRC Staff at the time it prepared Section 5.4. As such, it could not discuss the January 2016 tritium release. Entergy does not disagree with PHASE that this event should be discussed in the final version of the NRC Staff's supplement, in part because it would serve to inform the public's understanding of the event. However, as detailed below, Entergy disagrees with PHASE's characterization of the nature and significance of the event, which Entergy discussed in its March 4, 2016 comments on the Draft Supplement, and thus whether it is required to be addressed under NEPA.”

“Several additional points bear emphasis, particularly in light of PHASE's claims that overall tritium levels in onsite groundwater at Indian Point are "progressively increas[ing]." First, the elevated tritium levels that were measured in samples taken from the abovementioned monitoring installations (including the approximately 8 million picocuries per liter ("pCi/L") value cited by PHASE on pages 2-3 of its comments) resulted from a transient release, and were reflected only in a certain subset of the existing array of on-site monitoring installations for a short duration. Such measurements also occurred for groundwater samples that were collected from monitoring installations located proximate to the source and shortly after the January 2016 release. Furthermore, to date, no trend of increasing tritium concentrations has been detected in most of the on-site monitoring installations, including those located in the riverfront area. These data trends support the conclusion that the 2016 tritium release resulted from a discrete, now-ceased spill event. The effects of that short-term release on subsurface tritium levels are therefore expected to continually abate with time, with some fluctuations in individual monitoring installations occurring, and likely to continue occurring, as the tritium released during the January 2016 event migrates underground. Moreover, based on the current data, Entergy expects those transient effects to be eclipsed by the overall site trend of declining tritium levels evident since all of the identified spent fuel pool leaks were previously terminated (multiple termination dates, all prior to 2008). Thus, it is misleading for PHASE to assert that there has been a "1000 fold increase in levels of radiation *being* leaked into the ground water and Hudson River," when in fact the evidence shows only elevated tritium levels in a fraction of on-site groundwater and no releases to the Hudson River at this time.”

Comment 5-L22-8: “In its March 4, 2016 comments, Riverkeeper also makes statements related to tritium in Indian Point site groundwater. First, it states that the January 2016 release "has caused groundwater radioactivity levels to rise more than 65,000 percent," and that "[t]he tritium leak is just the latest of an increasing number of safety incidents at [Indian Point] in the past year." Second, it states that "[e]xamination must be made now of precisely why the tritium

levels suddenly increase by many orders of magnitude and whether the fuel pools are the source."

"Each of the foregoing statements by Riverkeeper is factually incorrect. First, it is incorrect and misleading to state that "groundwater radioactivity levels" have increased by 65,000 percent. As explained above, although the 2016 isolated, short-term release resulted in elevated tritium levels at certain elevations in certain monitoring installations located proximate to the source, those levels' cannot reasonably be considered representative of groundwater conditions generally at Indian Point. As explained above, current data trends support the conclusion that the effects of 2016 release on subsurface tritium levels are transient, and thus will continually abate with time, with some fluctuations in individual monitoring installations occurring as the tritium released during the January 2016 event migrates underground. Further, based on the current data, Entergy expects those transient effects to be eclipsed by the overall site trend of declining tritium levels evident since all of the identified SFP leaks were previously terminated (multiple termination dates, all prior to 2008)"

On February 6, 2016 a radioactive tritium leak at IPEC caused groundwater radioactivity levels to rise more than 65,000 percent.

Response: *These comments indicate that the FSEIS supplement does not reflect leaks of tritium into the groundwater that occurred in 2016. These comments also express an opinion about the long-term trend of tritium concentrations. One commenter expresses disagreement with the NRC staff's conclusion that tritium concentrations are decreasing with time, and another commenter states that tritium concentrations are decreasing with time and will continue to do so, despite the recent leaks to groundwater.*

Regarding the comments stating that information which became available after publication of the draft FSEIS supplement should be considered, the NRC staff agrees with the comments. The NRC published the FSEIS supplement in December 2015. It has updated Section 5.4.2 of this final supplement to the FSEIS to incorporate 2015 and 2016 data that were not previously available and has added text describing known leaks of tritium into the groundwater in 2016.

Regarding the overall trend in radionuclide concentrations, as discussed in Section 5.4.2, tritium concentrations from 2007 through 2015 have generally decreased, whereas strontium concentrations stayed the same or decreased. The implication is that the two plumes are being diluted by clean groundwater as the radionuclides move toward the river, and as the plumes approach the river, they are further diluted by river water moving into the groundwater when river water levels are high. Because of this process, the concentrations of radionuclides in groundwater entering the river have generally remained the same or decreased. Therefore, inasmuch as the 2016 leak to groundwater has been stopped, the NRC staff expects that, like past releases of tritium, the overall downward trend in radionuclide concentrations will reestablish itself as the tritium plume moves through the Indian Point Marble and into the river. In sum, appropriate changes were made to the supplement to address new information, as proposed in these comments.

Comment 17-L14-1: "The NRC's staff conclusion that during the relicensing period, rapid dilution of an unknown amount of radionuclides into the Hudson has SMALL (SEIS p 99) environmental impact, has no rational basis, since the source of the leaks from Spent Fuel Pool #2 remains unknown "the full extent of the leaks is not known" (SEIS p 92, 8) and therefore cannot be sustained."

"Since the Hudson is a tidal estuary river, radioactive pollution does not only go downriver, but also goes up-river, where communities, including environmental justice communities of Poughkeepsie, has no other supply and rely on the Hudson for its the drinking water."

“If the NRC accepts this SEIS as accurate, it will be improperly condemning communities that rely upon the Hudson River to drink tritium spiked water.”

“Once ingested, tritium's minimal penetration depth could be sufficient to inflict deleterious effects”. (4.2.1 Physical and Chemical Properties of Tritium, Lawrence Berkeley National Laboratory <http://www2.lbl.gov/ehs/esg/tritium/tritium/TritCh4.html>.”

“SEIS incorrectly states that IP2 and IP3 will not adversely affect operations of the proposed Haverstraw Water Supply Project. While currently the Hudson River is not currently being used as a drinking water supply, in part it is due to the increasing radioactive pollution into the Hudson by Indian Point. The Suez/United Water plan to desalinate the Hudson River water in the Haverstraw Bay, three (3) miles downriver from Indian Point, was vehemently opposed by Rockland County residents, for among other reasons, the people of Rockland County refused to finance the desalination plant which would always be at risk of contamination in the event the leaks at Indian Point continue to increase.”

“The samples from the pilot desalination plant in the Haverstraw Bay identified measurable levels of Strontium 90 detected in the majority of the samples which were taken in 2007, (see Exhibit I).”

“The SEIS fails to consider the airborne impacts of increased leaks which releases increased levels of radiation into the Hudson River, as a result of evaporation and condensation.”

“The SEIS's planned use of monitored natural attenuation is NOT an acceptable approach to managing the remaining strontium-90 and tritium plumes.”

“Entergy's aging management plan to increase radioactive pollution in the Hudson River cannot rationally or reasonably be approved as have SMALL impact” (PHASE 2016).”

Response: *This comment indicates that the NRC staff failed to consider impacts from leakage of radionuclides to groundwater and has not accounted for airborne releases of tritium, that monitored natural attenuation is not an acceptable approach, and that monitored natural attenuation will not be able to mitigate groundwater contamination to an impact ranking of SMALL. The comment also states that potable water supplies will be adversely affected. The NRC staff disagrees with the comment.*

As discussed in Section 5.4.3, the concentration of tritium in groundwater discharging to the Hudson River is below the MCL concentration established under the SDWA, and the recent concentrations of strontium have been at or below the MCL. Given that the volumetric flow rate of water being discharged to the river is relatively small when compared to the volumetric flow rate of the river (approximately 17 gpm (65 L/min) compared to approximately 80 million gpm (302 million L/min), or 0.0002 percent of the water flowing in the river), radionuclide concentrations are further significantly reduced. Furthermore, over the period of license renewal, the concentrations of radionuclides in groundwater discharging to the Hudson River should be rapidly diluted to very low levels that may not be noticeable. As such, the leakage of radionuclides to groundwater at the IP2 and IP3 site is unlikely to affect any current or future use of the Hudson River as a drinking water source. Similarly, given the relatively low concentrations and volumes of radionuclides reaching the river, airborne impacts from evaporation and condensation are expected to be insignificant.

Known leaks into the groundwater have all been subsurface leaks (i.e., below the land surface). These leaks did not flow across the land surface and so did not release radionuclides to the atmosphere via evaporation and redeposition (condensation). Surface spills, should they occur, would be addressed in NRC's ongoing Reactor Oversight Process and subject to NRC review. However, inasmuch as such spills have not occurred and are not realistically expected to occur,

they need not be addressed as reasonably foreseeable impacts of the IP2 and IP3 license renewal.

Regarding monitored natural attenuation, as described in Section 5.4.2 of the supplement, this is a methodology endorsed by EPA and NYSDEC that, depending on site-specific circumstances, is used to reduce or attenuate the concentration of contaminants in the groundwater (EPA 1999a, 2012; NYSDEC 2010). Natural attenuation relies on natural processes, such as dilution, sorption, evaporation, radioactive decay, and chemical reactions with natural substances.

The NRC staff has concluded that the current impact on the onsite groundwater quality for tritium is MODERATE. The NRC staff also concluded that the groundwater quality is being improved by natural attenuation processes. The site is being monitored to judge the effectiveness of radionuclide attenuation and to quickly identify any inadvertent future releases of radionuclides. Section 5.4.3 states that, with the elimination of radionuclide leaks to the groundwater and with the use of monitored natural attenuation, the impact on groundwater quality could move to SMALL.

However, should natural attenuation not reduce the groundwater contamination to a SMALL impact level, the impact on groundwater at the site would continue to be MODERATE. Therefore, the overall impacts to groundwater caused by the IP2 and IP3 license renewal would be SMALL to MODERATE.

Also, as stated in Section 5.4.3, should onsite groundwater contamination remain after the period of license renewal, Entergy would be required to address any residual contamination of the facility, as necessary.

No changes were made to the supplement as a result of this comment.

Comment 17-L14-1: “Although the NRC has acknowledged that Spent Fuel Pool #2 has seismic cracks and a 9 inch "pin-hole", they had failed to require it be repaired, or even fully inspected. To date, only 40% of the pool has been inspected.”

“The SEIS provides no mitigation measures to find, stop and remediate all the leaks at Indian Point. Although more comprehensive monitoring is necessary for both air and water releases, just increasing monitoring or watching as leaks occur is not an aging management strategy to protect the environment and human health of increase exposure to toxic radiation. Thus, the SEIS is incomplete, since the only mitigating measures considered is to increase "natural attenuation" leaking into New York State's groundwater and Hudson River.”

“Therefore, since it is acknowledged that tritium contamination primarily came from the IP2 spent fuel pool, and since, "the full extent of the leaks is not known because of an inability to inspect the liner in the IP2 spent fuel pool while the unit is operating", the NRC must order IP2 spent fuel pool to be immediately shut down, excessive spent fuel must be removed from the pool and placed into dry cask storage, immediately, and a complete inspection, identification and remediation of the entire spent fuel pool must be conducted.”

Response: *This comment suggests that the source of previous leaks has not been definitively identified and that the FSEIS supplement should impose mitigation measures on the licensee. The NRC staff disagrees with this comment. The FSEIS supplement is a disclosure document and provides information to inform the decisionmaking process. It does not, and is not intended to impose requirements on the licensee. Under NEPA, before issuing licenses, the NRC must consider the environmental impacts of its licensing actions. The FSEIS supplement has responsively and adequately described reasonably foreseeable environmental impacts and known mitigation measures, including monitored natural attenuation, being applied at the site,*

as well as NRC oversight activities. Any measures deemed necessary to protect workers and members of the public would be imposed, as appropriate, with respect to the current operating licenses and any renewed licenses, under the NRC's ongoing Reactor Oversight Process.

No changes were made to the supplement as a result of this comment.

Comment 11-L21-1: "In June 2013, the NRC revised its regulations regarding which environmental issues associated with license renewal are common to all plants and therefore should be analyzed in the Generic EIS and which should be analyzed in the plant-specific EISs. "Radionuclides Released to Groundwater" was added to the issues identified as those that do not lend themselves to generic consideration, and therefore is discussed in this Draft Second Supplement. While information is provided on this issue in the document, EPA has become aware of another tritium leak in the vicinity of the IP2 fuel handling building through data collected from the monitoring wells on the Indian Point site. As of this writing, the exact source of this leak has not been determined. The facts that EPA has received indicate this leak was discovered pursuant to the Nuclear Energy Institute's NEI-07-07 guidance and the licensee's reporting thereof. Since NEI-07-07 guidance is being applied to the IPEC and used to assure that any release of radionuclides to the groundwater is discovered, reported, assessed and evaluated, EPA recommends that a more comprehensive discussion of NEI-07-07 and its application by the licensee be addressed in this second supplemental EIS to ensure the public is well informed especially given the recent operational difficulties at the facility."

Response: *This comment states that the NRC staff should update the FSEIS supplement to include a discussion of the recent tritium leak to groundwater, as well as an expanded discussion of the Nuclear Energy Institute (NEI) 07-07, "Industry Ground Water Protection Initiative" and its application.*

The NRC staff agrees with the comment. The NRC staff has updated Section 5.4.2 of the FSEIS supplement to insert into Table 5-3 the 2015 groundwater quality data that were not available when the draft supplement was published. In addition, the NRC staff has added text describing identified leaks of tritium into site groundwater in 2016 and has revised Section 5.4.2.3 to include a discussion of NEI-07-07 and its application.

B.1.7 Human Health

Comment 5-L17-13: "In Section 5.11, page 82, lines 37-39, the Draft Supplement states: "Wastewater discharges from IP2 and IP3, including wastewater that may contain minimal amounts of chemicals or metals, are controlled in accordance with a water discharge permit issued by the State of New York." Given that Entergy Indian Point has multiple SPDES permits, Entergy suggests that the NRC Staff revise this statement to read: "Wastewater discharges from IP2 and IP3, including wastewater that may contain minimal amounts of chemicals or metals, are controlled in accordance with a water discharge permits issued by the State of New York."

Response: *This comment recommends a change to the text to specify that Entergy has multiple water discharge permits. The NRC staff agrees with the comment and has revised the text in Section 5.11 of the supplement as suggested.*

Comment 13-L06-2: IS IT POSSIBLE FOR AN EPIDEMIC TO BE invisible?

Since 1991 the annual number of newly documented cases of thyroid cancer in the United States has skyrocketed from 12,400 to 62,450. It's now the seventh most common type of cancer.

Relatively little attention is paid to the butterfly-shaped thyroid gland that wraps around the throat. Many don't even know what the gland does. But this small organ (and the hormone it produces) is crucial to physical and mental development, especially early in life.

Appendix B

Cancer of the thyroid also gets little attention, perhaps because it is treatable, with long-term survival rates more than 90 percent. Still, the obvious question is what is causing this epidemic, and what can be done to address it?

Recently, there has been a debate in medical journals, with several authors claiming that the increase in thyroid cancer is the result of doctors doing a better job of detecting the disease at an earlier stage. A team of Italian researchers who published a paper last January split the difference, citing increased rates and better diagnosis. But as rates of all stages of thyroid cancer are soaring, better detection is probably a small factor.

So, what are the causes?

The Mayo Clinic describes a higher frequency of occurrence of thyroid cancer in women (not a telling clue, unless more is known about what predisposes women to the condition). It mentions inherited genetic syndromes that increase risk, although the true cause of these syndromes aren't known. And Mayo links thyroid cancer to exposure to radiation. The latter is perhaps the only "cause" for which there is a public policy solution.

In the atomic age, radioactive iodine (chiefly Iodine-131) has proliferated, from atom bomb explosions and now from nuclear power reactors.

The thyroid gland requires iodine, a naturally occurring chemical. But it doesn't distinguish between radioactive Iodine 131 and naturally occurring iodine. Iodine 131 enters the human body via the food we eat, the water we drink and the air we breathe, damaging and killing cells, a process that can lead to cancer and other diseases.

The current debate in medical journals, or lack of one, ignores the obvious. Although the specific process that causes thyroid cancer isn't known, many scholarly studies have already linked exposure to radioactive iodine to increased risk. Studies of Japanese survivors of the atomic bombs the United States dropped on Hiroshima and Nagasaki found the cancer with the greatest increase was thyroid cancer.

- A U.S. government survey of cancer rates among residents of the Marshall Islands, who were exposed to U.S. bomb testing in the 1950s, found thyroid cancer outpaced all others.
- A 1999 federal study estimated that exposure to I-131 from bomb testing in Nevada caused as many as 212,000 Americans to develop thyroid cancer.
- A 2009 book on the Chernobyl nuclear plant disaster found soaring levels of local thyroid cancer rates after the meltdown, especially among children, and workers called "liquidators," who cleaned up the burning plant.
- More recently, studies have documented thyroid cancer rates in children near Fukushima, Japan, site of the 2011 meltdown, to be 20 to 50 times above the expected rate.

Today, one of the main sources of human exposure to radioactive iodine is nuclear power reactors. Not only from accidents like the ones at Chernobyl and Fukushima, but from the routine operation of reactors. To create electricity, these plants use the same process to split uranium atoms that is used in atomic bombs. In that process, waste products, including I-131, are produced in large amounts and must be contained to prevent exposure to workers and local residents. Some of this waste inevitably leaks from reactors and finds its way into plants and the bodies of humans and other animals.

The highest rates of thyroid cancer in the United States, according to federal statistics, are found in New Jersey, Pennsylvania, and New York, states with the densest concentration of

reactors in the nation. In a study conducted in 2009, one of this article's authors (Janette Sherman) found the highest rates of thyroid cancer occurring within 90-mile radiuses of the 16 nuclear power plants (13 still operating) in those states.

Declaring "we don't know why" and continuing to diagnose and treat the growing number of Americans suffering from thyroid disease is not sufficient. Causes must be identified, preventive strategies must be implemented, and ultimately policy makers will have to take a serious look at closing the 99 nuclear reactors currently operating in the United States.

Response: *This comment concerns the human health effects of radiation exposure from nuclear power plants, specifically cancers resulting from exposure to radioiodines. The NRC's mission is to protect public health and safety and the environment from the effects of radiation from nuclear reactors, materials, and waste facilities. The NRC's regulatory limits for radiological protection are set to protect workers and the public from the harmful health effects (i.e., cancer and other biological impacts) of radiation on humans. The limits are based on the recommendations of standards-setting organizations. Radiation standards reflect extensive scientific study by national and international organizations. The NRC actively participates in and monitors the work of these organizations to keep current on the latest trends in radiation protection. If the NRC determines that there is a need to revise its radiation protection regulations, it will initiate a rulemaking. Members of the public who believe that the NRC should revise or update its regulations may request that the NRC do so by submitting a petition for rulemaking in accordance with the NRC's regulations at 10 CFR 2.802.*

The NRC has based its dose limits and dose calculations on a descriptive model of the human body referred to as "standard man." However, the NRC has recognized that dose limits and calculations based on "standard man" must be informed and adjusted in some cases for factors such as age and gender. For example, the NRC has different occupational dose limits for pregnant women workers once they have declared (i.e., made known) they are pregnant, because the rapidly developing human fetus is more radiosensitive than an adult woman. NRC dose limits are also much lower for members of the general public, including children and elderly people, than for adults who receive radiation exposure as part of their occupation. Finally, NRC dose calculation methods include age-specific dose factors for each radionuclide to consider the varied sensitivity to radiation exposure by infant, child, and teen bodies, which are also generally smaller than adult bodies. In addition, the calculation methods recognize that the diets (amounts of different kinds of food) of infants, children, and teens are different from those of adults.

Although radiation may cause cancers at high doses, currently there are no reputable scientifically conclusive data that unequivocally establish the occurrence of cancer following exposure to low doses (i.e., below about 10 rem (0.1 Sv)). However, radiation protection experts conservatively assume that any amount of radiation may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold (LNT) dose response relationship is used to describe the relationship between radiation dose and adverse impacts such as incidents of cancer. Simply stated, in this model, any increase in dose, no matter how small, results in an incremental increase in health risk. The NRC accepts the LNT dose-response model, recognizing that it probably overestimates those risks (see additional information at <http://www.nrc.gov/about-nrc/radiation/health-effects/rad-exposure-cancer.html>). Having accepted this model, the NRC believes that this model is conservative when applied to workers and members of the public who are exposed to radiation from nuclear facilities. This is based on the fact that numerous epidemiological studies have not shown increased incidences of cancer at low doses. Some of these studies included: (1) the 1990 National Cancer Institute study (NCI 1990) of cancer mortality rates around 52 nuclear power plants, (2) the University of Pittsburgh study that found

no link between radiation released during the 1979 accident at the Three-Mile Island nuclear power station and cancer deaths among residents, and (3) the 2001 study performed by the Connecticut Academy of Sciences and Engineering that found no meaningful associations from exposures to radionuclides around the Haddam Neck nuclear power plant in Connecticut to the cancers studied. In addition, a position statement entitled "Radiation Risk in Perspective" by the Health Physics Society (2004) made the following points regarding radiological health effects: (1) radiological health effects (primarily cancer) have been demonstrated in humans through epidemiological studies only at doses exceeding 5–10 rem delivered at high dose rates. Below this dose, estimation of adverse effect remains speculative; and (2) epidemiological studies have not demonstrated adverse health effects in individuals exposed to small doses (less than 10 rem delivered over a period of many years).

Although a number of studies of cancer incidence in the vicinity of nuclear power facilities have been conducted, no studies to date accepted by the scientific community show a correlation between radiation dose from nuclear power facilities and cancer incidence in the general public. The following is a list of some of the most recent radiation health studies that the NRC recognizes:

- *In 1990, at the request of Congress, the National Cancer Institute conducted a study of cancer mortality rates around 52 nuclear power plants and 10 other nuclear facilities. The study covered the period from 1950 to 1984 and evaluated the change in mortality rates before and during facility operations. The study concluded that there was no evidence that nuclear facilities may be linked causally with excess deaths from leukemia or from other cancers in populations living nearby.*
- *In June 2000, investigators from the University of Pittsburgh found no link between radiation released during the 1979 accident at the Three Mile Island power plant and cancer deaths among nearby residents. Their study followed 32,000 people who lived within 5 miles (8 kilometers) of the plant at the time of the accident.*
- *The American Cancer Society in 2001 concluded that, although reports about cancer clusters in some communities have raised public concern, studies show that clusters do not occur more often near nuclear plants than they do by chance elsewhere in the population. Likewise, there is no evidence that links strontium-90 with increases in breast cancer, prostate cancer, or childhood cancer rates. Radiation emissions from nuclear power plants are closely controlled and involve negligible levels of exposure for nearby communities.*
- *In 2000, the Illinois Public Health Department compared childhood cancer statistics for counties with nuclear power plants to similar counties without nuclear plants and found no statistically significant difference.*
- *The Connecticut Academy of Sciences and Engineering, in January 2001, issued a report on a study around the Haddam Neck nuclear power plant in Connecticut and concluded that radiation emissions were so low as to be negligible and found no meaningful associations with the cancers studied.*
- *In 2001, the Florida Bureau of Environmental Epidemiology reviewed claims that there are striking increases in cancer rates in southeastern Florida counties caused by increased radiation exposures from nuclear power plants. However, using the same data to reconstruct the calculations as those on which the claims were based,*

Florida officials were not able to identify unusually high rates of cancers in these counties compared with the rest of the State of Florida and the Nation.

Based on the LNT dose-response model, the NRC has conservatively established limits for radioactive effluents and radiation exposures for workers and members of the public. Although the public dose limit in 10 CFR Part 20 is 100 mrem (1 mSv) for all facilities licensed by the NRC, the agency has imposed additional constraints on nuclear power reactors. Each nuclear power reactor has enforceable license conditions that limit the total annual whole body dose to a member of the public outside the facility to 25 mrem (0.25 mSv). The amount of radioactive material released from nuclear power facilities is well measured, well monitored, and known to be very small. The doses of radiation received by members of the public as a result of exposure to nuclear power facilities are very low (i.e., less than a few millirem) such that resulting cancers attributed to the radiation have not been observed and would not be expected. As stated in the GEIS, the NRC believes that the public and occupational impacts during the license renewal term would be SMALL.

NRC regulations require that radioactive effluent releases from nuclear power plants meet radiation dose limits specified in 10 CFR Part 20 and the as-low-as-is-reasonably-achievable dose criteria in Appendix I to 10 CFR Part 50. Regulatory limits are placed on the radiation dose that members of the public can receive from radioactive material released by a nuclear power plant. As part of the Radioactive Effluent Control Program, and as required by 10 CFR 50.36(a), IP2 and IP3 are required to submit an annual report to the NRC that lists the types and quantities of radioactive effluents (including radioiodines) released into the environment. In Section 2.1.4.2 of the 2010 FSEIS (NRC 2010), the NRC staff reviewed radioactive effluent release data for the years 2002 through 2006, and 2008 through 2009. Based on this review, the NRC staff concluded that the doses to members of the public were within the NRC's dose limits contained in 10 CFR Part 20. The NRC staff reviewed the most current effluent release report from IP2 and IP3, which contains data for effluent releases during 2015 (Entergy 2016d). The radioactive effluent releases for 2015 are consistent with the data reviewed in the 2010 FSEIS. The NRC staff expects variations in the amount of radioactive effluents released from year to year, based on the overall performance of the plant and the number and scope of maintenance and refueling outages. The radioactive effluent releases reported for IP2 and IP3 (including radioiodines) are small and are within the applicable limits, and the NRC staff noted no unusual trends.

In addition, the NRC staff, in Section 2.2.7 of the 2010 FSEIS (NRC 2010), evaluated data from IP2's and IP3's Radiological Environmental Monitoring Program (REMP). The REMP monitors the local environment around the IP2 and IP3 site, starting before the plant operates to establish background radiation levels and continues throughout its operating lifetime. The REMP provides a mechanism for evaluating the levels of radioactivity in the environment to determine if there is any buildup of radioactivity from plant operations. The REMP also measures radioactivity from other nuclear facilities that may be in the area (i.e., other nuclear power plants, hospitals using radioactive material, research facilities, or any other facility licensed to use radioactive material) and from natural background radiation and fallout from atomic weapons testing and nuclear accidents. Thus, the REMP monitors the cumulative impacts from all sources of radioactivity in the vicinity of IP2 and IP3. Based on its review of IP2's and IP3's REMP for the years 2002 through 2006, and 2008 through 2009, the NRC staff concluded that there was no indication of an adverse trend (i.e., increased buildup) in radioactivity levels in the area and that there is no measurable impact to the environment from operations at IP2 and IP3. The NRC staff reviewed the most current REMP report from IP2 and IP3, which contains data for 2015 (Entergy 2016e). The NRC staff reviewed 10 years of historical data, along with the 2015 REMP data, and observed no unusual trends; the data were consistent with the data

reviewed in the 2010 SEIS and showed no significant radiological impact on the environment from operations at the IP2 and IP3 site.

In summary, there are no studies to date that are accepted by the nation's leading scientific authorities that indicate a causative relationship between radiation dose from nuclear power facilities and cancer in the general public. The amount of radioactive material released from nuclear power facilities such as IP2 and IP3 is well measured, well monitored, and known to be very small.

No changes were made to the supplement as a result of this comment.

B.1.8 NRC's License Renewal and NEPA Processes

Comment 9-L16-7: We disagree with four (4) out of five (5) of the impact conclusions included in Table 9–1, Summary of Environmental Significance of License Renewal and 1 Alternatives because of the exclusion of environmental benefits. Even in the case where we agree with the impact assessment, we believe there should be much more consideration of environmental benefits.

Under 'License Renewal,' the impact is listed as SMALL. The negative impacts would be SMALL, but the positive impacts would be LARGE. The NRC should figure out a way to include this consideration. Under 'Plant Shutdown,' the impact is listed as SMALL. If the positive impacts of IP2 and IP3 are included, the environmental injustice mitigation impact would be very LARGE. The 'New Closed Cycle Cooling' alternative is a shutdown scenario, which would lead to a LARGE impact if the positive environmental benefits are lost due to such a closure. The 'NGCC at the IP Site or a Repowered Site,' alternative, again would eliminate the great environmental benefits of the facility and increase emissions in a nonattainment area. The 'NGCC at a New Site,' would have very LARGE negative consequences. The NRC's limiting the environmental justice benefits of IP2 and IP3 is a confounding variable that unfairly skews the impact conclusions.

Comment 6-L19-2: New York AREA urges, therefore, that NRC consider modifying the five impact conclusions presented in Table 9–1 (Summary of Environmental Significance of License Renewal and Alternatives) about IPEC's environmental impact to reflect these benefits (please see the list below). With regard to the first category, we agree that the term "small" is accurate in context regarding the magnitude of risk of detriment to air quality, but it would be even more accurate to describe IPEC as having large benefits and its loss to have large detrimental effects--due to its production of industrial-strength baseload power virtually emissions-free, unlike any feasible alternatives. For the same reasons, with regard to the second through fifth categories, we disagree with NRC's conclusions, as is detailed in the following list:

- 1) "License Renewal": IPEC's potential negative impact is small, but its positive impact is large
- 2) "Plant Shutdown": the negative environmental impact of loss of IPEC would be not be small; it would be large
- 3) "New Closed Cycle Cooling": this is a plant shutdown scenario, which would cause a large loss of environmental benefits
- 4) "NGCC at the IP Site or a Repowered Site": this alternative would cause a large loss of environmental benefits and would increase emissions in a nonattainment area
- 5) "NGCC at a New Site": this alternative would cause a large loss of environmental benefits and would increase emissions in a nonattainment area

Response: *These comments request that the NRC staff modify various conclusions in Table 9–1 of the 2010 FSEIS and as modified by the draft supplement (see Section 8.3), stating*

that the positive benefits of the continued operation of IP2 and IP3 are being minimized. Specifically, the comments state that IP2 and IP3 provide a large environmental benefit and that plant shutdown and replacement with natural gas-powered generation would cause a loss of that benefit and have an adverse impact on air quality.

As discussed in Section 8.2 of the 2010 FSEIS, the NRC staff's evaluation of the No-Action Alternative considers the immediate impacts that occur between plant shutdown and the beginning of decommissioning. Further, Section 8.2 of the 2010 FSEIS states the net loss in power generating capacity from the shutdown of IP2 and IP3 would likely be replaced by other power generation technologies, demand-side management and energy conservation, or a combination of options. The NRC staff evaluated the potential environmental impacts from a range of reasonable replacement power alternatives in Section 8.3 of the 2010 FSEIS. Specifically, the NRC staff noted that operation of an NGCC-based alternative would result in the release of hazardous air pollutants and would need to comply with the additional permitting requirements in place to operate in a nonattainment area. Based on its evaluation, the NRC staff determined that the impacts to air quality from the construction and operation of an NGCC alternative would range from SMALL to MODERATE, depending on the air quality of the surrounding airshed. While the continued operation of IP2 and IP3 may provide some environmental benefits relative to potential replacement power alternatives, depending on technology (e.g., avoided air emissions), this was not considered as part of the NRC staff's evaluation of the No-Action alternative. These comments provide no new or significant information that would change that conclusion.

Regarding the potential that Entergy may shut down IP2 and IP3 should the State of New York mandate the installation of a closed-cycle cooling system, the NRC has no role in the State's decision. Should that mandate occur, the decision on whether to continue to operate IP2 and IP3 rests with Entergy. Moreover, the NRC staff notes that the State of New York and Entergy have reached an agreement on the early shut down of IP2 and IP3, and the State has issued the necessary CWA Section 401, WQC, and SPDES permits, and has approved Entergy's CZMA consistency certification, as discussed elsewhere in this final supplement to the FSEIS.

No changes were made to this supplement in response to these comments.

Comment 7-L18-1: In Dec 2013, the Indian Point Safe Energy Coalition delineated the unsupported and invalid assumptions contained in the Draft GEIS and presented a lengthy annotated list of support References. We hereby reference and incorporate IPSEC's GEIS Comments herein, since every single flaw noted with respect to the GEIS remains or is amplified in the SEIS.

In the Coalition's GEIS Comments, we also made a genuine entreaty to your staff. We wrote as citizens in the hope that the NRC was not an entirely industry captured agency and our message would reach individuals who see themselves, not just as actors in a bureaucracy, but as true public servants.

We know those individuals work at the NRC. We have met them. But something is seriously amiss at the Commission when it issues a document as utterly empty of analytical substance as is this SEIS.

Frankly, to describe the shoddy and inert nature of the "analysis" presented in the SEIS would involve [j]ust cutting and pasting the entire document into these Comments.

So we will simply list here - for the public record and consideration - risks the SEIS deems inconsequential:

1. The possibility of major catastrophic accident at Indian Point.

Appendix B

2. Indian Point's location: the most populated and most densely populated region of any nuclear plant in the nation, with 300,000 people living within 10 miles, 1 million within 20, and over 17 million within 50.
3. The likelihood a catastrophic radiation release could render large segments of the NY Metropolitan Region uninhabitable for decades, even centuries.
4. The fact an accident - even a mitigated one - could contaminate a reservoir source of NYC drinking water and severely contaminate the Hudson River for centuries.
5. The problem-plagued operational history of Indian Point during its first 40 years of operation.
6. The fact NRC oversight has failed to prevent the multiple fires, explosions, electrical problems, cooling system malfunctions, clogged water intakes, debris clogged switchgear room drains, boric acid corrosion, reactor control rod malfunctions, emergency backup generator failures, emergency communication system failures, alarm malfunctions, computer software problems, pipe breaks, and radiation leaks at Indian Point in the past. (Rest assured the NRC will catch every problem in time.)
7. All the natural and man-made disaster risks most specifically applicable to the site: earthquake; flooding (including from dam burst); extreme storms; fires; cyber-related dangers, and the hazard of the near proximity to high-pressure gas pipelines.
8. Terrorism. (The NY Metro area is a top terror target. The 9/11 Commission revealed Indian Point was actually considered by the attack team leader. But let's continue to remain oblivious to the homeland security peril.)
9. The high-level nuclear waste at the site - including the 2 times as hot and radioactive high burnup fuel - which will continue to mount every single year the plant continues operation.
10. The non-robust spent fuel pools, which have already experienced deterioration, are inaccessible to full inspection, and are now reconfigured to hold more than 5 times the amount of waste for which they were originally designed.
11. The full cumulative health and environmental impacts of additional decades of radioactivity emitted into the environment. (At this point representations of impact being "small" or "moderate" are prima facie unfounded, since monitoring data is minimal and population health data unassessed.)
12. The environmental and health toll exacted by the full nuclear fuel cycle; including BTU impact, surface and groundwater despoliation, the substantial contribution of greenhouse gases, and the disproportionate burden placed on Native American and other environmental justice communities - especially in connection with uranium mining, fuel processing and radioactive waste disposition.

An honorable and honest SEIS for Indian Point would have make these points clear. The Commission's failure to do so does not bury the untenable risk this plant presents to millions of Americans. All it does is expose the subservience of this agency to the industry it purports to regulate.

You have violated the public trust and you are putting our lives our communities and our children's futures at risk.

Response: *This comment expresses disagreement with the scope of the analysis as presented in the FSEIS supplement and cites a list of issues that the commenter feels the NRC staff failed to address in the supplement. Additionally, the comment incorporates by reference comments submitted to the NRC in December 2013, which the NRC staff interprets to mean comments submitted on the draft Continued Storage GEIS.*

The potential for and consequences of severe accidents were considered in the NRC staff's evaluation of severe accident mitigation alternatives in Chapter 5 of the FSEIS, as modified by this supplement. Similarly, the NRC staff considered the impacts of spent fuel storage after the permanent cessation of reactor operations in the Continued Storage GEIS, NUREG-2157. Regarding the incorporation of comments submitted on the Continued Storage GEIS (NRC 2014c), the comments provided were considered, as appropriate, during the development of that document (see Appendix D of NUREG-2157). As directed by 10 CFR 51.23(b), the impacts assessed in NUREG-2157 regarding continued storage are deemed incorporated by rule into this FSEIS supplement. This comment provides no new and significant information.

No changes were made to the supplement in response to this comment.

Comment 3-L20-8:

IV. CONCLUSION

In sum, because the [draft FSEIS supplement] fails to adequately address existing and new information concerning the IPEC's significant adverse environmental impacts, it cannot serve as a basis supporting a relicensing decision, especially when numerous issues remain outstanding such as New York State's analysis of IPEC's water quality impacts.

Response: *This comment expresses the opinion that this FSEIS supplement is inadequate and should not be used to support a decision on relicensing. As reflected in the NRC's response to comment 3-L20-7 below, the NRC staff considers that it has addressed the issues cited in the comment, as appropriate. The comment offers no new and significant information and was not evaluated further in preparation of this supplement.*

No changes were made to the supplement in response to this comment.

Comment 5-L17-6:

VI. The NRC Staff Should Revise the Draft Supplement To Indicate That the Haverstraw Water Supply Project Has Been Abandoned at the Direction of the State of New York Public Service Commission

In Section 5.4.1.3 of the Draft Supplement, the Staff states that United Water has proposed to construct and operate a desalination facility in the town of Haverstraw, approximately 4 miles south-southwest and downstream of the Indian Point site. This facility, referred to as the Haverstraw Water Supply Project, would provide desalinated (fresh) water from the Hudson River as a source of drinking water for Rockland County. In Section 5.14.4, the Staff concludes that it is unlikely that the proposed Haverstraw Water Supply Project would be adversely affected by groundwater discharging to the Hudson River at the Indian Point site, due to "the extremely low levels of contamination in the Hudson River that might result from the flow of groundwater into the river." It further states that should the facility be built, United Water will be required to meet NYSDEC's permit requirements and EPA's drinking water standards, thus assuring public safety.

Entergy agrees with the conclusions reached by the NRC Staff regarding the impact of Indian Point operation on the proposed Haverstraw Water Supply Project. However, Entergy notes that SUEZ Water New York Inc. (formerly United Water) has abandoned the project at the direction of the State of New York Public Service Commission ("NYPSC"), as there is no longer an immediate need for a new water supply source. This fact is documented in a December 18, 2015 NYPSC Order, and a December 21, 2015 letter from SUEZ Water New York Inc. to the NYPSC responding to the Order and stating that the company "hereby confirms abandonment of the plan to construct the desalination plant in the Town of Haverstraw."

In view of the aforementioned development, Entergy recommends that the discussion related to the Haverstraw Water Supply Project be removed throughout the Draft Supplement. Affected portions of the Draft Supplement include the following:

Section	Page	Line(s)
5.4.1.3	56	32 – 37
5.4.3	75	32
Table 5–5	96	NA
5.14.1.1	97	40 – 47
	98	1 – 3
5.14.3	102	41
5.14.4	105	45 – 46
	106	1 – 4
5.14.6	107	9 – 19
9.0	144	7 – 10
		26 – 29

Response: *This comment recommends deleting discussions in the FSEIS supplement on the Haverstraw Water Supply Project, based on the termination of that project. The NRC staff agrees with the recommendation and has updated this supplement to remove references to that project.*

Comment 5-L17-16: In Section 6.1.2, page 122, line 16, the citation to "10 CFR 51.2353(c)(3)(iii)and (iv)" is incorrect and should be changed to "**10 CFR 51.53(c)(3)(i) and (iv).**"

Response: *This comment recommends correcting a citation to the NRC's regulations. The NRC staff agrees with the comment and has revised the citation as suggested.*

Comment 20-L04-2: In addition I am concerned that the plant is aging and I haven't seen a workable plan to dismantle it keeping it safe for those of us who live in the vicinity as well as the entire metropolitan area.

Response: *This comment expresses concern about aging management at IP2 and IP3 and the perceived lack of a plan to decommission the facility. To be granted renewed licenses, Entergy must demonstrate that aging effects will be adequately managed such that the intended functions of the systems, structures, and components within the scope of license renewal will be maintained consistent with the current licensing basis for the period of extended operation. The NRC staff's evaluation of Entergy's aging management programs is part of the safety review of the license renewal application, which is separate from the environmental review. The NRC staff has documented the results of its safety review in NUREG–1930, Safety Evaluation Report Related to the License Renewal of Indian Point Nuclear Generating Unit Nos. 2 and 3, dated November 2009, as supplemented in August 2011 and July 2015 (NRC 2009, 2011, 2015b). A third supplement to the safety evaluation report will be issued in 2018. No license would be issued prior to a determination that license renewal is in accordance with the Commission's regulations.*

Regarding decommissioning plans, a licensee's plan to decommission a nuclear power plant would be documented in a post-shutdown decommissioning activities report (PSDAR). The PSDAR would document planned decommissioning activities, along with a schedule for their completion. The NRC's regulations at 10 CFR 50.82(a)(4)(i) require licensees to submit a PSDAR before, or within 2 years following, the permanent cessation of operations. As such,

PSDARs are not required until after a licensee has made the decision to permanently cease operations and are not required for license renewal.

No changes were made to the supplement as a result of this comment.

B.1.9 Opposition to License Renewal or Nuclear Power

Comment 2-L01-1: For the safety of New Yorkers, please close the aged plant at Indian Point, whose li[cens]es have long expired and which is not only fatiscent but also a threat to million of people, other than a target for terrorists.

Comment 20-L04-3: I think we must take seriously immediately moving to renewable energy sources and to do all we can to support the governor in his goal of making the state significantly less fossil fuel and nuclear energy dependent by 2030.

Comments 1-L02-1 and 20-L04-4: Top Ten Reasons to Close Indian Point

10. Nowhere to put Indian Point's highly-radioactive spent fuel - IP's storage pools are already overfilled with spent fuel rods from the last 40 years of operations. The spent fuel pools are also leaking radioactive water into the ground and the Hudson River.

9. Two different earthquake fault lines cross just north of Indian Point, leading Columbia University to conclude that Indian Point is in pretty much the worst location for a nuke plant in the NY metro area.

8. The United States Nuclear Regulatory Commission ("NRC") revised its estimates of earthquake risk in 2010, concluding that Indian Point is the most likely nuke plant in the nation to experience core damage due to an earthquake. NRC higher ups say this is "not a serious concern" and won't do further studies until 2012.

7. Indian Point: don't worry - we can handle up to a 6.1 magnitude earthquake. Columbia University called a 7.0 quake "quite possible."

6. Indian Point has been granted so many exemptions from safety rules in the last ten years that an NRC spokesman says he couldn't possibly recount them all. To help jog NRC's memory - it has relaxed requirements for insulation on electrical cables controlling the reactors; reduced inspection requirements on rusting containment domes and leaking spent fuel pools, extended deadlines for equipment designed to prevent sabotage, etc.

5. A New York State report on the evacuation plan for Indian Point concluded that the plan is based on shaky assumptions and won't protect the public in the event of a real emergency. A subsequent federal study also found serious problem areas, especially in connection with the risk of attack on the spent fuel pools. Indian Point's response: "it's a very good plan."

4. Indian Point's evacuation plan only covers people living within ten miles from the plant. While NRC has told Americans living 50 miles from Fukushima to evacuate, it has not ordered Indian Point to prepare plans for a similar evacuation in case of an emergency in our area. Indian Point says any talk of a 50-mile evacuation plan here is "completely premature." Twenty million Americans in three states live within 50 miles of Indian Point.

3. We don't even really need the juice. Indian Point represents 12.5% of the electricity generating capacity in downstate New York. California conserved more than that in six months. If they can do it, we can too.

2. New York City's most important drinking water reservoir lies fifteen miles from Indian Point. Nine million people depend on the safety of that water supply every day.

1. If we don't do something, Indian Point could operate for another 40 years. Its original 40-year licenses are just about up and NRC says it sees no reason not to grant renewals. NRC, our

only nuclear watchdog, refused to consider earthquake risk or evacuation problems during the Indian Point relicensing process. A leading nuclear physicist and former White House staffer calls NRC a "textbook case" of what happens when the industry gains control of a regulatory agency. Indian Point is old, dangerous and near more people than any other nuke plant in the country. The Nuclear Regulatory Commission has given Indian Point more safety waivers than it can remember and its own data shows IP poses the greatest risk of reactor core damage due to earthquake in the country. There's no plan for evacuating people in the danger zone.

It's time for President Obama to act. Deny the license renewals for Indian Point and close it now!

Comment 16-L03-1: Americans are slowly, but surely, becoming more familiar with, and fearful of, acts of terror. "Terrorism" dominates the presidential campaign debates with few other policy topics getting such prominence. Yet with all of the front runners' hometown familiarity with one of America's most frequent terror targets (i.e. New York City) - from Donald Trump to Hillary Clinton to Bernie Sanders - it's surprising that they don't do more, rhetorically at least, to protect the city's safety. To be fair, however, if you'd ask New Yorkers about potential threats to Manhattan, they too may not know the security risk that looms several miles up the Hudson River.

It's an aging nuclear power plant called Indian Point Energy Center, just 25 miles north of New York City, and while it's eluded presidential candidates, it has moved quickly to the front of New York State's political burner lately as the company's operating licenses, which expired a while ago, are getting a strong rebuke from New York State Governor Andrew Cuomo. He doesn't want a Fukushima-style nuclear disaster happening to New Yorkers.

Cuomo, to his credit, seems serious about safety, ordering a probe last month into the recent, multiple, unexpected and forced shutdowns at the plant. And while the governor is not keen to close all of New York's nuclear power plants, as he transitions the state off carbon-emitting fossil fuels, he has made it clear that he wants this particular nuclear plant shut down due to security concerns.

New Yorkers, especially those in Manhattan, should take note. Tens of millions of Americans are within the reach and wake of an Indian Point nuclear disaster, which is why New York City councilmembers have come out against Indian Point and are attempting to close it. Evacuation strategies are pointless and impossible, as the roads can't handle the escaping throngs. Emergency responses (e.g. local residents are encouraged to take iodine tablets) are futile. And with the Nuclear Threat Initiative saying this month that we're only making slow progress on preventing nuclear terrorism, with cyber attacks increasing, we must take these warnings seriously, especially in our backyard.

Add to the precariousness of the security situation a new Spectra gas pipeline, approved by the Federal Energy Regulatory Commission, which will cross Entergy property in proximity to the plant (which is currently storing 1500 tons of radioactive waste) – a move Members of Congress are calling into question given recent successful cyber attacks on local New York infrastructure.

And yet, despite all of that, Indian Point Energy Center continues to operate beyond its license date. The operating permits for the two plants were set to expire in 2013 and 2015 but have been extended until the Nuclear Regulatory Commission decides whether or not to renew them. If the licenses are not renewed, the plants will be shut down. Meanwhile, the Nuclear Regulatory Commission, known for its close ties to the nuclear power industry, seems to accept Entergy's word that certain safety and environmental mitigation measures aren't necessary, while withholding the data on which they base their assertions. Unsurprisingly, local organizations like Hudson Riverkeeper couldn't disagree more with Entergy on this.

This could all be easily avoided. We could keep debating the serious security concerns, as they will continue to compromise the safety of millions of Americans in the NYC area even if the licenses are renewed. Or we could nip this in the bud now, once and for all, and transition the region to something more sustainable and safe. It's totally doable.

Based on a recent Synapse Energy Economics study, we know that the New York electric power system can be "operated reliably even in the absence of both of the Indian Point Energy Center units as of 2016 as long as 1) a number of anticipated electric system infrastructure improvements are completed across different parts of the New York electric power system," and as "2) anticipated generation supply increases from either new merchant plants or existing resources (currently mothballed or requiring repair) come online".

So let's do this. We've got sufficient capacity to support a reliable electric system without IPEC, and the cost of replacing IPEC - a mere 1-3 percent increase in electricity costs - with new, less dangerous and more renewable energy sources will be outweighed by the health and safety benefits. Besides, if Governor Cuomo is going to reach his 50 percent renewable energy goal by 2030, this is a great place to start.

By exploiting large amounts of untapped energy efficiencies, maximizing surpluses and reserves, expanding renewables and improving generation and transmission, we know we can retire the nuclear plant hovering above Manhattan on the Hudson River (something every New Yorker should be telling NRC to do before the public comment period closes). And we should do everything in our power to transition the bright minds at IPEC into the clean renewable energy sector in New York, which is growing daily. Let's keep them employed - and then some. But most importantly, let's keep this country safe. Every candidate, especially those from Westchester County, should be queuing to close IPEC before disaster strikes. The time is now. Our safety is at stake.

Comment 15-L05-1: From what we already know about the dangers of radioactive power and its cumulative waste products, it would be unconscionable to let these Nuclear Plants continue to operate, under any conditions. So many lives and livelihoods are at stake. You must make it a priority to safely shut down these NPP at Indian Point.

Comment 13-L06-1: Yesterday I heard about yet another problem that had just happened at Indian Point, yet another warning to close this dangerous nuclear power plant as soon as possible. Governor Cuomo had ordered an investigation in January into the several recent mishaps at Indian Point, the aging nuclear power plant 25 miles north of New York City, that had forced it to shut down temporarily. The Governor is very aware of the potential dangers to people within the area that would be affected by a serious accident at Indian Point and wants to see it shut down for good. NYC councilmembers are also attempting to close this dangerous power plant.

An act of terrorism, internal malfunction or natural disaster could put the lives and health of many millions of people at risk, Evacuation of these numbers of people is not realistically possible. I have been concerned about Indian Point for many years. So far we have been lucky, but counting on that luck continuing is becoming increasingly irresponsible as these nuclear reactors age further and risks of terrorism, including cyber-attacks, become more likely.

Indian Point is storing 1500 tons of radioactive waste, which is not only a source of potential disaster, but also a source of ongoing damaging effects on vegetation and human and animal health due to inevitable leaks. An article in the February 1 issue of The Washington Spectator states that "one of the main sources of human exposure to radioactive iodine is nuclear power reactors. Not only from accidents...but from routine operations of reactors." "The highest rates of thyroid cancer in the United States, according to federal statistics, are found in New Jersey,

Pennsylvania, and New York, states with the densest concentration of reactors in the nation." Attached is a copy of the article. [Note: This article has been identified as comment 13-L06-2]

We no longer even need the energy produced by Indian Point Energy efficiencies [and] expanded renewable energy would enable New York to do without these plants in the near future. In fact, recent research by Synapse Energy Economics has concluded that New York's electric power system can be "operated reliably even in the absence of both of the Indian Point Energy Center units as of 2016," if certain infrastructure projects are completed soon. I urge you to consider all of the potential dangers and ongoing damage caused by Indian Point and come to a determination that the already expired licenses for units #2 and #3 not be renewed. Indian Point should be retired permanently - and soon.

Comment 8-L07-1: Indian Point 2 and 3 are at the end of their design basis. Miles of underground pipes are corroded, inaccessible, and leaking radionuclides into the soil and flowing into the Hudson River. Two known plumes of highly radioactive isotopes sub lie the plant and sit in the groundwater, but rather than remediate this problem via extraction wells, as it did with much success at Vermont Yankee, Entergy has chosen to implement Monitored Natural Attenuation, which is a fancy name for doing absolutely nothing. The crack in the Unit 2 fuel pool was discovered in 2005 and pinhole leaks in the transfer canal lines were noticed later, but there is so much debris at the bottom of the pool and the fuel assemblies are packed so tightly inside that no repairs can be made without emptying the pool. Instead of mandating that this be done, the NRC accepts the findings of Entergy's cursory, partial, visual inspection as proof that this cracked and leaking spent fuel pool will last at least another twenty years.

I am in total agreement with Governor Cuomo and the State Assembly of New York that this plant should not be relicensed but rather shut down. Indian Point has been poorly maintained by Entergy and severe safety issues have been exempted from regulations by the NRC rather than mandated to be mitigated and resolved. Indian Point is located just 24 miles from Manhattan in the most densely populated area of any nuclear plant in the United States and there is no workable evacuation plan. We have been very, very lucky. Let us not push our luck. For the good of the northeast section of this country, its human population, its drinking water, its agriculture, and its wildlife, do not relicense Indian Point.

Comment 21-L10-1: As a resident of New York City, I am deeply concerned with the security and operations of this facility.

In the 12 years that I have lived here, tritium has been detected in wells on site. In this day and age, when the municipal water sources of so many cities are now being destroyed by illegal dumping of various substances, I am not confident that Entergy is going to do any better of a job protecting our waterways.

The security protocol for Indian Point assumes the possibility of only one strike team attempting to breach security. There were 19 people involved in the attacks on September 11th 2001. How does Entergy expect a team of five to protect this facility? This is unacceptable.

The following is a list of safety problems that Indian Point has had since the day it was built:

In 1973, five months after Indian Point 2 opened, the plant was shut down when engineers discovered buckling in the steel liner of the concrete dome in which the nuclear reactor is housed.

On October 17, 1980, 100,000 gallons of Hudson River water leaked into the Indian Point 2 containment building from the fan cooling unit, undetected by a safety device designed to detect hot water. The flooding, covering the first 9 feet of the reactor vessel, was discovered when

technicians entered the building. Two pumps which should have removed the water were found to be inoperative. NRC proposed a \$2,100,000 fine for the incident.

In February 2000, Unit 2 experienced a Steam Generator Tube Rupture (SGTR), which allowed a small amount of primary water to leak into the secondary system through one of the steam generators. All four steam generators were subsequently replaced.

In 2005, Entergy workers while digging discovered a small leak in a spent fuel pool. Water containing tritium and strontium-90 was leaking through a crack in the pool building and then finding its way into the nearby Hudson River. Workers were able to keep the spent fuel rods safely covered despite the leak. On March 22, 2006 The New York Times also reported finding radioactive nickel-63 and strontium in groundwater on site.

In 2007, a transformer at Unit 3 caught fire, and the Nuclear Regulatory Commission raised its level of inspections, because the plant had experienced many unplanned shutdowns. According to The New York Times, Indian Point "has a history of transformer problems"

On April 23, 2007, the Nuclear Regulatory Commission fined the owner of the Indian Point nuclear plant \$130,000 for failing to meet a deadline for a new emergency siren plan. The 150 sirens at the plant are meant to alert residents within 10 miles to a plant emergency. Since 2008, a Rockland County-based private company has taken over responsibility for the infrastructure used to trigger and maintain the ATI siren system. The sirens, once plagued with failures, have functioned nearly flawlessly ever since.

On January 7, 2010, NRC inspectors reported that an estimated 600,000 gallons of mildly radioactive steam was intentionally vented to the atmosphere after an automatic shutdown of Unit 2. After the vent, one of the vent valves unintentionally remained slightly open for two days. The levels of tritium in the steam were within the allowable safety limits defined in NRC standards.

On November 7, 2010, an explosion occurred in a main transformer for Indian Point 2, spilling oil into the Hudson River. Entergy later agreed to pay a \$1.2 million penalty for the transformer explosion.

July 2013, a former supervisor, who worked at the Indian Point nuclear power plant for twenty-nine years, was arrested for falsifying critical safety records and lying to federal regulators.

On May 9, 2015, a transformer failed at Indian Point 3, causing the automated shutdown of reactor 3. A fire that resulted from the failure was extinguished, and the reactor was placed in a safe and stable condition. The failed transformer contained about 24,000 gallons of dielectric fluid, which is used as an insulator and coolant when the transformer is energized. The U.S. Coast Guard estimates that about 3,000 gallons of dielectric fluid entered the river following the failure.

In June, 2015, a mylar balloon floated into a switchyard, causing an electrical problem resulting in the shutdown of Reactor 3.

In July 2015, Reactor 3 was shut down after a water pump failure.

On December 5, 2015, Indian Point 2 was shutdown after several control rods lost power.

On 6 February 2016, Governor Andrew Cuomo informed the public that radioactive tritium-contaminated water leaked into the groundwater at the Indian Point Nuclear facility. There are also environmental considerations beyond the radioactive leaks and oil spills. The cooling system kills over a billion fish eggs and larvae annually. Indian Point, however, claims their studies show that there is no problem. This leaves me even less confident in this company.

Comment 4-L12-1: This nuclear power plant needs to be SHUT DOWN IMMEDIATELY, not re-licensed beyond its capacity.

Let's talk bluntly, there is a cancer epidemic near this nuclear power plant, it is currently leaking high levels of uncontrollable radiation into the Hudson River. Entergy is lying, as they usually do.

At this point, re licensing this plant would make the NRC a party to premeditated murder. It is murder to allow this nuclear power plant to be relicensed. The NRC ought to be demanding that Entergy be putting money into resolving the harm they cause, not allowing them to cause more death and destruction.

THE FACTS ARE: There is NO safe level of radiation, as shown time and again by REAL scientists who care about our planet.

The "limits" have been made up as conjecture based on greed and avarice and have nothing to do with real science.

INDIAN POINT NEEDS TO BE SHUT DOWN IMMEDIATELY. PERIOD. ANYTHING ELSE IS WILLFUL NEGLIGENCE AND INTENTIONAL DISREGARD FOR HUMAN LIFE.

Re licensing this plant is Anti American and an blatant act of terrorism. It IS terrorism to allow radiation to be constantly leaked into the Hudson River, terrorizing people for generations and killing all life along the Hudson Bay.

NO. NO. NO. THAT MUST THE THE NRC'S ONLY RESPONSE.

Comment 22-L23-1: Yes, I am talking about another problem down at the Entergy/Indian Point site. Let's start with this one.

Item 1

Unit 2 was shutdown from March 7, 2016 to June 4, 2016. That is about 3 months. During that time, 30 to 40 site-based system "engineers" could not realize that a circuit breaker that can only be tested when the plant is off line, (which it was for 3 months), needed to be tested. Their ageing management program, (usually needed by plants aged 40 years), did NOT notice this need. All the technical mid-level management at Indian Point were too busy to notice. And, then there are the site vice presidents, of which I think they have two. They did not ask about anything else needed, either. So, now that the plant "has", to shutdown, let's just check it out and, probably, take another week or two rebuilding it.

Actually, I have no words to describe this situation.

Item 2

Generally, a nuclear plant has two, (or more), of everything. (The leak was given as 1 drop every 5 seconds.) Then, can somebody explain in a press release available to the public why you just can't take one of the two out of service and fix it in 3 days?

Item 3

Just because the leak is at a weld doesn't mean, (to me, anyway), that it is the weld that is leaking. Did anybody look to see if the nearby metal corroded away due to its exposure to Hudson River water? You know, pumping river water to the city of Flint, Michigan didn't work out too well either. Or, is Entergy/Indian Point Unit 2 exempt from doing root cause investigations BEFORE making repairs?

Item 4

Earlier this year, Entergy/Indian Point site groundwater monitoring wells showed increased contamination levels. The excuse was that there was something in the way in the truck bay that could not be touched until the current refueling outage was over. Well, the refueling outage is over. Has the root cause been completed? (Why doesn't the containment building contain contaminated water?)

Item 5

Recently when I sent a 2.206 request on a FirstEnergy plant to the NRC at the listed NRC address, it got returned to me. (See attached.) I received word that I would get a written explanation. That never happened.

Item 6

So, instead of a letter, I am using this e-mail as a 2.206 request to the EDO/US NRC Commissioners to reject the Entergy application for a license extension for their Indian Point, Unit 2 (only). The basis would be a general failure of their site staff to be aware of needs related to reliable supply of electrical power. Also, an inability to do timely root cause investigations. Also, the lack of an effective, implemented ageing management program.

Response: *These comments express opposition to the continued operation and relicensing of IP2 and IP2. The comments cite a variety of concerns, including the generation and storage of spent fuel, leaks of radionuclides into the groundwater, seismic risk, emergency preparedness, terrorism and security, plant safety, the need for the power generated by IP2 and IP3, and the presence of a gas pipeline as reasons for opposition. Some comments expressed support for replacement power to be provided by renewable energy sources. These comments are general in nature and provide no new and significant information for the NRC to evaluate.*

The 2010 FSEIS and this supplement addressed site-specific matters such as SAMAs (which includes a consideration of seismic risk), and groundwater leaks at IP2 and IP3. Regarding terrorist-initiated severe accidents, as discussed in the 2010 FSEIS, the Commission's long-standing position is that NEPA does not require inquiry into the consequences of a hypothetical terrorist incident. The 2013 revision to the license renewal GEIS (NRC 2013a) affirms the NRC's position that the overall risk from sabotage is small and that the consequences of an accident resulting from sabotage, should one occur, would be similar to those from internally initiated events.

Regarding the need for power, that issue is considered to be outside the scope of license renewal, and the FSEIS supplement need not address it (see 10 CFR 51.95 (c)(2)).

Emergency preparedness programs requiring specified levels of protection are required at all nuclear power plants, regardless of plant design, construction, or license date. Requirements related to emergency planning are in the regulations at 10 CFR 50.47 and Appendix E to 10 CFR Part 50. Emergency preparedness and planning issues are addressed under the NRC process under the current operating license and are outside the scope of the environmental analysis for license renewal. The NRC, in 10 CFR 50.47, has determined that there is no need for a special review of emergency preparedness issues for license renewal.

Topics such as the seismic licensing bases for IP2 and IP3, security, plant safety and performance, and offsite hazards (such as the proposed Algonquin Incremental Market (AIM) project (see also response to comment 20-L04-1, below)) are addressed as part of the plants' current licensing basis and are outside the scope of the license renewal process. The NRC provides continuous oversight of nuclear power plants through its ongoing Reactor Oversight Process to verify that they are being operated and maintained in accordance with NRC

regulations and their operating license requirements; this applies to plants with initial operating licenses as well as any renewed licenses. This oversight includes having full-time NRC inspectors located at the plant and periodic safety inspections conducted by NRC inspectors based in an NRC regional office. Should the agency discover an unsafe condition, or that a licensee is not complying with its licensing basis, the NRC has full authority to take whatever action is necessary to protect public health and safety.

No changes were made to the supplement as a result of these comments.

B.1.10 Out of Scope

Comment 11-L21-2: EPA is aware that on February 29, 2016 the New York State Homeland Security and Emergency Services letter dated February 29, 2016 to the Secretary of the Federal Energy Regulatory Commission about a State investigation on the operational problems at IPEC and an independent safety risk analysis of Spectra Energy's Algonquin Incremental Market (AIM) project proximity to IPEC that the State agencies have been directed to undertake by the Governor. That information should be reviewed.

Comment 3-L20-3:

C. The [Draft FSEIS Supplement]'s Safety Analysis is Inadequate to Satisfy NEPA

Since the DGEIS was issued in 2014, the IPEC has suffered a series of significant safety related mishaps. On February 29, 2015 New York State sent a letter (attached herewith) to the Federal Energy Regulatory Commission (FERC) highlighting IPEC's safety problems which have grown worse over time. The Governor has ordered four state agencies to conduct "a full investigation into recent significant issues at IPEC" and listed several safety incidents:

- May 7, 2015 IPEC's nuclear reactor Unit 3 was shut down by plant operators to repair a steam leak associated with the steam generator.
- May 9, 2015 a main transformer at Unit 3 short-circuited and caught fire due to a failure of insulation within the transformer. The plant shut down automatically and Entergy declared an unusual event level emergency.
- June 15, 2015 Unit 3 automatically shut down after an electrical disturbance in the switchyard caused a turbine to shut down.
- July 8, 2015 Unit 3 was shut down by plant operators after they determined that steam generator water levels were lowering due to the unexplained failure of a condensate pump.
- December 5, 2015 IPEC's nuclear reactor Unit 2 was powered down after approximately 10 control rods inserted into the reactor core.
- December 14, 2015 Unit 3 shutdown due to an electrical disturbance in the switchyard.

The tritium leak is just the latest of an increasing number of safety incidents at the IPEC in the past year. Nuclear reactor Units 2 and 3 at IPEC have shutdown unexpectedly seven times in 2015. An investigation is underway to determine the impacts of these shutdowns on operations of the units and to determine whether Entergy is appropriately investing in capital expenditures and operation and maintenance budgets to ensure reliable and adequate operations of the facility.

It is possible that the tritium leak investigation will pinpoint the IPEC spent fuel storage pools as the source of the contamination. Thus, in order to meet its NEPA obligations the NRC cannot simply rely on generic nation-wide waste storage protocols. Examination must be made now of

precisely why the tritium levels suddenly increase by many orders of magnitude and whether the fuel pools are the source. In the absence of such an investigation, the NRC cannot have taken a "hard look" at the potential impacts resulting from the longterm storage of nuclear waste at IPEC.

Comment 3-L20-5: The placement of the pipeline also raises the potential for an accident disrupting the spent fuel containment pools. IPEC's spent fuel pools are not housed under containment, but rather in non-reinforced cinderblock industrial buildings that may fail as the result of a pipeline failure/explosion. The results of a release of spent nuclear fuel could be catastrophic potentially contaminating a significant portion of the 10-mile emergency planning zone and the 50-mile ingestion pathway zone affecting millions of people. Thus, the NRC should postpone issuing a record of decision or a relicensing decision until the state completes its investigations.

Comment 20-L04-1: I am concerned about the expanded natural gas pipeline cutting so close to the IP facility even though a much smaller version has been there for some time. The 42" new line will be pushing gas through using high pressure increasing the risk factor significantly.

Response: *These comments state that the NRC staff should consider recent operational performance and the potential for accidents resulting from the proposed AIM project. Current operational performance, including the potential for the AIM project to increase the chance of an accident at IP2 and IP3, are addressed as part of the plants' current licensing basis and are outside the scope of the NRC staff's review of the license renewal application. The NRC provides continuous oversight of nuclear power plants through its ongoing Reactor Oversight Process, which applies as well to any IP2 or IP3 renewed operating licenses to verify that they are being operated and maintained in accordance with NRC regulations. This oversight includes having full-time NRC inspectors located at the plant and periodic safety inspections conducted by NRC inspectors based in an NRC regional office. The inspections look at a licensee's compliance with NRC's regulations, which include the following: plant safety (routine and accident scenarios), radiation protection of plant workers and members of the public, radioactive effluent releases, radiological environmental monitoring, emergency preparedness, radioactive waste storage and transportation, quality assurance, and training. Should the NRC discover an unsafe condition, or that a licensee is not complying with its licensing basis, the agency has full authority to take whatever action is necessary to protect public health and safety. Additional information related to the NRC's assessment of current performance at IP2 and IP3 can be found at http://www.nrc.gov/NRR/OVERSIGHT/ASSESS/IP2/ip2_chart.html (IP2) and http://www.nrc.gov/NRR/OVERSIGHT/ASSESS/IP3/ip3_chart.html (IP3).*

With respect to the statement, "February 6, 2016 a radioactive tritium leak at IPEC that has caused groundwater radioactivity levels to rise more than 65,000 percent," the NRC staff has updated its evaluation of the impacts of "Radionuclides Released to Groundwater" presented in Section 5.4 of this supplement to account for the recently identified increase in radionuclides in groundwater at IP2 and IP3.

As for the proposed AIM project, the NRC staff performed an independent confirmatory analysis of Entergy's site hazards analysis and confirmed that the proposed pipeline does not introduce significant additional risk to safety-related structures, systems, and components at IP2 and IP3 (NRC 2014e).

No changes were made to the supplement as a result of these comments.

B.1.11 Postulated Accidents, including SAMAs

The following comments correspond to NRC comment identifier 5-L17-1. Because of the length of the comment, the NRC staff has reproduced relevant quotations from the comment to convey its intended meaning.

Comment:

IV. Entergy Does Not Agree With The NRC Staff That the Uncertainty in Its Refined Engineering Project Cost Estimates Is "Large"

"In the Draft Supplement, the NRC Staff states that "there appears to be large uncertainty in the cost estimates." That statement is based principally on the Staff's review of AACE International's Recommended Practice (RP) No. 18R-97, "Cost Estimate Classification System - As Applied in Engineering, Procurement, and Construction for the Process Industries", which Entergy cited as providing relevant cost estimating principles and guidelines in its November 20, 2014 RAI Responses. Specifically, in assessing the degree of uncertainty associated with Entergy's refined engineering project cost estimates and performing the sensitivity analyses described in Section 3.1.3.3 of the Draft Supplement, the Staff used the lowest and highest values of certain "accuracy ranges" listed in AACE International's RP No. 18R-97. As most relevant here, the Staff thus assumed that Entergy's revised cost estimates could have overestimated actual SAMA implementation costs by 100 percent-*i.e.*, by a factor of two."

Entergy does not view it as reasonable to assume that the refined cost estimates are high by a factor of two (*i.e.*, +100 percent), insofar as that assumption informs the Staff's statement that "there appears to be large uncertainty in the cost estimates." Assuming that the refined cost estimates could be high by a factor of two is, in Entergy's view, akin to a worst-case assumption and thus contrary to NEPA's rule of reason."

"Furthermore, Entergy's refined cost estimates contain a level of detail that far exceeds that recommended in NRC Staff and NRC-approved industry guidance, or contained in the SAMA implementation cost estimates prepared by other license renewal applicants and approved by the NRC Staff. [...] The revised cost estimates reviewed by the NRC Staff in the Draft Supplement are, in fact, detailed engineering project cost estimates."

V. The Estimated SAMA Benefits to Which Entergy's Refined Engineering Project Cost Estimates Are Compared Reflect Substantial Conservatism in the Risk-Based Portion of the SAMA Analysis That Likely Bound the Uncertainties in the Cost Estimates

"It also is important to bear in mind that the "Estimated Benefit with Uncertainty" to which each refined SAMA implementation cost estimate is compared is a conservative value. In its 2010 FSEIS, the NRC Staff stated that "Entergy's bases for calculating the risk reduction for the various plant improvements...are reasonable and generally conservative (*i.e.*, the estimated risk reduction is higher than what would actually be realized.)" The NRC Staff further noted: "The SAMA evaluations were performed using realistic assumptions with some conservatism. On balance, such calculations *overestimate the benefits and are conservative.*"

VI. In View of the Foregoing Considerations, Entergy Recommends That SAMAs IP2-021 and IP2-053 Not Be Retained For Further Consideration

"In the Draft Supplement, the Staff recommends that Entergy retain SAMAs IP2-021 and IP2-053 for further consideration because "the incremental difference by which the SAMAs are not cost beneficial, when viewed in the context of uncertainties in the cost estimates, is too small to exclude them from further consideration." The Staff explains that:

The corrected refined estimated cost for SAMA IP2-021 is approximately \$4.63 million. When compared to the benefit with uncertainty of \$4.41 million, the SAMA is not cost beneficial by approximately \$224,000, which represents less than a 5-percent difference.

The corrected refined cost estimate for SAMA IP2-053 is approximately \$1.47 million. When compared to the benefit with uncertainty of \$1.39 million, the SAMA is not cost beneficial by approximately \$82,000, which represents less than a 6-percent difference.

Entergy respectfully disagrees with the NRC Staff's recommendation to retain SAMAs IP2-021 and IP2-053 for further evaluation for several reasons. First, as noted above, the Staff's recommendation to retain SAMAs IP2-021 and IP2-053 for further consideration is based on the notion that there is "large uncertainty" in the refined cost estimates-possibly on the order of +100 percent."

"Second, as stated in the ACEC International guidance, the Expected Accuracy Range "depend[s] on the technological complexity, appropriate reference information, and the inclusion of an appropriate contingency determination." Consideration of these factors relative to the two SAMAs in question-IP2-021 and IP2-053-leads Entergy to conclude that it is highly unlikely that refined cost estimates overestimate the cost of implementing those two SAMAs at IPEC."

"Third, the refined SAMA implementation cost estimates were compared to the estimated "Benefit with Uncertainty" for each of those SAMAs. As discussed in Section V, supra, the Benefit with Uncertainty value reflects various conservatisms, such that the the[sic] estimated risk reduction is higher than what would actually be realized by the implementation of the SAMA."

"Finally, as the NRC Staff notes, when any SAMA that was previously determined to be potentially cost-beneficial is implemented, the risk profile from which the SAMA analysis is derived will necessarily change. Therefore, after the initial SAMA analysis is completed, decisions to implement potentially cost-beneficial SAMAs should be viewed as a dynamic process."

Response: *This comment expresses disagreement with the NRC staff's recommendation that Entergy retain two SAMAs, IP2-021 and IP2-053, for further consideration, citing the level of detail in the cost estimates and the substantial conservatism in the calculated benefit with uncertainty for the two SAMAs as reasons for disagreement. The NRC staff acknowledges that the level of detail Entergy provided in its refined, engineering project cost estimates for the 22 SAMAs previously determined to be potentially cost beneficial exceeds that recommended in NRC and NRC-approved industry guidance, or contained in SAMA implementation cost estimates prepared by other license renewal applicants.*

Regarding the disagreement over the level of uncertainty associated with Entergy's revised cost estimates, the NRC staff based its judgement about uncertainties in the cost estimates on two factors: (1) the "Estimate Level" on the "Implementation Estimate Work Sheet" for each SAMA was marked as "Conceptual," and (2) each "Implementation Estimate" was classified as a "Class 4" or "Class 5" estimate defined per the ACEC Cost Estimate Classification System, in ACEC's RP No. 18R-97. As described in Section 3.1.3.3 of the FSEIS supplement, ACEC's RP No. 18R-97 defines five classes of cost estimates. Figure 1 of the recommended practice identifies secondary characteristics for the five estimate classes, one of those being the expected accuracy range. The NRC staff used the expected accuracy range for a Class 5 estimate because a few of the estimates were listed as Class 5, and it had the largest uncertainty range. As stated in Section 3.1.3.3 of this supplement, the NRC staff performed a cost-benefit estimate sensitivity analysis to determine if uncertainty in the cost would affect the outcome of the SAMA. When using the largest uncertainty, the NRC staff found that the

outcome for the SAMAs, with the exception of IP2-021 and IP2-053, would not be affected. Even if the NRC staff used the uncertainty range for a Class 2 estimate, whose “description” is more in line with the level of detail that was provided, the outcome would remain unchanged when using the upper end of the high range (high by 20 percent). The NRC staff notes that, if the lower end of the high range (high by 5 percent) is used, neither SAMA would be cost beneficial.

Regarding the calculated benefit for each of the SAMAs, the NRC staff agrees with the comment that there is conservatism built into the estimates. As discussed in Sections 5.2.4 and G.4 of the 2010 FSEIS, the NRC staff reviewed Entergy’s methodology and determined that the calculated benefits are “reasonable and generally conservative (i.e., the estimated risk reduction is higher than what would actually be realized).” Further, as noted in Section 3.1.4 of this supplement, the NRC staff acknowledges the dynamic nature of the SAMA process and that Entergy’s implementation of four SAMAs, as well as plant improvements associated with Order EA-12-049, will tend to lower the benefit derived from the remaining potentially cost-beneficial SAMAs. When providing its revised cost estimates, Entergy was not required to, nor did it choose to, provide revised benefit estimates. As such, the NRC staff compared the revised costs to the benefits documented in the 2010 FSEIS.

The NRC staff disagrees with the comment that SAMAs IP2-021 and IP2-053 should be excluded from further consideration. The NRC staff recommended against excluding SAMAs IP2-021 and IP2-053 from further consideration because both SAMAs are within 5 to 6 percent of being potentially cost beneficial, when compared with the current derived benefit. As discussed in NUREG–1555, Supplement 1, Revision 1, Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal (NRC 2013c), the NRC staff analyzes “any SAMAs with estimated implementation costs within a factor of 2 to 5 of the estimated dollar benefits to ensure that a sufficient margin is present to account for uncertainties in assumptions used to determine the cost and benefit estimates.” Although Entergy has provided an unprecedented level of detail in its revised cost estimates, given the relatively small amount by which the two SAMAs are not cost beneficial (i.e., less than 6 percent), retention of those SAMAs is reasonable in light of the uncertainties in assumptions used to determine the cost estimates. The NRC staff has revised the discussion throughout Chapter 3 to clarify that its recommendation is based on uncertainty associated with cost estimates, rather than the supposed “large” uncertainty associated with Class 4 or Class 5 estimates.

As noted in Section 3.2 of this supplement, the Commission directed the NRC staff to supplement the IP2 and IP3 SAMA evaluation with additional sensitivity analyses. The additional sensitivity analysis can be found in Section 3.2 of this supplement.

Comment:

VII. Although Entergy Agrees That the "Minor Discrepancies or Unexplained Costs" Identified in the Draft Supplement Do Not Alter Entergy's Conclusions About the Economic Viability of Any Proposed SAMA, Some Clarifications Are Warranted

“With respect to the six SAMAs identified by Entergy as being no longer cost-beneficial based on the refined engineering project cost estimates, the NRC staff noted that certain, limited aspects of those cost estimates “appeared to be errors, overestimations, or could not be readily understood.” Upon further review and assessment, however, the NRC staff concluded in Section 3.1.3.1 of the Draft Supplement that none of those issues affected Entergy’s conclusions regarding the economic viability of the relevant SAMAs.

Entergy agrees that none of the issues identified by the Staff in Section 3.1.3.1 has any effect on the SAMA cost-benefit analysis conclusions. Clarifications provided by Entergy in response to the Staff's statements in Section 3.1.3.1, confirms that any increases or decreases in the cost estimates associated with the minor issues identified by the NRC staff are less than 1.0 percent and thus are negligible in effect, especially when one considers of the overall scope and complexity of the cost estimates."

Response: *This comment provides additional detail to explain cost-estimate discrepancies noted in Section 3.1.3.1 of the supplement and affirms the NRC staff's conclusion that accounting for those discrepancies will not change the overall cost-benefit conclusions. The NRC staff acknowledges the clarifications to the staff's observations. As stated in the FSEIS supplement, the inclusion or exclusion of certain cost items would not alter Entergy's conclusion about the economic feasibility of the proposed modifications.*

No changes were made to the supplement as a result of this comment.

B.1.12 Special Status Species and Habitats

Comment 14-L11-2: Threatened and Endangered Species

The following comments are provided as technical assistance pursuant to the Endangered Species Act (ESA) of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.).

In a letter dated July 14, 2015, the Department's U.S. Fish and Wildlife Service (Service) provided its concurrence with the Nuclear Regulatory Commission's "not likely to adversely affect" determinations for the Indiana bat (*Myotis sodalis*) and northern long-eared bat (*M. septentrionalis*). No further consultation or coordination pursuant to the ESA is required with the Service unless project plans change (including the construction of cooling towers) or additional information on listed or proposed species or critical habitats becomes available. The most recent compilation of federally listed and proposed endangered and threatened species for each county in New York is available for your information on the New York Field Office website. Until the proposed project is complete, we recommend that you check this website every 90 days from the date of this letter to ensure that listed species presence/absence information for the proposed project is current. For additional information on fish and wildlife resources or state listed species, we suggest you contact the appropriate NYSDEC regional office(s) and the New York Natural Heritage Program Information Services.

Response: *This comment pertains to the NRC's concluded Endangered Species Act of 1973, as amended (ESA), section 7 consultation with the U.S. Fish and Wildlife Service (FWS) concerning Federally listed bats and the NRC's continuing duty to consider new information regarding Federally protected species and to reinstate consultation or coordination with the FWS as necessary. Section 7.0 of this supplement describes the outcome of the NRC's reinstated consultation with the FWS related to the listing of the northern long-eared bat (*Myotis septentrionalis*) as threatened under the ESA. Regarding the most recent lists of Federally listed and proposed species for New York counties, the NRC staff reviewed the FWS's Environmental Conservation Online System (ECOS) Web site (<https://ecos.fws.gov>) to determine if any new species or information exists that would require the NRC to reinstate consultation with the FWS for the proposed license renewal. At the time of publication of this supplement, the FWS lists the Indiana bat (*Myotis sodalis*), northern long-eared bat, and bog turtle (*Clemmys muhlenbergii*) as occurring in Westchester County, New York. The NRC staff has consulted with the FWS for each of these species, and the December 2010 FSEIS and Section 7.1 of this supplement document the results of these consultations. The NRC staff has no new information concerning these species that would require it to reinstate consultation at this time. Concerning other fish and wildlife resources and State-listed species, the NRC staff*

has not identified any new and significant information that would call into question its previous conclusions regarding the effects of the proposed IP2 and IP3 license renewal on terrestrial resources, which includes those effects that could be experienced by species and habitats designated with special status by the State.

No changes were made to this supplement as a result of this comment.

Comment 5-L17-7: In its December 2010 Final Supplemental Environmental Impact Statement ("FSEIS") for the Indian Point Units 2 and 3 ("IP2" and "IP3") license renewal application, the Nuclear Regulatory Commission ("NRC") Staff concluded that the closed-cycle cooling alternative would have "SMALL" impacts on federally-listed endangered and threatened species, including the endangered Indiana bat (*myotis sodalis*), because "of the lack of evidence of [endangered or threatened] species existing at the facility." Likewise, it concluded that the New York State-listed threatened bald eagle (*Haliaeetus leucocephalus*) was not present on the Indian Point site. However, Algonquin Gas Transmission, LLC ("Algonquin") recently commissioned surveys in connection with its Algonquin Incremental Market Project ("AIM Project"), parts of which are located on the Indian Point site. Those surveys establish that the Indiana bat and the recently listed threatened Northern Long-eared bat (*myotis septentrionalis*) are potentially present on the Indian Point site, and that the bald eagle is present on the site. Therefore, Entergy requests that in revising its December 2015 Draft Supplement (Volume 5) to the FSEIS in response to public comments, the NRC Staff consider this information, and include an evaluation of the impacts of alternative actions (e.g., the closed-cycle cooling alternative) on these federally-listed terrestrial species.

Comment 5-L17-9:

A. The Indiana Bat and Northern Long-eared Bat

In 2014, Algonquin commissioned a U.S. Fish and Wildlife Service ("FWS")-approved acoustic survey for the Indiana bat and Northern Long-eared bat in connection with its AIM Project, parts of which are located on the Indian Point site.⁷ As stated by the New York State Department of Environmental Conservation ("NYSDEC"), the Algonquin bat survey establishes that "both Indiana bats and the Northern Long-Eared [b]at may utilize the IPEC site as part of its summer habitat."

The closed-cycle cooling alternative action reviewed in the FSEIS involves activities that are known to adversely affect both the Indiana bat and Northern Long-eared bat. Specifically, construction of closed-cycle cooling at Indian Point is estimated to involve the elimination of 16 acres of forested land, blasting for 3 to 4 years and overall construction of six (6) years in duration within the forested area of the Indian Point site. In addition, the operation of closed-cycle cooling will increase noise levels within the remaining forested area on the site by at least 16 decibels (dBA).

The FWS previously considered construction, tree clearing and noise activities in its consultation on the renewal of Indian Point's NRC operating license, which underscores the potential for these activities to adversely affect both the Indiana bat and Northern Long-eared bat. Likewise, FERC's FEIS for the AIM Project stated that should bats be present in suitable summer habitat, tree clearing could potentially kill, injure, or disturb breeding or roosting bats and that bats could also be impacted by the loss of tree habitat or changes to vegetation if significant amounts of clearing were done. These statements were made with respect to the AIM Project but they apply as well to the construction and operation of closed-cycle cooling at Indian Point. Finally, the FWS previously has agreed that "noise may impact bats by interfering with echolocation, causing arousal during roosting or hibernation, inducing stress, causing avoidance of preferred habitats, or causing hearing loss." For these reasons, sustained

construction activities, including blasting, and the 16 dBA operational noise increases associated with the closed-cycle cooling alternative may adversely affect both the Indiana and Northern Long-eared bats.

Accordingly, Entergy respectfully requests that NRC revise and update the Draft Supplement to discuss the potential impacts of the closed-cycle cooling alternative action on both the Indiana and Northern Long-eared bat.

B. The Bald Eagle

In connection with the AIM Project, Algonquin also commissioned a survey of bald eagles. Conducted in March and April 2014, the survey identifies a bald eagle wintertime roost on the southern edge of the Indian Point site and northern edge of Lent's Cove Park (near the forested block of the Indian Point site). NYSDEC has confirmed these findings.

As with the Indiana and Northern Long-eared bats, the closed-cycle cooling alternative action reviewed in the 2010 FSEIS involves activities that are known to adversely affect the bald eagle. Specifically, the NYSDEC Draft Conservation Plan for Bald Eagles recognizes that new construction and blasting in the vicinity of bald eagle habitat, as required for the closed-cycle cooling alternative action, have the potential to adversely affect the bald eagle.

Therefore, Entergy respectfully requests that NRC revise and update the Draft Supplement to discuss the potential impacts of the closed-cycle cooling alternative action on the bald eagle.

C. Conclusions Regarding Impacts of Closed-Cycle Cooling Alternative Action on the Indiana Bat, Northern Long-eared Bat and Bald Eagle

Entergy is not aware of any reasonable mitigation for the impacts on the Indiana bat, Northern Long-eared bat and bald eagle of the protracted, continuous blasting that is necessary to install the closed-cycle cooling alternative. Entergy therefore respectfully requests that NRC revise Table 8–1 ("Summary of Environmental Impacts of a Closed-Cycle Cooling Alternative at IP2 and IP3") of the 2010 FSEIS (FSEIS Volume 1) to account for the unmitigated impacts that the closed-cycle cooling alternative action would have on the endangered and threatened species present at the Indian Point site, as presented above.

Response: *Comments 5-L17-7 and 5-L17-9 request that the NRC staff evaluate impacts to the Indiana bat, northern long-eared bat, and bald eagle (*Haliaeetus leucocephalus*) that could occur as a result of the closed-cycle cooling alternative in light of recent surveys in connection with the Algonquin Incremental Market Project that indicate these species' presence near IP2 and IP3. In Section 8.1.1.2 of the December 2010 FSEIS, the NRC states that impacts of the closed-cycle cooling alternative on Federally threatened or endangered species would be SMALL, because of both the site-specific environment and the lack of evidence that the species is present at the facility. The FSEIS further states that should the NYSDEC determine that cooling towers must be installed at the IP2 and IP3 site, the NRC would initiate ESA section 7 consultation with the FWS regarding the potential for impacts to Federally listed species.*

The NRC staff considered the recent survey information referenced in the comments and performed in connection with the Algonquin Incremental Market Project in the NRC's reinitiated consultation with the FWS concerning the Indiana bat and northern long-eared bat described in Section 7.0 of this supplement. In connection with that consultation, the NRC staff prepared a biological assessment (NRC 2015a) that considers the impacts of the proposed license renewal on the two species of bats. Biological assessments are not required to analyze alternatives to

proposed actions.¹⁴ Therefore, the NRC's biological assessment did not address the potential impacts that could result from implementation of the closed-cycle cooling alternative. The FWS concurred with the NRC's biological assessment in a letter dated July 14, 2015 (FWS 2015). The FWS's concurrence letter states that no further consultation or coordination pursuant to the ESA is required unless project plans change or additional information on listed or proposed species or critical habitat becomes available. Accordingly, and as stated in Section 8.1.1.2 of the December 2010 FSEIS, in the event that NYSDEC requires the installation of cooling towers at IP2 and IP3, consultation with FWS would be reinitiated to address impacts to Federally listed species. The NRC staff would, at that time, evaluate impacts based on the specific timing, location, and other parameters related to construction and operation of the cooling towers, in conjunction with any license amendment application that may be filed. During such a consultation, the NRC and FWS would address the impacts of both construction and operation, which could include habitat loss, disturbance, or modification resulting from tree clearing; noise; altered behavior caused by human activity; impacts related to salt drift, icing, and fogging; or direct injury or mortality caused by collisions with the cooling towers.

Concerning the bald eagle, this species was removed from the Federal list of threatened and endangered species in 2007. As such, Federal agencies are no longer required to consult under ESA section 7 for this species. However, bald eagles continue to be protected under the Bald and Golden Eagle Protection Act, which prohibits the taking of eagles, including their nests or eggs, without a permit issued by the FWS. The commenter requests that, in addition to the Indiana bat and northern long-eared bat, the NRC staff revise its assessment of impacts to terrestrial resources resulting from implementation of the closed-cycle cooling alternative to specifically include bald eagles because new survey information indicates that the species is present on the IP2 and IP3 site. At the time the NRC staff issued the December 2010 FSEIS, bald eagles had not been specifically documented as being present on the IP2 and IP3 site. However, Sections 2.2.6.1 and 2.2.6.2 of the 2010 FSEIS state that bald eagles congregate along the lower Hudson River in the winter and that Hudson River Miles 44 through 56, which are designated as a Significant Coastal Fish and Wildlife Habitat, provide important habitat for substantial numbers of bald eagles in the vicinity of the site. Further, Section 2.2.6.2 of the December 2010 FSEIS states that bald eagles have nested at locations along the Hudson River in the vicinity of the site in recent years. Because eagles are mobile and migratory and because bald eagles were known to occur in the vicinity of the IP2 and IP3 site at the time the NRC staff prepared the December 2010 FSEIS, the staff's evaluation of impacts from implementation of a closed-cycle cooling alternative on terrestrial resources in the December 2010 FSEIS is inclusive of potential impacts on bald eagles. The recent survey information indicating the bald eagle's presence on the IP2 and IP3 site does not change the NRC staff's conclusions regarding potential impacts to terrestrial resources described in Section 8.1.1.2.

No changes were made to this supplement as a result of this comment.

B.1.13 Support for License Renewal

Comment 19-L08-1: Keeping Indian Point Nuclear Generating Unit Nos. 2 and 3 working and on-line is critically important. We need them for fighting pollution and climate change. The wind does not blow all the time and the sun does not shine all the time. So wind and solar guarantee we burn fossil fuels most of the time. Stick with me and I will get to what will work.

¹⁴ See p. 3-12 of the "Endangered Species Consultation Handbook: Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act" (https://www.fws.gov/endangered/esa-library/pdf/esa_section7_handbook.pdf).

"Wind turbines generate electrical energy when they are not shut down for maintenance, repair, or tours and the wind is between about 8 and 55 mph. Below a wind speed of around 30 mph, however, the amount of energy generated is very small. Wind turbines produce at or above their average rate around 40% of the time. Conversely, they produce little or no power around 60% of the time." Please see:

<http://TinyURL.com/WindWatch>

Both wind and solar need to be backed up by other kinds of power plants. That backup is primarily coal, natural gas and biomass, which worsens Climate Change. In addition, new statistics show that windmills in the U. S. alone, are killing a million birds and a million bats every year - and insect-borne diseases are on the rise! A good web related web site is:

<http://TinyURL.com/WindTricks>

To be environmentally correct, we should be promoting super-safe, CO₂-free, 90% efficient, 24/7 nuclear power. France, which is about 75 % nuclear, provides a shining example, producing far less CO₂ per person than any other nation! France set these records with traditional nuclear plants, but today's Generation IV plants are even safer and more efficient. One of these new plants is the Molten Salt Reactor - MSR. Here is how MSRs compare to the reactors we have been using for 40-50 years. Unlike conventional reactors, MSRs

- are "walk away" safe: Automatically shut down if needed without human input.
- don't make hydrogen, so they can't explode.
- can consume about 90% of the stored waste created by conventional reactors.
- can't melt down because the fuel is supposed to be molten.
- don't need water cooling, so they can be built anywhere.
- are more efficient because they run much hotter.
- are better suited to desalinate water.
- don't need a huge, costly containment dome because they operate at normal air pressure.
- can be powered by super-abundant, highly efficient thorium. (A proof of concept MSR successfully ran at Oak Ridge National Labs for 22,000 hours during the 1960s.)

Let's eliminate subsidies for fossil fuels burners and massive wind and massive solar "farms" and increase the build rate for Generation-IV nuclear plants, especially MSRs.

There are remote areas where wind power and solar power make sense, but on a massive national scale, they don't because their inefficiency requires back up by power plants that burn more carbon.

For the negatives about wind and solar, and the reasons to promote CO₂-free, safe Generation IV nuclear power, especially MSRs, please investigate the Thorium Energy Alliance at:

<http://TinyURL.com/ThEnergyA>

Please also watch this YouTube video by Robert Hargraves, the author of *THORIUM: Energy Cheaper than Coal*, (available at Amazon books) which compares all the energy sources and promotes MSRs:

<http://TinyURL.com/ThCheaper>

Also see George Erickson's web site which covers energy and environmental topics in depth and supports nuclear power:

<http://TinyURL.com/EnergyReality>

The ball is in your court, and I hope that you will get everyone at the U.S. Nuclear Regulatory Commission on board. We must stop burning fossil fuels, especially coal. We must use what really will work - and that is nuclear power. Nothing else will address pollution and climate-change as effectively. Many organizations are already doing the engineering for MSRs.

Again, let's keep as many existing nuclear power plants on line as long as we can while building the newer Generation IV kind for the sake of addressing pollution and climate-change. Burning fossil fuels is killing more than 5 million people per year world wide. See:

<http://TinyURL.com/SmogKills5-5>

Comment 10-L09-1: Indian Point is a vital source of safe, reliable, clean energy to power the residential and industrial needs of New York state. Without the energy that Indian Point produces, New York will not only take an economic hit, but will also face rising carbon emission levels as less clean forms of energy are used in its place. Please keep Indian Point reactors in operation at least until a new generation of reactors can be built to replace the facility. Thank you.

Comment 9-L16-1: The African American Environmentalist Association (AAEA) is a national environmental organization based in Washington, DC with a local office in New York City. AAEA was founded in 1985 and is dedicated to the application of practical solutions to environmental problems.

Indian Point Nuclear Generating Units Nos. 2 and 3 (IP2 and IP3) are located in Westchester County in the Village of Buchanan, New York, approximately 24 miles north of New York City.

AAEA supports the renewal of operating licenses DPR-26 and DPR-64, held by Entergy Nuclear Operations, Inc. (Entergy), for the operation of IP2 and IP3, for an additional 20 years of operation.

Comment 6-L19-3: We appreciate that NRC must thoughtfully consider many factors in license renewal. For those of us who live in New York City and Westchester County, the prospect of losing IPEC is not a theoretical construct; it would mean breathing air that would contain millions of tons of pollutants that only IPEC's continued operation spares us. It would mean more illness and deaths from asthma and respiratory and pulmonary disorders. This kind of environmental impact is all too real.

Indian Point's continued operation reduces New York's need for fossil fuels. In light of New York's often poor air quality and continuing non-compliance with the federal Clean Air Act, it is imperative that IPEC's license be renewed.

Response: *These comments express support for the continued operation of IP2 and IP2, or nuclear power, in general. Comments cite the positive impacts from continued operation on air quality and climate change, the unreliability of wind and solar, and the likelihood that CO₂ emissions would increase, along with the concomitant negative impacts on climate change and human health, should the licenses not be renewed, as reasons for support.*

These comments are general in nature and provide no new and significant information. As such, no changes were made to the supplement in response to these comments.

B.1.14 Surface Water Resources

Comment 3-L20-7:

F. Reservation of Rights With Respect to State Water Quality Certification Denial Appeal and State Pollutant Discharge Elimination System Permit (SPDES) Proceeding

Riverkeeper understands that NRC Staff is directed to comply with NEPA, and further understands that NRC Staff is reviewing the environmental impacts within its jurisdiction which relate the continued operation of IPEC as presently configured. NRC [sic] Staff is similarly aware that the State of New York has denied a 401 water quality certification [for] IPEC and is completing proceedings combining Entergy's administrative appeal of the denial of a water quality certification with an ongoing SPDES proceeding. In that regard, Riverkeeper notes that Section 51 I(c)(2) of the Clean Water Act (CWA) precludes the NRC from second-guessing state conclusions and conditions contained in NPDES permits. 33 USC §1371 (c)(2); see also *Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions and Related Conforming Amendments*, 4 FR 9352-01 (*Public Service Co. of New Hampshire* (Seabrook Station, Units 1 and 2), CLI- 77-8, 5 NRC 503 (March 31, 1977); *In the Matter of Consol. Edison Co. of New York, Inc. (Indian Point, Unit No. 2) Power Auth. of the State of New York (Indian Point, Unit No. 3)*, 13 NRC 448, 449 (May 12, 1981). The NRC may not impose effluent limitations. *In the Matter of Pub. Serv. Co. of Oklahoma Associated Electric Coop., Inc. W. Farmers Electric Coop., Inc. (Black Fox Sta., Units 1 and 2)*, 8 NRC 281, 283 (Aug. 24, 1978) (*In the Matter of S. Texas Project Nuclear Operating Co. (S. Texas Project, Units 3 & 4)*, 72 N.R.C. 101, 137; (*In the Matter of Carolina Power and Light Co. (H.B. Robinson, Unit No. 2)*, 10 NRC 557, 561 [Oct. 31, 1979]; see also *In the Matter of Tennessee Val. Auth. (Yellow Cr. Nuclear Plant, Units 1 and 2)*, 8 NRC 702, 711-12 [Dec. 27, 1978]).

Response: *As Riverkeeper is aware, subsequent to its submission of this comment, the parties to legal proceedings related to the renewal of the operating licenses for IP 2 and IP 3 signed a closure agreement in January 2017. The terms of this agreement and outcomes are described in Chapter 2 of this supplement. Specifically, in accordance with the terms of the agreement and as detailed in Section 7.3 of this supplement, the State of New York has issued a renewed State Pollutant Discharge Elimination System (SPDES) permit for IP2 and IP3, as well as a Water Quality Certification in accordance with Sections 402 and 401, respectively, of the Federal Water Pollution Control Act (i.e., Clean Water Act (CWA)).*

NRC licensees are subject to conditions deemed imposed by the CWA as a matter of law, or State matters already governed by statute through CWA requirements and certification limitations. To operate a nuclear power plant, NRC licensees must comply with the CWA, including associated National Pollutant Discharge Elimination System permit requirements imposed by EPA or by NPDES program delegated States (the State of New York in the case of IP2 and IP3), as well as State Water Quality Certification requirements. More specifically, issuance of a renewed operating license for a nuclear power plant requires that the State has issued the licensee a Water Quality Certification as required by Section 401 of the CWA, or otherwise waived the requirement. In order to recognize that conditions and effluent limitations are deemed imposed by the CWA, the NRC's regulations at 10 CFR 50.54(aa) provide that each 10 CFR Part 50 "...license shall be subject to all conditions deemed imposed as a matter of law by section 401(a)(2) and 401(d) of the Federal Water Pollution Control Act, as amended (33 U.S.C.A. 1341(a)(2) and (d))[".]"

As a result of the actions taken by the State of New York pursuant to the closure agreement, the NRC staff has determined that Entergy has obtained all the necessary approvals to comply with 10 CFR 50.54(aa), including the necessary Water Quality Certification to demonstrate compliance with Section 401 of the CWA.

Comment 17-L14-4: The SEIS fails to consider the impacts of direct of [sic] thermal pollution produced by Indian Point 2 and 3 on climate change.

The above thermal infra-red image taken by scientists from GER/SpectroTech, Inc. indicates discharge temperatures from Indian Point to be up to 14.5 degrees hotter than ambient river water. One scientist noted that the plume appeared to be devoid of life. This image was taken in 1998, prior to the use of high-burn up fuel, which burns much hotter and most likely creates hotter discharge temperatures.

One of the primary byproducts of nuclear fuel generation is hot water, since water is used to cool the nuclear reactor and heats up during the process. Much of that hot water is dumped into lakes and streams; the process could potentially raise the temperature both of these bodies of water and of the ground.

Swedish scientists Bo Nordell and Bruno Gervet, in the International Journal of Global Warming, 2010, found that heat itself, not just gas, could change the climate, as net heat emissions, which includes low-temperature waste heat which is dumped into sea/river water or the atmosphere or heat leakage from buildings is transferred to the surrounding air or ground. Accordingly nuclear power is a large contributor to global warming.

Forty years of nuclear energy production worldwide has produced approximately 11% of worldwide electricity, yet has released approximately $1.58E+18$ BTUs, which is enough thermal heat to melt 25% of the earth's ice.

Indian Point 2 and Indian Point 3 has released $7.89E+15E$ BTUs over the past 40 years. 20 more years of operation, if permitted, would increase thermal pollution by $3.84E+15$ BTU. The cumulative thermal pollution releases from Indian Point 2 and 3 are approximately $1.18E+16$.

The SEIS does not consider thermal pollution impacts to climate change.

Response: *This comment expresses concern that this supplement does not consider the direct impacts of thermal pollution from IP2 and IP3 on climate change caused by the contribution of the heat produced by nuclear power plants and induced warming of land and water bodies.*

The NRC staff disagrees that it should have specifically considered the impacts of thermal pollution on climate change. The NRC staff did consider thermal impacts to receiving waters from IP2 and IP3 operations, GHG emissions from continued operation of IP2 and IP3 on global climate change, and the impacts of climate change on land and water resources. The preponderance of evidence, as expressed in the scientific literature, is that projections from climate change models continue to indicate that future climate change is primarily dependent on current and future GHG emissions (IPCC 2007a; USGCRP 2009, 2014). Future global GHG emission concentrations (emission scenarios) and climate models are commonly used to project possible climate change. This is the foundation for the NRC staff's analysis as presented in Sections 5.13.2 and 5.14.12 of this supplement. Section 5.13.2.2 of this supplement presents potential future climate change based on climate model simulations under future global GHG emissions scenarios and the NRC staff's analysis of the potential effects of climate change relative to the license renewal environmental review for the IP2 and IP3 site. As described in Section 5.13.2.2, the NRC staff considered the U.S. Global Change Research Program's (USGCRP's) most recent compilations of the state of knowledge relative to global climate change effects. The USGCRP brings together the best available climate change science from around the Nation and the world based on the collective efforts of 13 Federal departments and agencies, which carry out research and develop and maintain capabilities that support the Nation's response to global change.

Most researchers agree that human activities have an impact on local and regional climate. For example, USGCRP has extensively documented case studies of the “heat-island effect,” where temperatures in urban areas trend warmer as cities produce, absorb, and retain more heat than surrounding land areas (USGCRP 2009, 2014).

A recent study (Zhang et al. 2013) found a strong correlation between worldwide energy consumption and corresponding waste heat generation and seasonal temperature changes across part of the globe. The study’s authors conclude that the generation of waste heat in urban areas has had and can continue to have a measurable impact on surface temperatures (up to 1 degree Celsius (°C) (1.8 °Fahrenheit (F)) at considerable distances (thousands of miles) away by inducing changes in atmospheric circulation. In contrast, the study finds that, while the net effect on global mean temperatures is measurable, it is negligible, with waste heat contributing only about 0.02 °F (0.01 °C) to the average global temperature. The study results further show that total estimated human waste heat production is only about 0.3 percent of total global energy and heat transported, mainly natural solar energy, by atmospheric and oceanic circulations. The results suggest the need to account for energy consumption, in addition to anthropogenic GHGs, and other factors in future climate change projections.

Additionally, the NRC staff presented revised analyses of thermal impacts to receiving waters from IP2 and IP3 operations based on newly available thermal plume studies in the 2013 supplement to the 2010 FSEIS. The NRC staff revised its conclusion to SMALL, from SMALL to LARGE, based on the availability of thermal plume studies that were not available at the time it published the 2010 FSEIS. This supplement evaluated certain new information relating to aquatic resource impacts, including thermal impacts. As summarized in Section 8.0 of this supplement, the NRC staff’s examination of the new information from consultations with the National Marine Fisheries Service (NMFS) found that the level of impact for aquatic special status species remained SMALL.

No changes were made to the supplement as a result of this comment.

Comment 5-L17-14: In Section 5.14.3, page 104, lines 16-27, Entergy suggests that the NRC Staff consider noting (as it did in the context of discussing seismic hazards) that flooding hazards are evaluated under an ongoing NRC oversight program, and flooding hazard evaluation is not within the scope of license renewal.

Response: *This comment suggests that the NRC staff clarify that the review of the IP2 and IP3 design-basis flooding hazard is separate from its review of the license renewal application. The NRC staff agrees with the comment and has revised the text in Section 5.14.3 to specify that the reviews are separate.*

B.1.15 Terrestrial Resources

Comment 5-L17-12: In Section 5.5, page 76, lines 20-22, the Draft Supplement states: "Collectively, these measures ensure that the effects to terrestrial resources from pollutants carried by stormwater would be minimized during the proposed license renewal term." Since no impacts to terrestrial resources were identified, Entergy suggests that the NRC Staff revise this statement as follows: "Collectively, these measures ensure that ~~the effects to terrestrial resources from~~ pollutants carried by stormwater ~~would be minimized~~ are unlikely to have any adverse effects on terrestrial resources during the proposed license renewal term."

Response: *The comment concerns the NRC staff’s conclusion regarding the potential impacts from stormwater management on terrestrial resources. The NRC staff agrees with the comment and has revised Section 5.5 accordingly.*

Comment 5-L17-15: In connection with Section 5.14.5, page 106, lines 10-21, Entergy suggests that the NRC Staff distinguish between current impacts on terrestrial resources resulting from IP2 and IP3 operation, and *cumulative* impacts on terrestrial resources from past, present and foreseeably projects, by including a statement similar to the following: "**As previously discussed in Section 5.5, the NRC Staff concluded that the incremental impacts to terrestrial resources from the proposed license renewal of IP2 and IP3 would be SMALL.**"

Response: *This comment concerns the NRC staff's distinction between impacts of the proposed action and other past, present, and reasonably foreseeable projects in its assessment of cumulative impacts to terrestrial resources. The NRC staff agrees with the comment and has revised Section 5.14.5 accordingly.*

Comment 5-L17-11: In Section 5.5, page 76, lines 17-18, the Draft Supplement states: "Entergy further monitors areas with the potential for spills of oil or other regulated substances under a Spill Prevention, Control, and Countermeasure Plan [SPCC]..." Since IP2 and IP3 each have a SPCC, Entergy suggests that the NRC Staff revise this statement as follows: "Entergy further monitors areas at **IP2 and IP3** with the potential for spills of oil or other regulated substances under a **each unit's** Spill Prevention, Control, and Countermeasure Plan..."

Response: *This comment recommends a change to the text to specify that Entergy maintains a Spill Prevention, Control, and Countermeasure Plan for each unit. The NRC staff agrees with the comment and has revised the text in Section 5.5 of the supplement as suggested.*

B.1.16 Waste Management

Comment 17-L14-7: 6.0 Continued Storage of Spent Nuclear Fuel

The SEIS finding that short term (120 year) storage of additional radioactive waste produced if the requested new 20 years of a license is approved will have only SMALL impacts is wholly unsupported by fact.

The statement that indefinite timeframe -- continuing to store nuclear fuel indefinitely -- is unlikely, as well as wholly unsupported by fact or historical evidence.

Additionally the SEIS fails to consider how both long and short term storage will be maintained and continued without adequate decommissioning funds being available in perpetuity.

Response: *This comment expresses disagreement with the analysis and conclusions presented in NUREG-2157, Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel (NRC 2014c), with respect to short-term (60 years following licensed life) and long-term (100 years following the short term) onsite storage, including the provision of adequate decommissioning funding. As discussed in Section 6.1.1 of this supplement, the analyses of the environmental impacts associated with spent fuel storage beyond the licensed life for reactor operations contained in NUREG-2157 are deemed incorporated into this FSEIS supplement.*

Disposal of spent fuel in a geologic repository remains the national policy, and Appendix B to NUREG-2157 discusses the feasibility of a repository. The lack of a repository does not require that the operating power reactors be shut down, that existing power reactor licenses not be renewed if all other NRC license renewal requirements are met, or that new licenses for nuclear power plants not be issued. The NRC has licensing requirements and regulations in place to assure that spent fuel remains safely stored in spent fuel storage facilities until a repository becomes available. This includes provisions for assuring that adequate licensee funding is available. Further, NUREG-2157 assumes, in its assessment of impacts for the short-term and long-term timeframes, that a repository will be available; in the indefinite timeframe, it assumes

that no repository becomes available. As discussed in Appendix B to NUREG–2157, the NRC believes that the most likely scenario is that a repository will be available by the end of the short-term timeframe (NUREG–2157, Vol 1, Appendix B at B-2). See also response to Comment 3-L20-1, below.

This comment provides no new and significant information for the NRC staff to consider.

No changes have been made to the supplement as a result of this comment.

Comment 3-L20-1:

A. The [Draft FSEIS Supplement]'s Discussion of Spent Fuel Storage Impacts Is Inadequate to Satisfy NEPA

The [draft FSEIS supplement] states that NRC is now relying on the Continued Spent Fuel Storage Generic Environmental Impact Statement (Continued Spent Fuel Storage GEIS) for impact findings regarding continued storage of spent fuel after cessation of operations, including pool leaks, fires, and dry storage for an extended period. Draft 2SEIS at iii, 115-123. The Continued Spent Fuel Storage GEIS is inadequate to support the re-licensing of Indian Point Units 2 and 3 because it suffers from the following failures:

- In blatant violation of NEPA and the Court's decision in *State of New York v. NRC*, 681 F3d 471 (DC Cir 2012) ("*New York I*"), the Continued Spent Fuel Storage GEIS fails to examine the probability and consequences of failure to site a repository. Instead of examining the risk of failing to site a repository, the GEIS rationalizes the risk away, by arbitrarily assuming that spent fuel will be protected by "institutional controls" for an infinite period of time at reactor sites. This assumption is not only absurd and inconsistent with the Nuclear Waste Policy Act ("NWPA"), but it also defeats the Court's purpose of forcing NRC to reckon with the environmental consequences of its failure to site a repository.
- The GEIS fails to acknowledge that the Continued Spent Fuel Storage Rule enables licensing and relicensing, and therefore it distorts the statement of purpose and need for the rule as relating solely to administrative rather than environmental concerns. As a result, the GEIS also mischaracterizes the alternatives that must be considered. Instead of evaluating alternatives related to storage and disposal of spent fuel, the GEIS examines alternatives related to the administrative question of how to prepare an EIS. The result is a farcical cost-benefit analysis that utterly fails to address alternatives for avoiding or mitigating the environmental impacts of storing spent fuel or siting a repository.
- The GEIS' analysis of the environmental impacts of extended spent fuel storage ignores the fact that NRC knows very little about the behavior of spent fuel in long-term or indefinite storage conditions, especially the potentially significant effects of long-term dry cask storage on high burnup fuel integrity. In violation of NEPA, the NRC makes no attempt to quantify these uncertainties.
- The GEIS fails to fully consider the environmental impacts of spent fuel pool leaks and fires. In violation of NEPA, the GEIS relies upon incomplete data, adopts a flawed concept of risk, and ignores a range of causes for accidents.
- In violation of NEPA, the GEIS makes no attempt to show how the environmental impacts associated with the Continued Spent Fuel Storage Rule will be quantified and incorporated into cost-benefit analyses for nuclear reactors. Although spent fuel disposal and long-term storage costs are high enough to tip the balance of a

cost-benefit analysis for reactor licensing away from licensing, nowhere does the NRC explain how it will take these costs into account in reactor licensing decisions.

- In violation of NEPA, the GEIS fails to support the limited conclusions in the Continued Spent Fuel Storage Rule and GEIS regarding the technical feasibility of spent fuel disposal.
- The NRC has splintered the analysis of environmental impacts associated with storage and disposal of spent fuel into an array of safety findings and environmental analyses. While the issues covered by these separate findings and analyses overlap and involve cumulative impacts, the NRC refuses to integrate them. The NRC also refuses to correct inconsistencies between them.

These deficiencies are discussed in detail in Riverkeeper's comments on the proposed version of the Continued Spent Fuel Storage GEIS and accompanying Rule. The Riverkeeper et al. Comments were supported by expert declarations by Dr. Arjun Makhijani, David Lochbaum, Dr. Gordon Thompson, and Mark Cooper (ADAMS Accession No. ML14030AI52). Riverkeeper has appealed the Rule and GEIS to the U.S. Court of Appeals for the D.C. Circuit.

Riverkeeper recognizes that the NRC Staff is precluded by 10 C.F.R. §51.23 from modifying the [draft FSEIS supplement] to address Riverkeeper's comments. Riverkeeper respectfully submits that such preclusion is unlawful, given the Continued Spent Fuel Storage GEIS' complete failure to comply with NEPA in addressing the environmental impacts of continued storage of spent fuel or reasonable alternatives to the continued generation of spent fuel through the re-licensing of Indian Point Units 2 and 3.

Response: *This comment states the opinion that NUREG–2157 is inadequate and should not be used to support a licensing decision. The NRC staff disagrees with this comment. As discussed in Section 6.1.1, NUREG–2157 went through a rulemaking process that involved significant input from the public. As noted in the comment above, the commenter's perceived deficiencies in NUREG–2157 were provided to the NRC during the public comment period for that document. The NRC staff considered all public comments received, including the ones referenced above, and modified NUREG–2157, as necessary and appropriate, to address the issues identified. Responses to public comments received on NUREG–2157 can be found in Appendix D of that document. The findings and conclusions in NUREG–2157 apply generically to NRC nuclear power reactors, and no information has been provided to indicate that those generic determinations do not apply to IP2 and IP3. Therefore, the NRC staff concludes that NUREG–2157 provides the appropriate NEPA analyses of the potential environmental impacts associated with the continued storage of spent fuel beyond the licensed life for reactor operations at IP2 and IP3 and that this comment offers no new information.*

No changes were made to the supplement in response to this comment.

Because of the length of the following comments, the NRC staff has reproduced relevant quotations from the comments to convey their intended meaning.

Comment 18-L13-1:

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

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

A. Population

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

"The area around Indian Point has a population density of 2,138 people per square mile. GEIS 2-4 to 2-5."

B. Drinking Water Resources

"The reactors and fuel pools are also 6 miles west of the New Croton Reservoir in Westchester County, which is part of the New York City reservoir system and provides drinking water to New York City residents. They are also in close proximity to other reservoirs in the New York metropolitan area."

C. Economic Costs

"The economic cost model of the MACCS2 code is intended to estimate the direct offsite costs from a severe nuclear accident. If other indirect costs were included such as medical expenses, adverse health effects, permanent income loss, costs of disposal of contaminated wastes, and economic impact of losing a resource--including the loss of drinking water and replacement for reservoirs during interdiction- the total economic cost would increase."

D. Topography and Meteorology

"The Indian Point facilities were constructed close to the river bank and are located at a relatively low point in the valley formed by the Hudson River."

"These river, hills, and topography tend to concentrate wind direction to the south (toward the New York City metropolitan area) or to the north toward the U.S. Military Academy at West Point or Hudson River cities and towns."

E. Improvements and Unique Sites within 50 miles

"The communities within the 50-mile radius around Indian Point also contain some of the most densely-developed and expensive real estate in the country, critical natural resources, centers of national and international commerce, transportation arteries and hubs, and historic sites."

F. The Hudson River Ecosystem

"The Indian Point facilities are located on the eastern bank of the Hudson River (at river mile 43). [...] The Hudson River is an important regional resource of significant aesthetic value in addition to providing transportation, recreation, and water supply."

G. Seismic Hazard

"Risk is a function of two components: the probability that the harm will occur and the severity of the consequences if it does. The probability of a pool fire depends in substantial part on the geography of the location, including the likelihood of earthquakes, as the GEIS recognizes."

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

H. Interaction with the Existing Algonquin Pipeline

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

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

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

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

“When the federal government first licensed the operation of Indian Point Unit 2 and Indian Point Unit 3 it authorized each unit's single spent fuel pool to hold 241 spent fuel assemblies. NRC subsequently authorized the pools to hold five times (5x) the original limit.”

K. History of Leaks at Indian Point

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

L. Decontamination Costs

“In 2010, the NRC informed the Environmental Protection Agency and the Federal Emergency Management Agency (FEMA) that the industry-funded account established under the Price Anderson Act would likely not be available to pay for offsite decontamination in the event of a severe accident at a nuclear plant.”

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

M. Sabotage

“Any site-specific review of the environmental impacts at Indian Point must examine the impacts of sabotage on the facilities.”

N. Need for Objective Site-Specific Analysis

“Given the combination of site-specific characteristics, the decontamination costs and resource replacement costs following a severe accident at Indian Point have the potential to be substantially larger than an accident at any other reactor in the country. Furthermore, in light of the site-specific characteristics and the considerable costs associated with a severe nuclear accident in the New York metropolitan area, mitigation alternatives are likely to be more cost effective at the Indian Point facilities.”

Response: *This comment states that the NRC staff should evaluate the site-specific environmental impacts from the continued storage of spent fuel at IP2 and IP3, listing various characteristics of the site and the surrounding area as a basis for support.*

The 2010 FSEIS and this supplement addressed site-specific matters such as SAMAs (which includes a consideration of seismically initiated severe accidents) and groundwater leaks at IP2 and IP3. The comment provides no new and significant information that the NRC staff has not considered with respect to these matters. Further, as discussed in Section 6.1 of this supplement, NUREG–2157 (NRC 2014c), contains the NRC’s evaluation of the environmental impacts of the continued storage of spent fuel. In preparing NUREG–2157, the NRC provided members of the public, Tribal governments, State governments, and various other organizations an opportunity to raise site-specific considerations that might indicate that certain analyses or impact determinations could not be generically resolved. Commenters raised a variety of issues that they felt warranted site-specific consideration, including the issues identified in this comment (e.g., response to comments 718-1-1 through 718-1-8, 718-1-11, 718-1-12 in Appendix D to NUREG–2157). In response to public comments, the NRC made clarifying changes and added additional information to some portions of NUREG–2157 and the final Continued Storage Rule (79 FR 56238). However, the public comments did not raise any information that would cause the NRC to conclude that any of the generic impact determinations in NUREG–2157 would be invalid at any particular site. Accordingly, the NRC issued its September 2014 revision to the regulations at 10 CFR 51.23, which adopts the generic impact determinations made in NUREG–2157 and codifies the NRC’s generic determinations regarding the environmental impacts of continued storage of spent nuclear fuel beyond a reactor’s operating license. The commenter has provided no information that would indicate that the generic findings and conclusions in NUREG–2157 do not apply at IP2 and IP3. As explained in Section 6.1.1 of this supplement, pursuant to 10 CFR 51.23, the impact determinations of NUREG–2157 are deemed incorporated into this FSEIS supplement. As these impact determinations are deemed incorporated in this proceeding by regulation, any participant seeking to revisit the generic analyses of NUREG–2157 based on asserted site-specific differences are required to seek a waiver from the application of 10 CFR 51.23 by satisfying the waiver requirements specified in the NRC’s regulations at 10 CFR 2.335. Further, regarding impacts at IP2 and IP3, no new and significant information has been provided that would warrant consideration in this site-specific proceeding.

Regarding the questions about decontamination in the event an accident that causes the release of radiological contamination offsite, the National Response Framework and National Disaster Recovery Framework describe the roles and responsibilities of Federal agencies, including the NRC, and their interactions with each other and State, local, and Tribal governments during and after an emergency (NRC 2014b). The NRC is designated as the coordinating Federal agency for incidents involving materials or facilities licensed by the NRC or Agreement States (FEMA 2008). For radiological accidents for which the NRC is the coordinating agency, the National Response Framework (FEMA 2008) states that:

[T]he coordinating agency coordinates environmental remediation/cleanup in concert with cognizant State, tribal, and local governments, and owners/operators, as applicable. While retaining technical lead for these activities, the coordinating agency may request support from a cooperating agency that has cleanup/recovery experience and capabilities (e.g., EPA, USACE).

State, tribal, and local governments primarily are responsible for planning the recovery of the affected area. (The term “recovery,” as used here, encompasses any action dedicated to the continued protection of the public and resumption of normal activities in the affected area.) Recovery planning generally does not take place until the initiating conditions of the incident have stabilized and immediate actions to protect public health,

safety, and property are accomplished. Upon request, the Federal Government assists State, tribal, and local governments with developing and executing recovery plans.

Regarding funding, the Federal Government has established a liability support infrastructure to ensure that there is no delay in the implementation of mitigation efforts or recovery because of liability concerns. Primary components of this infrastructure include the Price-Anderson Act and the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) (NRC 2014b).

The purpose of the Price-Anderson Act is to cover liability claims of members of the public for personal injury and property damage caused by a nuclear accident involving a commercial nuclear power plant. Insurance under Price-Anderson covers bodily injury, sickness, disease or resulting death, property damage and loss, as well as reasonable living expenses for individuals evacuated. If funding under the Price-Anderson Act is depleted, Congress is committed to determining whether additional disaster relief is required.

As further stated in NUREG-0728, NRC Emergency Preparedness and Incident Response Programs (NRC 2014b), in the event that:

[An] incident is anticipated to exceed state resources or when the Federal Government has unique capabilities needed by states, the governor may request Federal assistance under the Robert T. Stafford Disaster Relief and Emergency Assistance Act. In such cases, the affected local jurisdiction and the State, Tribal, territorial, insular area, and Federal governments coordinate to provide the necessary assistance. The Federal Government may provide assistance in the form of funding, resources, and services.

No change were made to the supplement as a result of this comment.

Comment 18-L13-2:

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

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

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

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

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

Comment 18-L13-5: The GEIS fails to consider site-specific impacts as well as migration measures and alternatives to long-term continued storage in spent fuel pools. Those deficiencies include the failure to conduct a site-specific severe accident mitigation alternatives analysis for the Indian Point spent fuel pools. Since no legally sufficient prior analysis of spent fuel pool severe accident mitigation alternatives has been completed, NRC is obligated to assure that such an analysis has occurred for Indian Point and that all reasonable severe accident scenarios and mitigation measures have been evaluated. Instead of focusing on only one pool at a time, that analysis should take into account both spent fuel pools as well as the specific site-wide profile presented by entire set of operations authorized by the operating licenses. Such site-specific mitigation alternatives analysis must be completed and incorporated into a revised draft environmental impact statement. Accordingly, Staff should withdraw the draft Supplement and complete such an analysis.

Response: *These comments state that the Continued Storage GEIS (NUREG–2157) and/or the draft FSEIS supplement failed to properly consider alternatives to and mitigation measures for the continued storage of spent fuel. Additionally, one comment states that the NRC staff should conduct a site-specific SAMA analysis for the IP2 and IP3 spent fuel pools.*

The NRC staff disagrees that it failed to properly consider alternatives and mitigation. The NRC’s regulations at 10 CFR Part 51 require the NRC staff to evaluate the impacts from reasonable alternatives to the proposed action, including the impact from not taking the action, referred to as the No-Action Alternative. As described in Section 1.3 of the 2010 FSEIS and restated in the Executive Summary of this supplement, the proposed action in this case is the renewal of the operating licenses for IP2 and IP3. Accordingly, Chapter 8 of the 2010 FSEIS evaluates a range of reasonable alternatives to the proposed action (license renewal) that would satisfy the purpose and need of the proposed action, which is described in Section 1.3 of the 2010 FSEIS as, “to provide an option that allows for power generation capability beyond the term of a current nuclear power plant operating license to meet future system generating needs.” Chapter 8 of the 2010 FSEIS also evaluates the impacts from the No-Action Alternative.

To the extent that these comments suggest that the NRC staff should consider the site-specific impacts from continued storage of spent fuel, pursuant to 10 CFR 51.23, the impact determinations of NUREG–2157 are deemed incorporated into this FSEIS supplement. No new and significant information has been provided to suggest that the generic findings and conclusions in NUREG–2157 do not apply to IP2 and IP3. As these generic impact determinations are deemed incorporated in this proceeding by regulation, any participant seeking to revisit the generic analyses of NUREG–2157 based on asserted site-specific differences is required to seek a waiver from the application of 10 CFR 51.23 by satisfying the waiver requirements specified in the NRC’s regulations at 10 CFR 2.335. Further, regarding impacts at IP2 and IP3, no new and significant information has been provided that would warrant consideration in this site-specific proceeding.

Regarding mitigation, the NRC staff disagrees with the comments that it did not appropriately consider mitigation. The issues identified in comments—spent fuel pool leaks and fires—are not unique to continued storage or to IP2 and IP3. In fact, they are equally relevant to the period of extended operation as they are to the short-term continued storage timeframe analyzed in NUREG–2157. Therefore, the discussion of mitigation measures considered for these issues during the period of extended operation is applicable as well for continued storage.

Regarding mitigating spent fuel pool fires, the license renewal GEIS evaluates the Category 1 issue of spent fuel storage during the license renewal term and concludes that the issue has SMALL environmental impacts. Further, like other Category 1 issues, the license renewal GEIS (NRC 2013a) concludes that "additional plant-specific mitigation measures are not likely to be sufficiently beneficial to warrant implementation." Similarly, NUREG-2157 (NRC 2014c) concludes that the environmental impacts of spent fuel pool fires during the short-term timeframe (after which the spent fuel will be removed from the spent fuel pool) are SMALL, further noting that "as the fuel continues to age after reactor shutdown, it will become less hazardous due to radioactive decay and the reduction of the heat generated by the spent fuel. Thus, both the consequences and risk [...] will continue to decrease" (NRC 2014c). Therefore, it is not necessary to consider mitigation measures beyond what was considered for the period of extended operation.

As for the mitigation of spent fuel pool leaks, the NRC staff evaluates the impacts from radionuclides released to groundwater at IP2 and IP3 in Section 5.4 of this supplement. As discussed in Section 5.4, Entergy has a groundwater monitoring program in place to readily detect new leaks, thereby allowing corrective actions to be quickly taken. Additionally, as discussed in Section 5.4.3, Entergy is employing monitored natural attenuation to mitigate the impacts of existing onsite contamination. This is consistent with what would be expected during the short-term continued storage timeframe (see Section E.1.3 of NUREG-2157); therefore, additional consideration of mitigation measures specific to continued storage is not necessary.

See response to Comment 18-L13-4 for a discussion about the need for a site-specific SAMA analysis for the IP2 and IP3 spent fuel pools.

Additionally, as discussed in Section E.3.7 of the license renewal GEIS (NRC 2013a) and as further elaborated in Section F.1.2 of NUREG-2157 (NRC 2014c), the NRC has required licensees to take additional actions since the terrorist attacks of September 11, 2001, and the March 11, 2011, reactor accidents at Fukushima Dai-ichi in Japan to reduce the likelihood of a spent fuel pool accident. Some examples of the actions taken since 2001 include requiring licensees to install additional spent fuel pool instrumentation and implementation of mitigating strategies to ensure that spent fuel pool cooling can be accomplished. Further, the NRC is engaged in a rulemaking (Docket ID NRC-2014-0240) that codifies the Orders issued in response to the reactor accidents at Fukushima Dai-ichi and contemplates additional actions to enhance spent fuel pool coolability in the event of a beyond-design-basis event. The sum of the NRC's actions taken since 2001 serve to further reduce the already low probability of a spent fuel pool accident.

No changes were made to the supplement as a result of these comments.

Comment 18-L13-3:

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

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

factors may make facilities more or less vulnerable to such fires, may require different mitigation measures, and may lead to different environmental impacts.

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

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

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

2. Other Alternatives

“While removing spent fuel and placing it in dry cask storage remains the safer alternative, there are other steps that can also contribute to reducing the risk of zirconium cladding fires in spent nuclear fuel pools. For example, the fuel assemblies in pools can be arranged in a checkerboard pattern so that newly discharged fuel is surrounded by older, cooler fuel.”

Response: *This comment states that the NRC should evaluate alternatives to mitigate spent fuel pool fires, including reducing spent fuel pool density by expediting the transfer of spent fuel into dry casks, as well as other alternatives, such as alternate spent fuel loading and additional administrative controls for spent fuel offload.*

The NRC staff disagrees with the comment. As discussed in the response to Comment 18-L13-2, above, the NRC staff has determined that additional mitigation for spent fuel pool accidents at nuclear power plants is not warranted.

Regarding the alternatives mentioned in the comment, including expedited transfer and alternate loading patterns, in November 2013, the NRC (2013e) completed a regulatory analysis in response to questions about safe storage of spent fuel in spent fuel pools following the March 2011 accident at the Fukushima Dai-ichi nuclear power plant. To determine if additional studies were needed, the NRC conducted a two-part analysis of expedited transfer. The NRC staff first assessed the potential safety benefits by using the Commission's 1986 Safety Goal Policy Statement. The NRC staff then performed a cost-benefit analysis to provide additional information for the Commission's consideration. As part of the analysis, the NRC staff performed sensitivity studies on key factors, such as the dollars per person-rem conversion factor, population density, habitability criteria, and the consideration of consequences beyond 50 miles, to measure each attribute's effect upon the overall result. The sensitivity studies showed that some of the cases could result in large economic consequences, such that the calculated benefits from expedited transfer of spent fuel to dry cask storage for those cases outweigh the associated costs; however, even in these cases, there is only a limited safety benefit when using the quantitative health objectives in the Commission's Safety Goal Policy Statement, and the expected implementation costs would not be warranted. Overall, the NRC staff (2013e) determined that requiring the expedited transfer of spent fuel would provide only a minor or limited safety benefit (i.e., below the safety goal screening criteria) and that its expected implementation costs would not be warranted.

As part of its regulatory analysis (NRC 2013e), the NRC considered other improvements to spent fuel pool storage in addition to assessing whether expedited transfer is warranted. For example, the NRC considered 1x8 high-density loading patterns, in which spent fuel recently unloaded from a reactor that still has relatively high decay heat is surrounded in the spent fuel pool by cooler spent fuel assemblies in each of the adjacent eight positions in a spent fuel pool rack. The NRC found that these alternatives would likely involve lower costs than expedited

transfer but that they would only provide limited safety benefit and the costs would not be warranted.

In 2014, the NRC closed the activity related to expedited transfer of spent fuel; however, the Commission directed the NRC staff to modify the regulatory analysis to explain why the 1x8 spent fuel pool loading configuration was not found to provide a substantial increase in safety (NRC 2014a). In response to the Commission's direction, the NRC staff issued an addendum to its regulatory analysis, in which it performed a cost-benefit analysis for the 1x8 spent fuel loading pattern (NRC 2014d). Based on its evaluation, the NRC staff concluded that the 1x8 loading pattern would provide only a minor safety benefit (i.e., less than safety goal screening criteria) and that its expected implementation costs would not be warranted.

No changes were made to the supplement as a result of this comment.

Comment 18-L13-4:

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

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

The State calls on NRC to revise its approach to severe accident mitigation alternatives (or SAMA) analyses. Under 10 C.F.R. §51.53(c)(3)(ii)(L), NRC must conduct a site-specific review of alternatives to mitigate a severe accident at a reactor that seeks to renew its operating license. NRC promulgated this regulation in 1996 in response to the court ruling in *Limerick*. However, while NRC purports to examine alternatives to mitigate severe accidents that occur in the reactor, applicants and NRC do not review alternatives to mitigate severe accidents that occur in the *spent fuel pool* that is adjacent to the reactor but outside of the containment shell.”

Response: *This comment states that the NRC staff should perform a SAMA analysis for the IP2 and IP3 spent fuel pools, citing the reactor accidents at Fukushima Dai-ichi as an example of spent fuel pool accident consequences. The comment also lists issues that should be considered in the preparation of a spent fuel pool SAMA analysis.*

The NRC staff disagrees with the comment. As noted in the comment, NRC regulations at 10 CFR 51.53(c)(3)(ii)(L) require SAMA analyses for power reactors, but the NRC does not currently require SAMA analyses for spent fuel pools. The NRC's regulations at 10 CFR 2.802 provide a procedure for interested parties to request a change to NRC regulations should they wish to do so.

As described in a 2008 Denial of Petition for Rulemaking (73 FR 46204), the NRC considers the likelihood of a spent fuel pool fire to be lower than that estimated in NUREG–1353 (NRC 1989), and NUREG–1738 (NRC 2001), which are the basis for consequence and probability values reported in NUREG–2157 (NRC 2014c). Thus, the very low probability calculated for a spent fuel pool fire means that the risk is less than that of a reactor accident. Therefore, a SAMA analysis would not be expected to have a significant impact on total risk for a site. Further, as discussed in the previous comment response in this section, the NRC has taken actions since the 2008 Denial that likely further reduce the probability of a spent fuel pool accident.

The NRC staff disagrees that the reactor accidents at Fukushima Dai-ichi support the need for a spent fuel pool SAMA. As discussed in Section F.1.2 of NUREG–2157 (NRC 2014c), none of the water levels for any of the spent fuel pools at the Fukushima Dai-ichi site dropped below the

top of the fuel and no significant damage occurred to the fuel in the pools, despite the fact that spent fuel cooling was lost for multiple days.

No changes were made to the supplement as a result of this comment.

B.2 Public Comments Received on the Draft Supplement Concerning Aquatic Resources and NRC Staff Responses

The NRC staff received comments concerning its assessment of impacts to aquatic resources that would result from the proposed IP2 and IP3 license renewal from the following sources: Entergy and its contractors (collectively referred to in this section as “Entergy”); NYSDEC; Riverkeeper, Inc. and its contractor Pisces Conservation Ltd (collectively referred to in this section as “Riverkeeper”); the U.S. Department of the Interior (DOI); and EPA. Consistent with how the NRC staff handled comments in Section B.1 of this appendix, the staff grouped individual comments by topic. Because many of the aquatic resource comments are voluminous, the NRC staff did not reproduce each comment in its entirety. Rather, under each topic, the NRC staff lists the relevant comment identifiers and briefly summarizes those comments. The NRC staff’s response then follows. Due to the length and complexity of the comments, many comments appear under more than one topic. Only the portion of the comment relevant to the applicable topic is addressed in each comment response; therefore, the reader may need to refer to several comment responses to view the NRC staff’s complete response to a single comment.

B.2.1 Comments Related to Impingement and Entrainment Mitigation and the Clean Water Act

Relevant Comments: 14-L11-1, 12-L15-1, 12-L15-2, 12-L15-8, 12-L15-9, 11-L21-3, 5-L22-1,5-L22-5

Comment Summary: A number of comments concern impingement and entrainment (I&E) mitigation, including the best technology available (BTA) for minimizing adverse environmental impact, and authorities and expertise under the CWA.

In its comments, DOI states that it understands that NYSDEC is considering adding wedgewire screens and cooling towers and imposing seasonal shutdowns during critical fish spawning periods as options for reducing the entrainment impacts of the IP2 and IP3 cooling system. DOI states that it believes cooling towers to be BTA under the CWA and to represent the most effective method of minimizing fish entrainment.

In its comments, NYSDEC states that it has the proper authority and expertise to make determinations of adverse impact to Hudson River fish populations under the CWA and, as such, should be afforded substantial deference in its determination regarding I&E impacts. The NYSDEC states that it and NMFS have identified closed-cycle cooling (i.e., cooling towers) as BTA. The NYSDEC states that the NRC should not issue renewed licenses for IP2 and IP3 without significant mitigation and that Entergy should be required to implement mitigation to address adverse impacts to aquatic resources. In some of its comments, the NYSDEC states that the NRC should require Entergy to install and operate a closed-cycle cooling system as part of the license renewal. The NYSDEC states that a closed-cycle system is the only option short of seasonal or permanent closure of IP2 and IP3 that will result in a minimal adverse impact on the Hudson River fish community.

The EPA states in its comments that IP2 and IP3’s Ristroph screen and fish return system was independently reviewed by Federal and state agencies and determined to be a compliant intake structure pursuant to CWA § 316(b).

In its comments, Entergy states that retrofitting IP2 and IP3 with cooling towers would be a complex and costly undertaking. Entergy also discusses evidence developed during ongoing State litigation proceedings that demonstrates numerous unresolved adverse environmental impacts associated with installing cooling towers at IP2 and IP3, as well as uncertainties associated with the various State and local environmental and zoning permits and authorizations that cooling tower installation would require. Entergy highlights EPA's comments and disputes DOI's comments concerning BTA. Entergy states that EPA's perspective is important because it acknowledges that the IP2 and IP3 Ristroph screens and fish return system are BTA. Entergy states that DOI's BTA comments lack sufficient factual support and that DOI is not responsible for and does not have the proper expertise for making BTA determinations under CWA §316(b). Entergy states that EPA or delegated state decisionmakers, and not DOI, are responsible for making BTA decisions pursuant to CWA § 316(b). Entergy states that the EPA's CWA §316(b) regulations provide flexibility to existing facilities in stating that there is no single technology that is BTA.

Response: *The NRC staff agrees in part and disagrees in part with these comments. Section 316(b) of the CWA and its implementing regulations establish requirements pertaining to cooling water withdrawal and discharge for existing power generating facilities that withdraw more than two million gallons of water per day from waters of the United States, such as IP2 and IP3. For such facilities, the CWA requires that the location, design, construction, and capacity of cooling water intake structures reflect the BTA for minimizing adverse environmental impacts, such as I&E. It is not the NRC but EPA and its authorized designees, such as the NYSDEC in New York State, who regulate cooling water withdrawals and discharges under the CWA. The NYSDEC implements the CWA § 316(b) requirements through SPDES permits. Accordingly, under its CWA authority, the NYSDEC can impose mitigation measures as conditions of the IP2 and IP3 SPDES permit to ensure that the IP2 and IP3 cooling water intake structure reflects BTA and minimizes I&E.*

On April 24, 2017, the NYSDEC (2017a) issued a final renewed SPDES permit for IP2 and IP3 with an effective date of May 1, 2017. In the associated fact sheet, the NYSDEC (2017b) determined that Entergy's commitment to early retirement of IP2 and IP3 in accordance with a January 8, 2017, agreement between the State of New York and Entergy (NYS et al. 2017), combined with the conditions in the SPDES permit, constitute BTA for minimizing the adverse environmental impact of the IP2 and IP3 cooling water intake system. More specifically, the NYSDEC determined that implementation of the following measures constitutes BTA: (1) early retirement of IP2 and IP3, (2) outage requirements that will reduce the annual intake flow rate, (3) continued use of traveling screens and the fish return and handling system that gently excludes organisms and provides passage to return to the Hudson River, and (4) continued use of multispeed pumps that can limit intake flow rates. Although the NYSDEC preliminarily determined in 2003 that closed-cycle cooling represented BTA for the IP2 and IP3 site, in light of the January 8, 2017, agreement, the NYSDEC (2017b) has determined that closed-cycle cooling no longer represents BTA, given the substantial, site-specific challenges and length of time that would be involved in retrofitting the existing cooling system and given the limited life span, if any, of IP2 and IP3 after such a retrofit. Section 4.4 of this supplement discusses the NYSDEC's BTA determination in more detail. This BTA determination and the final renewed SPDES permit effectively resolve the comments summarized above.

No changes were made to this supplement as a result of these comments.

B.2.2 Methodology for Assessing Impingement and Entrainment Impacts

Relevant Comments: 12-L15-1, 12-L15-4, 12-L15-5, 12-L15-6, 12-L15-7, 12-L15-8, 12-L15-9, 5-L17-2, 3-L20-2, 5-L22-3, 5-L22-4, 5-L22-5

Comment Summary: A number of comments discuss the NRC’s methodology for assessing the effects of I&E on Hudson River aquatic resources, including assessing impacts at the population level, questioning the methodology for estimating entrainment, correlating population-level impacts with an individual power plant’s operation, excluding early years of data, presenting overall impact findings, and a general questioning of the NRC’s methods. Each underlined heading below contains more detailed summaries of the comments by topic.

General Methodology To Support I&E Impact Findings

The NYSDEC recommends that the NRC assess impacts to aquatic resources from I&E based on the actual number of organisms impinged and entrained at IP2 and IP3, rather than taking a population-level approach as the NRC staff did in its draft supplement to the FSEIS. The NYSDEC also recommends that the NRC adopt its definition of “adverse environmental impact” caused by a cooling water intake structure as the number of fish and shellfish impinged and entrained, rather than continuing to use “SMALL,” “MODERATE,” and “LARGE” to define the level of I&E impacts. In the case of IP2 and IP3, the NYSDEC states that the adverse environmental impact equates to 1 billion fish of all life stages per year. Among several supporting examples, the NYSDEC cites the New York State Department of State’s 2015 objection to Entergy’s Coastal Zone Management Act (CZMA) consistency certification for the IP2 and IP3 license renewal application due to the State’s determination that license renewal would result in significant and direct losses to populations of numerous fish species as a result of I&E. The NYSDEC also expresses a general lack of confidence in the NRC’s methods for assessing I&E impacts.

Related to comments described above in Section B.2.1, the NYSDEC states that the NRC should give it substantial deference in its determination of IP2 and IP3’s adverse environmental impact on aquatic resources because the NYSDEC has the proper expertise and authority to make such a determination.

In its comments, Entergy disputes the NYSDEC’s recommendations to the NRC concerning these topics. Entergy cites a 2006 9th Circuit Court of Appeals decision to support its position that NEPA directs Federal agencies to consider the degree of adverse effect on a species rather than on individuals of that species. Entergy also briefly discusses differences between NRC NEPA guidance and the NYSDEC’s SPDES guidance and how these relate to the NRC staff’s assessment of impacts to aquatic resources. Entergy also states that NEPA and NRC guidance do not require the NRC to adopt the NYSDEC’s terminology for impact findings.

Response: *A portion of these comments question the NRC staff’s assessment methodology and impact finding terminology. The NRC staff acknowledges that its approach to assessing I&E impacts differs from NYSDEC’s approach, but the NRC staff disagrees that its methodology is inappropriate. The differences in the two agencies’ approaches primarily stem from the fact that the two agencies must comply with and implement different laws and regulations: the NYSDEC must implement the CWA and New York State regulations, and the NRC must implement NEPA and NRC’s regulations implementing NEPA at 10 CFR Part 51. NEPA has informed the NRC staff’s methodology and conclusions. In addition, the NRC staff has considered NYSDEC’s CWA assessments within this supplement to the FSEIS.*

The NRC staff prepares its environmental impact statements (EISs) under NEPA. According to the Council on Environmental Quality’s regulations, an EIS’s assessment of environmental consequences shall include discussions of direct effects and their significance as well as indirect effects and their significance (40 CFR 1502.16). The NRC staff uses three levels of impact (“SMALL,” “MODERATE,” and “LARGE”) to describe the potential effects of a proposed action on the environment, and the NRC has defined these levels of impact in its regulations

(Table B–1 in Appendix B to Subpart A of 10 CFR Part 51) and in NUREG–1437 (GEIS) (NRC 2013a).

As stated in its comments, the NYSDEC’s authority to evaluate the impacts from I&E originates from the CWA § 316(b). The EPA, the NYSDEC, and other authorized State designees evaluate whether the direct effects will have an “adverse environmental impact,” which EPA describes as direct losses of aquatic organisms drawn into cooling water intake systems that are either impinged on components of the intake structure or entrained in the cooling water system itself (79 FR 48299). For the purposes of assessing the adverse environmental impact of cooling water intake structures under CWA § 316(b), the Second Circuit Court (Riverkeeper Inc. Llc v. EPA, 475 F.3d 83, 2nd Cir., 2007) has upheld EPA’s interpretation by saying that “the EPA’s focus on the number of organisms killed or injured by cooling water intake structures is eminently reasonable.”

Given that the NRC staff has prepared this supplement to the FSEIS to fulfill its obligations under NEPA and 10 CFR Part 51, and the NYSDEC evaluates the impacts of I&E as required by CWS § 316(b), the NRC staff disagrees with the NYSDEC’s opinion that assessing impacts to overall fish populations is an incorrect metric and that the NRC should adopt the NYSDEC’s methods and definition of “adverse environmental impact.” As described above, the difference between the NYSDEC’s and the NRC staff’s approaches to assessing I&E impacts is a matter of emphasis or focus, which arise from the laws and regulations under which the two agencies’ impact assessments are prepared and the type of conclusions that each agency is required to make under the respectively applicable laws and regulations.

However, the NRC staff agrees with the NYSDEC’s view that the NYSDEC is entitled to due consideration in its determination of I&E effects at IP2 and IP3 for the purposes of CWA § 316(b) and that the NYSDEC has the proper expertise and authority to make such a determination of adverse impact. The NRC staff updated this supplement to include a discussion of the NYSDEC’s most recent determination of I&E effects based on the issuance of the final SPDES permit for IP2 and IP3 in Section 4.4 of this supplement. The NRC staff has considered the NYSDEC’s findings as part of its I&E evaluation and determination that the effects of the proposed IP2 and IP3 license renewal range would be MODERATE. The NRC staff’s indirect, population, and ecosystem-level findings for the purposes of NEPA are not intended to and do not contradict the NYSDEC’s direct adverse environmental impact findings.

Methodology for Estimating Entrainment

In its comments, the NYSDEC questions the NRC staff’s methods for estimating entrainment and states that the staff’s methods overestimate entrainment for some species and underestimate entrainment for others. The NYSDEC provides its calculations for baseline entrainment for seven representative important species (RIS) and its estimates of current entrainment for these RIS. In its comments, Entergy states that the NRC staff’s and the NYSDEC’s entrainment estimates are the result of the two agencies using different datasets.

Response: *The NRC staff recognizes that, for some RIS, the staff’s entrainment estimates contained in this supplement to the FSEIS differ from the NYSDEC’s entrainment estimates as presented in its 2003 Final Environmental Impact Statement for issuing draft SPDES permits for three Hudson River power plants (NYSDEC 2003) and as summarized in the NYSDEC’s public comments, but the staff disagrees with NYSDEC’s comments that question the reasonableness of the staff’s entrainment estimates. Section VII of the NYSDEC’s comments (Comment 12-L15-6) includes a table indicating that the NRC staff’s I&E analysis overestimates entrainment for striped bass, white perch, and Atlantic tomcod and underestimates entrainment for river herring. Some of the differences in these estimates are the result of different assumptions and calculation methodologies used by the NRC staff and the NYSDEC. Other*

differences may be the result of how the two agencies account for uncertainties in their respective analyses.

For those RIS for which the NYSDEC believes the NRC staff overestimated entrainment, the differences in the two agencies' entrainment numbers likely stem from each agency's assumptions regarding entrainment mortality. Entrainment can be expressed in terms of the total number of organisms that are drawn into the cooling water intake system regardless of survival or as the number of organisms killed (referred to as "cropped"). The number cropped is calculated as the total number entrained multiplied by the fractional mortality under various entrainment conditions such that the number cropped is typically some fraction of (and less than) the number entrained. As explained in Section 4.6.1.2 of the GEIS (NRC 2013a), the NRC, like EPA, considers the entrainment mortality at power plants to be 100 percent. When assuming a 100 percent mortality rate, the number of organisms cropped is equal to the number entrained. The NYSDEC's estimates, on the other hand, appear to be the annual number of cropped individuals, with selected taxa having some level of assumed entrainment survival, such that the number cropped is different than the number entrained (see table in Section VIII of Comment 12-L15-7). This difference in the NRC staff's and the NYSDEC's assumptions about entrainment survival would result in the two agencies calculating different numbers for any RIS that do not experience 100 percent mortality upon entrainment, and this difference would particularly explain the RIS for which the NRC "overestimated" entrainment. Because entrainment mortality rates can vary by species, the difference in assumptions may also, in part, explain the degree to which the NRC staff's and the NYSDEC's entrainment estimates differ among RIS.

For those RIS for which the NYSDEC believes the NRC staff underestimated entrainment, the NRC staff acknowledges that, for some RIS, particularly those in the herring family (e.g., alewife, American shad, Atlantic menhaden, blueback herring, and gizzard shad), its I&E analysis may underestimate the number of these RIS entrained because some specimens were likely reported within the "Herring Family" category in entrainment samples rather than reported to the species level. For entrainment studies, a common issue is the ability to accurately identify the species of fish eggs and larvae due to morphological similarities among species within the same family in early life stages. Reliable identification is also difficult with poor quality specimens, such as fish that have decayed or are otherwise degraded. To address data quality issues and other possible biases that may influence the staff's I&E analysis, the NRC staff has added a discussion of uncertainty in Section 4.5 of this supplement.

Correlating Population-Level Impacts with an Individual Power Plant's Operation

Several commenters question whether impacts on fish at the population level can be correlated with or attributed to an individual power plant's operation. The NYSDEC states that it, EPA, and the United States Second Circuit Court of Appeals have rejected a population analysis as the measurement of aquatic impacts caused by once-through cooling. The NYSDEC cites several studies and literature reviews that support its viewpoint that population-level impacts caused by I&E of fish at power plants are hard to detect. The NYSDEC also states that failing to demonstrate a direct impact does not prove that such an impact does not exist because many scientists have questioned whether population-level impacts from once-through cooling systems can actually be detected because of the difficulty in clearly identifying and correlating such effects.

In its comments, Entergy states that the health of the Hudson River aquatic community cannot be reconciled with the hypothesis that Indian Point operations have been adversely affecting the Hudson River ecosystem because a decline in the overall number of organisms in the river should be apparent after four decades of continuous riverwide monitoring. Entergy states that

the absence of a decline in the overall abundance of aquatic organisms in the Hudson River suggests that IP2 and IP3 operations are not having an adverse impact on the Hudson River's ability to support larval fish, the life stage most susceptible to potential entrainment. Riverkeeper states that attempting to assign cause from a single source of impact on a population is difficult because a lot of random noise exists in ecological data from both true variability of a species and the intrinsic error in sampling methodologies, such that a population must often vary by a large amount before the change is detectable. In additional comments, Entergy describes the robustness of the Hudson River Biological Monitoring Program (HRBMP) data and states that the HRBMP dataset has been used for decades as the basis for regulatory decisionmaking, fisheries management, and peer-reviewed publications. Entergy cites several of its own reports, as well as publications from others, including the NYSDEC, that support its view that the HRBMP dataset provides a sufficient basis to discern population-level impacts. Entergy disputes Riverkeeper's comments and includes a detailed discussion of striped bass as an example of how population trends and the causes of those trends can be readily detected.

Response: *The NRC staff acknowledges that discerning adverse effects in natural aquatic populations and linking them to power plant operations can be difficult, but the staff disagrees that such an analysis cannot be done. While the staff's I&E analysis in this supplement to the FSEIS demonstrates that it is possible to ascertain such effects, the staff recognizes that a number of factors can contribute to difficulties and uncertainties in determining the degree to which an individual power plant is affecting a particular aquatic population or populations. These factors include natural fluctuations in aquatic populations; variability and bias that result from sampling fish that school or inhabit hard to sample habitats or microrefuges; sampling difficulties due to weather and environmental conditions; difficulties in identifying individuals to species level; error introduced by subsampling; sampling biases of gear; and the confounding effects of other influences on population size, such as disease, interspecific and other trophic interactions, weather, pollution, fishing, dredging and other habitat change, and change in environmental and fishing regulations.*

The NRC staff accounted in part for these uncertainties in the Population Trend line of evidence (LOE) by examining the consistency of trends for each RIS across multiple indices of abundance and geographic scales and in the strength of connection (SOC) LOE by using conditional mortality rates developed by the Hudson River utilities (CHGE et al. 1999). Through the resulting analysis, the staff was able to discern long-term trends in Hudson River fish populations and show direct links between IP2 and IP3 operation and adverse impacts for some RIS. Although the NYSDEC cites Entergy's (Barnhouse 2013) recent conclusion that numerous studies have attempted and failed to detect population-level impacts caused by the I&E of fish at power plants, the NRC staff notes that the review from which that conclusion was drawn did not consider the 2010 FSEIS's conclusions of adverse effects from IP2 and IP3 operation on Hudson River fish populations or the NRC's subsequent supplements to the FSEIS. Nonetheless, to address these and other possible biases and concerns mentioned in these comments, the NRC staff has added a discussion of uncertainty in Section 4.5 of this supplement.

Exclusion of Early Years of Data

Riverkeeper explains in its comments why it believes that the NRC staff's use of data collected from 1985 onward in its I&E assessment renders much of the impact of IP2 and IP3 operation on aquatic resources invisible. Riverkeeper states that, because the plant had been operating for more than a decade prior, populations may have responded soon after IP2 and IP3 operation began in 1974 and 1976 and subsequently restabilized at lower levels before 1985. Entergy refutes Riverkeeper's comments and states that, because the NRC staff also used

Entergy's riverwide index, which reflects data from 1974 through 2011, early population trends, including declines in abundance over IP2 and IP3's operational history, would be apparent.

Response: *The NRC staff agrees in part and disagrees in part with the comments. The NRC staff recognizes that, if additional data were available before IP2 and IP3 operation that were comparable to the 1985–2011 HRBMP data, inclusion of such data might improve the NRC staff's I&E analysis. In performing its analysis, the NRC staff weighed the advantages and disadvantages of including 1974–1984 river data in its I&E analysis. Including earlier data could increase the chance of identifying preoperational to postoperational impacts but would be confounded by early changes to Hudson River sampling programs and collection methodology during these years. In Appendix A.3.5, the NRC staff conducted an uncertainty analysis to address the effect of changing the years analyzed from 1979–2005 to 1985–2011 for those RIS for which the NRC staff made an SOC finding. The staff also agrees with Entergy's comments that the NRC staff could (and did) detect significant declines in abundance following IP2's and IP3's startup and over its operational history. Additional discussion about the NRC staff's rationale can be found in Section 4.3 of this supplement. In response to these and other comments, the NRC staff has added a discussion of uncertainty in Section 4.5 of this supplement that includes a discussion of the uncertainties introduced through the NRC's use of postoperational data.*

Presentation of Overall Impact Findings

The NYSDEC states in its comments that it disagrees with the NRC staff's characterization of impacts to aquatic ecology as "SMALL to MODERATE" in Table 9–1, "Summary of Environmental Significance of License Renewal and Alternatives," of the draft supplement to the FSEIS because the NRC staff also concluded in the supplement that I&E impacts to blueback herring and rainbow smelt would be "LARGE" and that license renewal is "likely to adversely affect" shortnose and Atlantic sturgeon. The NYSDEC states that the NRC staff's "SMALL to MODERATE" conclusion favors RIS that would experience fewer impacts and minimizes the fact that the NMFS concurred that license renewal will adversely affect shortnose and Atlantic sturgeon and result in impacts to blueback herring and rainbow smelt. In its comments, Riverkeeper states that the change in the NRC staff's overall conclusion from "SMALL to LARGE" in the 2010 FSEIS to "SMALL to MODERATE" in the draft supplement to the FSEIS does not seem warranted given the overall decline in fish in the Hudson River.

Response: *These comments generally disagree with how the NRC staff used its species-specific I&E conclusions for the 18 assessed RIS to formulate a resourcewide conclusion, and the commenters suggest that the NRC staff should conclude that overall impacts to aquatic resources are larger than reported in Table 9–1 of the draft supplement to the FSEIS. The NRC staff disagrees with these comments. As an initial matter, the NRC staff notes that the draft supplement to the FSEIS did not change any of the staff's previous conclusions regarding aquatic ecology issues for license renewal, including the staff's overall conclusion regarding impacts to aquatic resources resulting from I&E. The staff concluded that the overall impacts were MODERATE in Section 4.1.3.5 of the 2010 FSEIS, and neither the 2013 supplement to the FSEIS nor the more recent draft supplement to the FSEIS modified this conclusion.*

The table referenced in the comments (Table 9–1) compares the effects of license renewal with other reasonable alternatives (e.g. construction and operation of a natural gas plant). The table is a summary of all potential impacts for each resource that would result under each alternative. Thus, for aquatic ecology, the finding in Table 9–1 in the proposed action column is a synthesis of the impacts from the 12 aquatic resource issues applicable to plants with once-through cooling systems identified in Table B–1 of 10 CFR Part 51, Subpart A, Appendix B. In the

2010 FSEIS, Table 9–1 stated that impacts from license renewal on aquatic ecology would be “MODERATE and SMALL to LARGE” with a footnote stating, “NRC staff analysis indicates that impingement and entrainment impacts are MODERATE, but that thermal shock effects could potentially range from SMALL to LARGE.” In the 2013 supplement to the FSEIS, the NRC staff re-evaluated thermal impacts following the completion of a triaxial thermal plume study at IP2 and IP3. In Section 3.0 of that supplement, the NRC staff revised its finding regarding thermal effects on aquatic resources to “SMALL.” The NRC staff also revised text in Section 9.1 of the FSEIS to read as follows:

The NRC staff concludes that the potential environmental effects for 9 10 of the 12 categorized issues are of SMALL significance in the context of the standards set forth in the GEIS. The NRC staff concludes that the combined impacts from impingement and entrainment (each a separate issue) are MODERATE. ~~Impacts from heat shock could range from SMALL to LARGE, based on the large uncertainties discussed in Chapter 4.~~

Thus, the staff updated Table 9–1 in this supplement to reflect updates the staff had previously made regarding aquatic resources in the 2013 supplement to the FSEIS. As previously indicated, this supplement to the FSEIS does not revise any overall findings related to any of the 12 aquatic resource issues applicable to IP2 and IP3. However, the NRC staff has added a new discussion in Appendix A, Section A.4.4, that discusses the NRC staff’s methodology for determining its overall conclusion of MODERATE impacts to aquatic resources resulting from I&E associated with IP2 and IP3 license renewal. This section also specifies that, while the NRC staff’s revised I&E analysis documented in this supplement resulted in revised RIS findings for certain species, the NRC staff’s overall conclusion remains MODERATE, as previously documented in Section 4.1.3.5 of the 2010 FSEIS.

B.2.3 NRC’s Species-Specific Conclusions

B.2.3.1 Rainbow Smelt

Relevant Comments: 5-L17-2

Comment Summary: Entergy states in its comments that the best available scientific data support a species-specific finding of “SMALL” impacts to rainbow smelt. Entergy states that the rainbow smelt population remained relatively stable and did not exhibit any decline for two decades after the start of IP2 and IP3 operations, after which time the Hudson River population suddenly collapsed in 1996. Entergy asserts that if I&E were the cause of the collapse, the population should have experienced gradual reductions over time rather than a catastrophic collapse. Entergy states that its Biological Team has determined that an infestation of the parasite *Glugea hertwigi* (“*Glugea*”) is likely the cause of the rainbow smelt collapse. Entergy cites several other recorded widespread *Glugea* infections and related widespread and sudden rainbow smelt die-offs in other northeastern and Great Lakes populations that occurred in the 1990s. Entergy also describes an investigation that its Biological Team undertook in which archived Hudson River Long River Survey (LRS) ichthyoplankton samples from 1991 and 1993 were examined for the presence of *Glugea* and were found to have a high rate of infestation.

Entergy states that the entrainment mortality rate (EMR) for rainbow smelt used in the NRC staff’s SOC analysis contains an error that compounds the staff’s “LARGE” species-specific finding. Entergy asserts that the NRC staff’s reliance on a single year of 1986 entrainment data to represent all 6 years of Season 1 egg entrainment at IP2 and IP3 does not appropriately account for interannual entrainment variability. Further, Entergy states that 1986 is neither a representative nor appropriate year to use in the EMR calculation because rainbow smelt eggs

are not typically in the vicinity of IP2 and IP3 and would, therefore, not typically be susceptible to entrainment. Entergy states that 1986 was an anomalous high-flow year, which likely washed rainbow smelt eggs out of their spawning beds upstream of IP2 and IP3 and resulted in a higher-than-typical rate of entrainment.

Response: *The NRC staff disagrees with Entergy's view that the available data support a species-specific finding of "SMALL" for rainbow smelt. The NRC staff also generally disagrees with Entergy's assertion that a population decline must precede population collapse for it to be attributable to IP2 and IP3 operations. In the face of continued stress, some populations do decline before extirpation or extinction, but populations in destabilized ecosystems may also suddenly collapse as the ecosystem moves through a critical transition or so-called "tipping point" (see ecological reviews in Scheffer 2009 and Petraitis 2013). In addition, high population variance is often an indicator of population and ecosystem instability and a warning of possible local population extinction (e.g., Carpenter and Brock 2006; O'Grady et al. 2004; Pimm et al. 1988) and is a criterion that the International Union for Conservation of Nature (IUCN 2001) considers in its Red List for classifying populations as threatened with extinction.*

Specifically related to rainbow smelt, the NRC staff disagrees with Entergy's assertions that the rainbow smelt population did not exhibit decline before population collapse. In its analysis, the NRC staff observed a long-term decline in the population as well as variable population levels since IP2 and IP3 began operations, suggesting that IP2 and IP3 operations have had a destabilizing effect on rainbow smelt. In the draft supplement to the FSEIS, the NRC staff detected significant declines in rainbow smelt abundance in both River Segment 4 and riverwide using HRBMP data from 1985–2011. The staff also estimated a "High" SOC to IP2 and IP3 operations and predicted a "Large" impact during the proposed license renewal period. These findings were based on the NRC staff's observations of a high degree of variability in riverwide abundance of rainbow smelt young-of-year (YOY) in LRS samples from 1974 to 1990 and a reduction in River Segment 4 Fall Shoals Survey (FSS) YOY density from 1979 to 1984. Figure B–2 and Figure B–3 below illustrate these observations, respectively. The high variability in LRS YOY may be related to Daniels' (1995) finding of a decline in the relative adult catches of rainbow smelt between 1974 and 1989. Daniels et al. (2005) stated that the last observed tributary run of rainbow smelt was in 1988 and that eggs and larvae essentially disappeared from Hudson River ichthyoplankton data after 1995. Overall, these results and observations indicate that the Hudson River rainbow smelt population experienced a long-term decline before collapse, contrary to Entergy's comments.

*The NRC staff agrees with Entergy that infestation of Hudson River rainbow smelt by the microsporidian parasite *Glugea hertwigi* occurred before its extirpation (Normandeau 2016), and the NRC staff acknowledges that *Glugea hertwigi* may have contributed to the rainbow smelt population collapse. However, the NRC staff disagrees with Entergy that the presence of a parasitic infestation necessarily means that population losses caused by I&E at IP2 and IP3 were not involved in the population collapse and extirpation. While the parasite might have increased the rate at which the rainbow smelt population declined, it is likely that parasitic infestation was one of multiple stressors that contributed to the population decline, and thus, the rainbow smelt collapse would be most appropriately characterized as the interactive result of multiple stressors. For example, *Glugea hertwigi* cyst growth may increase with increasing water temperature, such as near IP2's and IP3's thermal discharge (Delisle 1969). Additionally, a smaller, more vulnerable population size is more likely to crash with the infestation of a parasite, such as *Glugea hertwigi*, or another disease as compared to a healthier, larger population where the loss of many individuals would have a smaller proportional impact. Nevertheless, the NRC staff acknowledges that uncertainty exists related to the relative contribution of IP2 and IP3 operations, as well as other biological and physical stressors that*

could have affected the rainbow smelt population. The NRC staff has added a discussion of uncertainty in Section 4.5 of this supplement, including the uncertainty of attributing population changes to specific factors, both generally to all aquatic populations and specifically to the rainbow smelt.

Related to comments concerning the NRC staff's calculation of an EMR for rainbow smelt, Entergy accurately states in its comments that the NRC staff added the annual number of RIS entrained during Season 1 (January through March) of 1986 to each year's Season 2 (April through June) and Season 3 (July through August) numbers to calculate an EMR. Because Season 1 was only sampled in 1986 during the entrainment study, the NRC staff used the 1986 Season 1 data to estimate Season 1 entrainment for the other study years (1981, 1983-1985, and 1987). While the NRC staff acknowledges that this method inherently results in uncertainty because actual Season 1 entrainment in 1981, 1983-1985, and 1987 is unknown, the NRC staff also recognizes that, because Season 1 data are not available for these years, any method for calculating an EMR includes some measure of uncertainty. Thus, factoring in interannual entrainment variability into an EMR calculation, as Entergy has done in its comments, must rely on several assumptions that also create uncertainty. Entergy also asserts in its comments that 1986 is not a reasonably representative year because of an extraordinarily high flow event that occurred in early-to-mid-March in 1986. While the NRC staff agrees that the timing of high daily flows in 1986 contributed to the availability of and entrainment risk to rainbow smelt eggs within River Segment 4, identifiable rainbow smelt eggs were recorded in entrainment samples at similar levels both before the high flows and several weeks later when the extraordinary high flows of mid-March were no longer occurring. Further, in comparing the daily average discharge in March and April of 1986 to March and April flows from 1946 to 2015 measured at Green Island, New York (USGS 2016a), the NRC staff observes that the 1986 flows are within the range of average flows for this time period. Therefore, the NRC staff finds its EMR calculation to be reasonable. Although the NRC staff did not make changes to its EMR calculation or to its findings related to the rainbow smelt in response to this aspect of Entergy's comments, the NRC staff has added an uncertainty discussion in Section 4.5 of this supplement that addresses, among other topics, uncertainty associated with data quality and availability.

Figure B-2. Riverwide LRS YOY Rainbow Smelt Standardized Abundance Index, 1974–2011

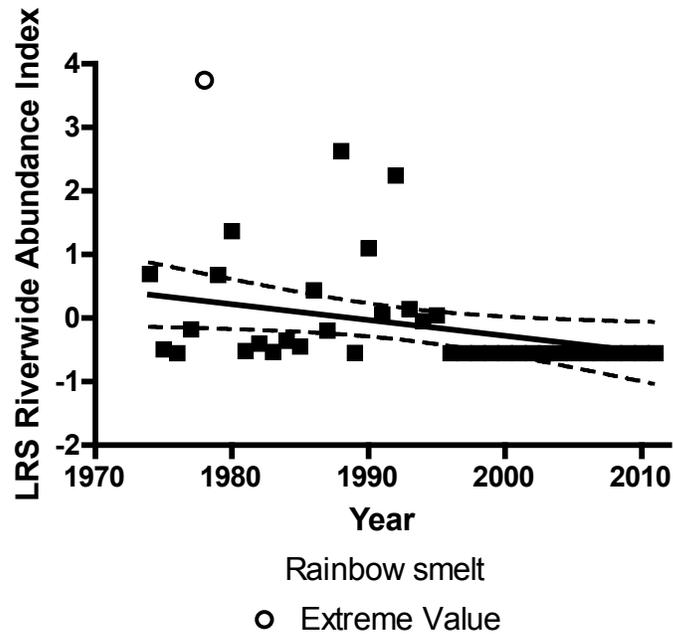
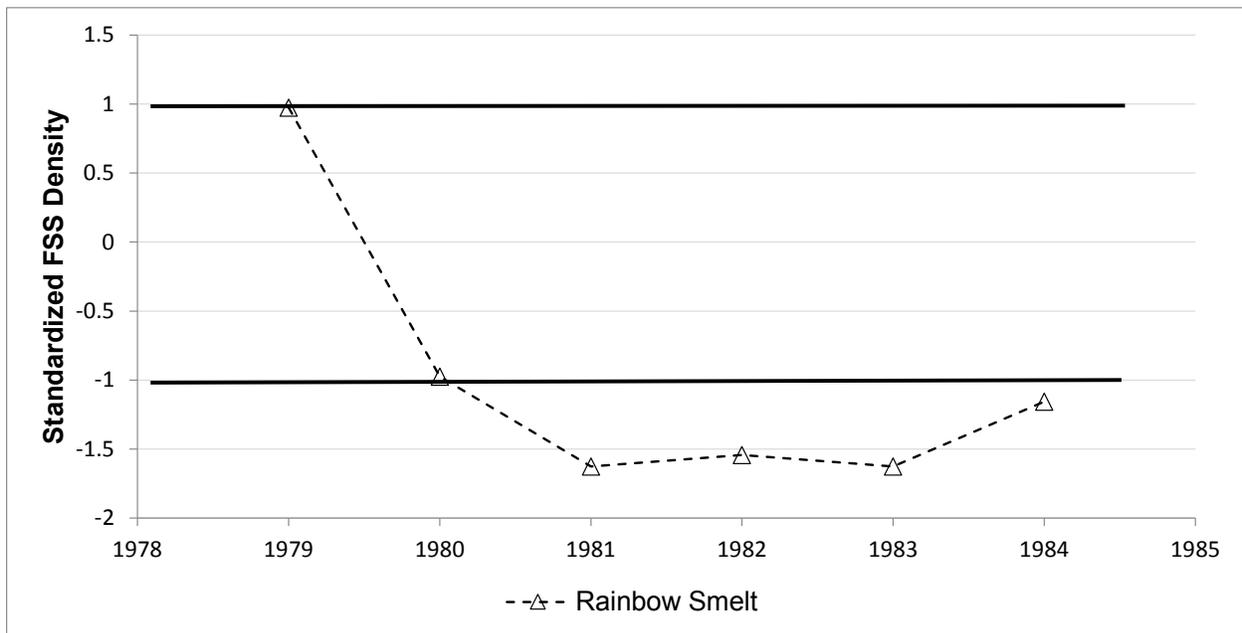


Figure B-3. River Segment 4 FSS YOY Rainbow Smelt Standardized Density, 1979–1984



B.2.3.2 Blueback Herring

Relevant Comments: 5-L17-2

Comment Summary: In its comments, Entergy disagrees with the NRC staff’s species-specific conclusion of “LARGE” impacts to blueback herring. Entergy states that, because the

9.5-percent EMR for blueback herring is much higher than any previous EMR estimates for river herring near IP2 and IP3, it cannot be considered reasonable. Entergy cites as supporting evidence the conditional mortality rates (CMRs) reported in the 1999 draft environmental impact statement for SPDES permits for three Hudson River power plants (CHGE et al. 1999). Entergy also describes an examination that its Biological Team undertook that considered patterns of temporal and spatial distribution of early life stage blueback herring collected in the LRS from 1979 through 2005 and maximum daily Hudson River flow between May 1 and June 15 for the same span of years. Entergy's Biological Team determined that the CMR value was below 1 percent in 15 of 24 years and did not exceed 3 percent in any year. Entergy proffers that only in unusual years with exceptionally high springtime river flow is it possible for entrainable life stages to be present in the Indian Point river region in sufficient numbers to result in a higher CMR but that, in such years, any larvae transported far enough downstream to be vulnerable to entrainment at IP2 and IP3 are highly unlikely to survive because of their large-scale downstream movement. Therefore, entrainment of these additional larvae in such years would not have an actual effect on the blueback herring population.

Response: *The NRC staff disagrees with these comments. The CMR estimates cited in Entergy's comments are based on CHGE et al.'s (1999) calculations, which assume mechanical and thermal mortality and which use riverwide abundance estimates for all 13 river segments. In its calculations, the CHGE et al.'s (1999) minimum CMR value for River Segment 4 was 0.02 percent (1985), and its maximum CMR value was 5.34 percent (1984) (see Table X-21d in CHGE et al. 1999). However, when CHGE et al. (1999) estimated CMRs based on only 12 river segments and assuming 100-percent mortality, the minimum CMR remained the same (0.02 percent in 1985), while the maximum CMR increased to 14 percent (1983) (see Table X-22d in CHGE et al. 1999). The average between these two maxima (5.34 and 14 percent) is 9.67 percent. Even though the NRC staff did not calculate the EMR in this manner, this discussion demonstrates that the 9.5-percent EMR used in the draft supplement to the FSEIS is a reasonable and conservative estimate of the CMR.*

No changes were made to this supplement as a result of these comments.

B.2.3.3 False Positive "High" SOC Findings for Rainbow Smelt, Blueback Herring, and Hogchoker

Relevant Comments: 5-L17-2

Comment Summary: Entergy states that, based on its Biological Team's replication of the NRC staff's SOC conclusions, the staff's methodology results in a one-in-four probability of a false positive "High" SOC for rainbow smelt, blueback herring, and hogchoker.

Response: *The NRC staff agrees in part with Entergy's assertion that the staff's SOC analysis may result in a false positive "High" SOC finding for certain RIS. To evaluate this claim, the NRC staff performed a sensitivity analysis to consider the potential for its SOC analysis to result in false positive conclusions; that is, whether the SOC analysis could indicate a "High" SOC when the direct effects of IP2 and IP3 operations (I&E) are assumed not to exist. The staff's sensitivity analysis appears in Appendix A, Section A.3.3, of this supplement. Through the sensitivity analysis, the staff determined that a false positive "High" result was unlikely for RIS with coefficients of variation (CVs) >1 and a larger negative slope but that a false positive "High" result was possible for RIS with CVs >1 and a larger negative slope.*

Because a high CV is indicative of population instability, SOC findings for unstable populations (CVs >1 and a larger negative slope), which include rainbow smelt, blueback herring, and hogchoker, are more uncertain than for other RIS populations. For these RIS, a false positive "High" SOC may be more likely, but a finding of "High" does not in itself indicate that the result is

a false positive. The NRC staff believes its “High” SOC findings for these and other RIS are reasonable results because the SOC predicts both direct and indirect effects of IP2 and IP3 operation, as described below.

The NRC staff’s SOC formulation includes terms to account for both direct and indirect effects of IP2 and IP3 operations. Direct effects (i.e., I&E) are represented by the EMR and impingement mortality rate (IMR), while indirect effects (e.g., changes in temperature, predator-prey and other food web effects, and disease-related mortality) are incorporated into the CV. Thus, depending on the CV value, an SOC result other than “Low” is possible even when no I&E is assumed and EMR and IMR values are set to zero. Such a scenario would indicate that, while a given RIS population is not highly affected directly by I&E of individuals into the IP2 and IP3 cooling water intake structures, IP2 and IP3 operations are affecting that population indirectly to a great enough extent for those indirect effects to be reflected in the SOC results. Accordingly, a “High” SOC finding when the EMR and IMR are set to zero does not necessarily indicate a false positive finding.

Even so, the NRC staff recognizes that various uncertainties may affect its SOC analysis in a manner that could indicate that an SOC exists between IP2 and IP3 operations and a given RIS’s Population Trend LOE conclusion that is not actually present. As discussed in the staff’s sensitivity analysis (see Appendix A, Section A.3.3, of this supplement), the staff accounted for some uncertainty through the use of variables in its SOC formulation. Other uncertainties that could affect the SOC results include sampling quality, data accuracy, data quantity, and the interactions of multiple environmental stressors. Sections 4.5 and A.4.3 of this supplement discuss these uncertainties and the potential effects on the staff’s I&E analysis, including how they pertain to specific RIS, where applicable. The NRC staff did not change any RIS conclusions or otherwise update this supplement to the FSEIS as a result of these comments.

B.2.3.4 New Data for Gizzard Shad and Atlantic Menhaden

Relevant Comments: 5-L17-2

Comment Summary: In its comments, Entergy states that, for the NRC staff’s “Unresolved” species (gizzard shad and Atlantic menhaden), data are available to support species-specific conclusions of “SMALL.” For gizzard shad, Entergy asserts that the lack of gizzard shad entries in entrainment density files previously provided by Entergy to the NRC indicate that no gizzard shad were recorded in entrainment sampling rather than that no data were available for this species. Therefore, Entergy finds a species-specific conclusion of “SMALL” to be appropriate for gizzard shad. For Atlantic menhaden, Entergy provides, with its comments, new in-river density data that had not been previously provided to the NRC. With this new information, Entergy states that a species-specific finding of “SMALL” can be made for Atlantic menhaden. Entergy provides a supporting analysis for its findings of “SMALL” for each of the two species.

Response: While the NRC acknowledges Entergy’s submission of new in-river data for Atlantic menhaden that had not previously been provided to the NRC, the NRC staff disagrees with Entergy’s recommendations and findings regarding Atlantic menhaden and gizzard shad. As these comments indicate, in the draft supplement to the FSEIS, the NRC staff made species-specific findings of “Unresolved” for gizzard shad and Atlantic menhaden because a Population Trend LOE could not be established and because insufficient data were available to model the associated SOC. In response to these comments and Entergy’s (2016b) new data submitted with its comments, the NRC staff reassessed the Population Trend LOE, the SOC parameter estimates, and the staff’s previous assumptions for these two species. The results of the staff’s reassessment are briefly discussed below.

For gizzard shad, Entergy provided clarifications in its comments regarding the absence of gizzard shad from entrainment density data but did not provide new data on this species. In the draft version of this supplement to the FSEIS, the NRC staff had acknowledged that gizzard shad were absent from entrainment samples (see Table A–7, “Annual Estimated Number of RIS Entrained at IP2 and IP3 (in thousands of fish),” which shows zero values for gizzard shad in all entrainment sample data years. Within the LRS, FSS, and Beach Seine Survey (BSS) data and the utilities’ Abundance Index that the NRC staff used to assess trends in the Population Trend LOE, gizzard shad did not appear in any River Segment 4 abundance measures and appeared in only two riverwide abundance measures. Thus, the in-river density data for gizzard shad remains insufficient to analyze trends in this species’ population, and the NRC staff determined that its previous Population Trend LOE finding of “Undetected Decline” remains reasonable and appropriate. The lack of in-river density data also prevented the NRC staff from producing regression results for River Segment 4 population trends in YOY density or to estimate the River Segment 4 standing crop of gizzard shad eggs, larvae, or YOY. Because of lack of sufficient data to estimate SOC parameters, the NRC staff did not conduct a new SOC analysis for gizzard shad and determined that its previous SOC LOE finding of “Unresolved” remains appropriate. Accordingly, the NRC staff did not change its overall species-specific finding for gizzard shad of “Unresolved” as a result of these comments.

For Atlantic menhaden, the NRC staff reanalyzed its Population Trend and SOC LOEs for this species using Entergy’s (2016b) newly submitted data. For the Population Trend LOE, the NRC staff analyzed the new YOY abundance data and incorporated the results of this analysis into Section 4.0 and Appendix A of this final supplement. The NRC staff was able to assess population trends within River Segment 4 and riverwide (see Table A–12 and Table A–13), and as a result, the NRC staff revised its Population Trend LOE finding from “Unresolved” to “Undetected Decline.” While Entergy’s newly submitted data allowed the NRC staff to produce independent regression results for River Segment 4 population trends in annual YOY density, it did not provide sufficient annual in-river density data to allow the NRC staff to independently estimate the River Segment 4 standing crop of eggs and larvae. Entergy’s contractor (AKRF 2016c) was also unable to calculate the standing crop of Atlantic menhaden eggs, larvae, and YOY from the data. Because of the lack of sufficient data, the NRC staff did not conduct a new SOC analysis, did not change its SOC LOE finding of “Unresolved,” and did not change its overall species-specific finding of “Unresolved” for Atlantic menhaden in this final supplement.

B.2.3.5 Declining Population Trends and High Year-to-Year Population Variances for Hudson River RIS Populations

Relevant Comments: 3-L20-2

Comment Summary: Riverkeeper states that, while there is no evidence for an appreciable change in total number of fish species in the Hudson River estuary, there have been great changes in the actual species present and their relative abundances. Specifically, some RIS populations have exhibited declining trends or high year-to-year variance in the Hudson River since 2008, which was when Riverkeeper last submitted comments to the NRC. In its comments, Riverkeeper describes recent declining trends in Hudson River populations of striped bass, spottail shiner, bluefish, white perch, Atlantic tomcod, American shad, blueback herring, rainbow smelt, white catfish, and weakfish, and high year-to-year variation in populations of Atlantic tomcod and alewife. For some populations, Riverkeeper suggests that the trends it describes in its comments indicate destabilization or what it considers to be dramatic population declines.

Response: *The NRC staff agrees in part and disagrees in part with Riverkeeper’s observations and conclusions regarding RIS. Some of Riverkeeper’s comments relating to declining population trends and high year-to-year variation appear to disagree with some of the NRC staff’s species-specific conclusions regarding impacts to RIS resulting from I&E. While the NRC staff found “LARGE” impacts for blueback herring and rainbow smelt in the draft supplement to the FSEIS, the NRC staff made species-specific findings of “SMALL” for the other RIS addressed by the comments. Generally, Riverkeeper’s comments address changes in population trends since Pisces Conservation last assessed the status of Hudson River fish populations for Riverkeeper in 2008, while the NRC’s analysis documented in this supplement assesses population trends over the course of the past several decades. Because the scope of the two analyses is different (e.g., Riverkeeper analyzed fish population trends from 2008–2015, while NRC considered trends from 1985–2011), Riverkeeper may have identified recent short-term trends for some RIS that do not necessarily imply long-term decline when considered in the context of longer term population data for those RIS. Appendix A, Section A.2, of this supplement describes in detail the NRC staff’s methodology and reasons for using this time period to evaluate I&E impacts. In response to public comments, the NRC staff has added details in this section regarding its I&E assessment methodology. Further, the NRC staff acknowledges that the selected methodology includes several sources of uncertainty, and the staff has added a new section to this supplement (Section 4.5) to discuss uncertainty associated with the staff’s I&E analysis. The NRC staff has not changed its I&E analysis methodology or findings as a result of these comments.*

B.2.4 Federally Listed Species

B.2.4.1 Federally Listed Species Impact Conclusions

Relevant Comments: 5-L17-8, 5-L17-10

Comment Summary: Entergy requests in its comments that the NRC staff provide further explanation of the new characterization of impacts to shortnose and Atlantic sturgeon as “likely to adversely affect, but not likely to jeopardize the continued existence” of these species. Entergy states that continued operation of IP2 and IP3 would not change the status or trends of either species in the Hudson River, in New York, or in either population as a whole, given the demonstrated lack of entrainment and limited impingement impacts to these species. Entergy also requests that the NRC staff explain in the supplement a number of life history factors that minimize the likelihood of sturgeon interacting with the IP2 and IP3 cooling water intake structure.

Response: *The NRC staff agrees in part and disagrees in part with these comments. The staff disagrees with Entergy that it should provide more detailed information regarding these impacts in this supplement because the staff has adequately described such impacts and addressed them in the FSEIS and in consultation with the NMFS. In the 2010 FSEIS (NRC 2010), the NRC staff characterized the impacts to Federally listed aquatic species resulting from the proposed IP2 and IP3 license renewal as “SMALL.” In the 2013 supplement to the FSEIS (NRC 2013b), the NRC staff provided updated information related to shortnose and Atlantic sturgeon and described the outcome of ESA section 7 consultation with the NMFS for shortnose and Atlantic sturgeons. In Section 4.5 of the 2013 supplement, the NRC staff (2013b) stated that, because NMFS (2013) finds, in its biological opinion, that license renewal would not change the status or trend of the Hudson River populations of shortnose or Atlantic sturgeon or either species as a whole, the NRC concludes that impacts to these species would be SMALL. In the same year, the NRC staff issued Revision 1 to NUREG–1437 (NRC 2013a). In preparing the revised GEIS, the NRC staff determined that the levels of impact that it developed to implement NEPA (i.e., SMALL, MODERATE, and LARGE) are not sufficiently clear with respect*

to the ESA, as this law defines and requires other findings. Accordingly, the NRC staff determined that, with respect to ESA-listed species and critical habitats, it would report its plant-specific findings in future SEISs in terms of the following ESA-defined impact levels: (1) no effect, (2) not likely to adversely affect, (3) likely to adversely affect, or (4) is likely to jeopardize the listed species or adversely modify the designated critical habitat. Further, if the NRC staff finds that the action is “likely to adversely affect” the listed species or critical habitat, the NRC staff may further characterize the effects as “is [or is not] likely to jeopardize listed species” or “is [or is not] likely to adversely modify designated critical habitat.” Because of this change in how the NRC staff characterizes impact findings for ESA-listed species and critical habitats, the staff revised its species-specific findings for shortnose and Atlantic sturgeon in this supplement to the FSEIS related to the proposed IP2 and IP3 license renewal. These findings are consistent with the findings made by NMFS (2013) in its biological opinion.

The NRC staff agrees with Entergy’s comments that sturgeon only interact with the IP2 and IP3 cooling water intake structure to an extremely limited extent, that sturgeon eggs and larvae are generally not susceptible to entrainment, and that all but the smallest juveniles would be able to avoid impingement into the IP2 and IP3 intake structure. These facts have been previously documented in the NMFS (2013) biological opinion and in Section 4.0, “Section 7 Consultation,” of the NRC staff’s 2013 supplement to the FSEIS. Although the NRC staff does not explicitly reiterate these facts in this supplement, it has added a new section to this supplement (Section 7.3, “Revised NEPA Findings for Threatened and Endangered Species”) in response to these comments that describes the reasons why it revised its findings for Federally listed species and habitats, and more clearly lists its findings in a table.

B.2.4.2 Cumulative Impacts of Tappan Zee Sturgeon Mortality

Relevant Comments: 3-L20-2, 5-L22-2

Comment Summary: Riverkeeper requests that the NRC staff consider the cumulative impacts of the Tappan Zee Bridge replacement project on Atlantic sturgeon. Specifically, Riverkeeper highlights recent data on sturgeon mortalities that have resulted from the project and states that the NRC staff should examine whether its prior assumptions of impacts to sturgeon remain valid in light of the increases in mortality resulting from Tappan Zee Bridge construction activities. Entergy, in response to Riverkeeper’s comments, states that, because IP2 and IP3 do not cause sturgeon mortality, IP2 and IP3 operations cannot reasonably be considered to impact sturgeon population dynamics, including in a manner relevant to the NRC staff’s NEPA analysis.

Response: The NRC staff generally disagrees with the comments that indicate that it should further consider the impacts of the Tappan Zee Bridge replacement project on Atlantic sturgeon in this supplement to the FSEIS. During its ESA section 7 consultation with NMFS for shortnose and Atlantic sturgeon, the NRC and NMFS considered cumulative impacts to sturgeon resulting from the continued operations of IP2 and IP3 in addition to other projects and factors that could affect sturgeon in the Hudson River. The NMFS (2013) considered the Tappan Zee Bridge replacement project in the environmental baseline when formulating its biological opinion for IP2 and IP3, and Section 4.7.4 of the biological opinion describes the Tappan Zee Bridge replacement project and states that the NMFS has determined that the project “may affect but is not likely to jeopardize the continued existence of” shortnose sturgeon or any distinct population segment (DPS) of Atlantic sturgeon. The associated biological opinion and Incidental Take Statement dated June 22, 2012, exempted the lethal take of two shortnose and two Atlantic sturgeon as well as the capture and injury of sturgeon individuals.

Since the NMFS issued its biological opinion to the NRC, the Federal Highway Administration has reinitiated ESA section 7 consultation with NMFS for the Tappan Zee Bridge replacement

project several times because of changes in project plans and other information. Most recently, the NMFS (2017) issued a new biological opinion to the Federal Highway Administration on January 4, 2017. In the environmental baseline (Section 6.0) of the biological opinion, NMFS considers the impacts of IP2 and IP3 operations on sturgeon, among other Federal projects that have the potential to affect sturgeon in the Hudson River. The NMFS (2017) concludes, in that biological opinion, that the Tappan Zee Bridge replacement project “is likely to adversely affect but is not likely to jeopardize the continued existence of” shortnose or the Gulf of Maine, New York Bight, or Chesapeake Bay DPS of Atlantic sturgeon and that the project is “not likely to adversely affect” the Carolina or South Atlantic DPS of Atlantic sturgeon. The NMFS also draws conclusions regarding sea turtles and whale species that are not relevant to this comment response. In the Incidental Take Statement, the NMFS (2017) determined that the remaining pile driving to be carried out for construction of the new bridge is expected to result in the injury of three or fewer shortnose sturgeon and three or fewer Atlantic sturgeon. All of these fish are expected to suffer minor injuries and no serious injury or mortality is anticipated. NMFS (2017) expects that up to six sturgeon (combination of shortnose and Atlantic sturgeon) will be struck and killed by a project vessel over the remaining years of the project (2017 to 2019). All noise and vibration exposure related to construction activities will have insignificant and discountable effects on sturgeon, and the NMFS (2017) does not anticipate any take of sturgeon as a result of any remaining aspects of the project. Thus, in total, NMFS exempts the injury of three shortnose sturgeon and three Atlantic sturgeon caused by exposure to pile driving noise and the mortality of six total sturgeon (shortnose or Atlantic) caused by vessel strike through the remainder of the project. As of January 2017, one shortnose sturgeon mortality and no Atlantic sturgeon mortalities have been attributed to Tappan Zee project vessels (NMFS 2017). No sturgeon have been collected with injuries or death to exposure to pile driving noise (NMFS 2017).

Based on the above information, the NRC staff does not find significant differences in the potential cumulative impacts to sturgeon from the Tappan Zee Bridge replacement project as compared to those that were already considered during the staff’s previous NEPA analyses and during consultation with the NMFS under ESA section 7.

No changes were made to this supplement as a result of these comments.

B.2.5 Other Comments Related to Aquatic Resources

B.2.5.1 Hudson Highlands Significant Coastal Fish and Wildlife Habitat

Relevant Comments: 12-L15-2

Comment Summary: The NYSDEC states that the NRC staff did not recognize the update to the Hudson Highlands Significant Coastal Fish and Wildlife Habitat that the NYSDEC recently finalized. The NYSDEC states that the update added River Segment 4 to the boundary of the Hudson Highlands Significant Coastal Fish and Wildlife Habitat because it is a major spawning area for Hudson River striped bass and because Atlantic and shortnose sturgeon frequent deep water areas in this reach of the river.

Response: *The NRC staff agrees with the comment and has incorporated the updated Hudson Highlands Significant Coastal Fish and Wildlife Habitat boundaries into this supplement in Appendix A, Section A.4, “Discussion and Conclusions.”*

B.2.5.2 Information Submitted by Entergy as Comments of the Draft Supplement to the FSEIS

Relevant Comments: 12-L15-3, 12-L15-4, 12-L15-5

Comment Summary: The NYSDEC states that it does not consider the information submitted by Entergy as comments on the draft supplement to FSEIS to be new because no new I&E data have been collected. The NYSDEC asserts that the changes presented in Section 4.0 of the supplement to the FSEIS appear to be a dispute between the NRC and Entergy's biological experts on the proper assumptions, calculations, and data to be used in determining the impacts of I&E from the proposed IP2 and IP3 license renewal. The NYSDEC also states that the latest submission of information by Entergy is a continued attempt to minimize the adverse effects of IP2 and IP3 operation and to attribute factors other than IP2 and IP3 to the decline in the overall health of the Hudson River fish community.

Response: *The NRC staff agrees in part with these comments. As indicated in the comments, Entergy provided, with its comments on the draft version of this supplement to the FSEIS, information that it considered to be "new" and to affect the NRC staff's I&E analysis. This "new" information includes abundance and trend data for Atlantic menhaden and clarifying information on data previously submitted to the NRC for gizzard shad. While the NRC staff agrees with the NYSDEC that Entergy has not collected any new I&E data, the information that Entergy provided with its comments on these species had not been previously made available to the NRC staff and, therefore, had not been considered in the staff's I&E analysis. In its review of Entergy's newly provided information, the NRC staff determined that the information could potentially inform its I&E impact assessment and, therefore, the staff reassessed potential I&E impacts to the affected RIS with the additional information. The NRC updated its I&E analysis in Section 4.0 and Appendix A of this supplement to incorporate the newly provided information, but the information did not ultimately result in changes to the NRC staff's species-specific I&E findings for Atlantic menhaden or gizzard shad. The NRC staff's comment response in Section B.2.3.4 of this appendix further discusses the staff's use of Entergy's newly provided information and how that data affected the staff's I&E analysis and RIS conclusions.*

No changes were made to this supplement as a result of these comments.

B.2.5.3 Climate Change

Relevant Comments: 3-L20-2

Comment Summary: Riverkeeper states that the NRC staff's revised conclusion from "SMALL to LARGE" to "SMALL" for thermal impacts to aquatic resources is at odds with the evidence the NRC staff presents on climate change and the warming of the Hudson River.

Response: *The NRC staff disagrees with this comment. In the 2010 FSEIS, the NRC (2010) concluded that the thermal impacts on aquatic resources could range from SMALL to LARGE because the NRC staff did not have sufficient information to quantify the extent and magnitude of the IP2 and IP3 thermal plume. Following issuance of the 2010 FSEIS, Entergy performed a triaxial plume study, which it submitted to the NYSDEC for review as part of its SPDES permit renewal application. The NRC staff reviewed the triaxial plume study as well as NYSDEC's conclusions regarding the study. Based on its review, the NRC staff found that thermal impacts to aquatic resources resulting from IP2 and IP3 license renewal would be SMALL. The NRC staff documented this conclusion in Section 3.0 of the 2013 supplement to the FSEIS (NRC 2013b).*

The present supplement does not reanalyze or revise the NRC's previous finding of "SMALL" for thermal impacts on aquatic resources. Further, the NRC staff's "SMALL" thermal impact conclusion applies only to the impacts of IP2 and IP3 license renewal on aquatic resources and not to the impacts of license renewal when considered cumulatively with other past, present, or reasonably foreseeable future actions, such as climate change. The NRC staff addressed cumulative impacts, including climate change, in Section 4.8.1 of the 2010 FSEIS and

concluded that the impacts of IP2 and IP3 license renewal, considered together with other past, present, and reasonably foreseeable future actions, would result in “LARGE” impacts on aquatic resources. In Section 5.14 of this supplement to the FSEIS, the NRC staff updated the cumulative impacts analysis presented in the 2010 FSEIS. Section 5.14 considers new information and projects since publication of the 2010 FSEIS, but the NRC’s previous conclusion of “LARGE” cumulative impacts on aquatic resources remains unchanged. Additionally, in Section 5.13 of this supplement, the NRC staff further evaluated the impacts of GHG emissions and climate change on environmental resources, including aquatic resources. No changes were made to this supplement as a result of this comment.

B.3 References

10 CFR Part 2. *Code of Federal Regulations*, Title 10, *Energy*, Part 2, “Agency rules of practice and procedure.”

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, “Standards for protection against radiation.”

10 CFR Part 50. *Code of Federal Regulations*, Title 10, *Energy*, Part 50, “Domestic licensing of production and utilization facilities.”

10 CFR Part 51. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, “Environmental protection regulations for domestic licensing and related regulatory functions.”

40 CFR Part 125. *Code of Federal Regulations*, Title 40, *Protection of the Environment*, Part 125, “Criteria and standards for the National Pollutant Discharge Elimination System.”

40 CFR Parts 1500–1508. *Code of Federal Regulations*, Title 40, *Protection of the Environment*, Parts 1500–1508, “Regulations for implementing the procedural provisions of the National Environmental Policy Act.”

59 FR 7629. Executive Order No. 12898. “Federal actions to address environmental justice in minority populations and low-income populations.” *Federal Register* 59(32):7629–7634. February 16, 1994.

73 FR 46204. U.S. Nuclear Regulatory Commission. “The Attorney General of Commonwealth of Massachusetts, The Attorney General of California; Denial of Petitions for Rulemaking.” *Federal Register* 73(154):46204–46213. August 8, 2008.

78 FR 37282. U.S. Nuclear Regulatory Commission. “Revisions to environmental review for renewal of nuclear power plant operating licenses.” *Federal Register* 78(119):37282–37324. June 20, 2013.

79 FR 48299. U.S. Environmental Protection Agency. “National Pollutant Discharge Elimination System; Final regulations to establish requirements for cooling water intake structures at existing facilities and amend requirements at Phase I facilities.” *Federal Register* 79(158):48299–48439. August 15, 2014.

79 FR 56238. U.S. Nuclear Regulatory Commission. “Continued storage of spent nuclear fuel.” *Federal Register* 79(182):56238–56263. September 19, 2014.

80 FR 81377. U.S. Nuclear Regulatory Commission. “Entergy Nuclear Operations, Inc.; Indian Point Nuclear Generating Unit Nos. 2 and 3.” *Federal Register* 80(249):81377–81378. December 29, 2015.

80 FR 81818. U.S. Environmental Protection Agency. “Environmental Impact Statements; Notice of Availability.” *Federal Register* 80(251):81818. December 31, 2015.

Appendix B

[AKRF] AKRF, Inc. 2014. Update of Aquatic Impact Analyses Presented in NRC's FSEIS (December 2010) Regarding Potential Impacts of Operation of Indian Point Units 2 and 3. Attachment 1 To NL-14-030, Entergy Nuclear Operations, Inc., Indian Point Nuclear Generating Unit Nos. 2 & 3, Docket Nos. 50-247 and 50-286. February 19, 2014. Prepared for Indian Point Energy Center, Buchanan, NY. Prepared by AKRF, Inc., Hanover, MD. ADAMS Accession No. ML14063A529.

[AKRF] AKRF, Inc. 2016a. Appendix 2A: Hudson River Rainbow Smelt Population Projection Model for Examining Conditions that Could Have Led to Catastrophic Decline. March 2016. Prepared for Indian Point Energy Center, Buchanan, New York. Prepared by AKRF, Inc., Hanover, Maryland. Submitted as an attachment to Entergy 2016a.

[AKRF] AKRF, Inc. 2016b. Appendix 2D: Assessment of Potential Bias in NRC Staff's Estimate of Entrainment Mortality Rate (EMR) at IPEC for Rainbow Smelt. Prepared for Indian Point Energy Center, Buchanan, New York. March 2016. Prepared for Indian Point Energy Center, Buchanan, New York. Prepared by AKRF, Inc., Hanover, Maryland. Submitted as an attachment to Entergy 2016a.

[AKRF] AKRF, Inc. 2016c. Appendix 2F: Application of NRC Staff's Aquatic Impact Analysis Methodology to Atlantic Menhaden and Gizzard Shad Data for IPEC. March 2016. Prepared for Indian Point Energy Center, Buchanan, New York. Prepared by AKRF, Inc., Hanover, Maryland. Submitted as an attachment to Entergy 2016a.

[AKRF] AKRF, Inc. 2016d. Attachment 6 TO NL-16-044. Review of Estimates of Entrainment Reported in NYSDEC Staff's Comments on the NRC Draft Supplement. April 20, 2016. Prepared for Indian Point Energy Center, Buchanan, New York. Prepared by AKRF, Inc., Hanover, Maryland. Submitted as an attachment to Entergy 2016c.

Applebome, P. 2009. Cool Waters and the Lure of Danger. *The New York Times*. July 2, 2009. Available at <http://www.nytimes.com/2009/07/02/nyregion/02towns.html?_r=1&> (accessed 2 March 2015).

[ASA] ASA Analysis & Communication, Inc. 2016. Attachment 5 TO NL-16-044. Critique of Community Analyses in 2008 and 2015 Versions of "The Status of Fish Populations and Ecology of Hudson River." Submitted as an attachment to Entergy 2016c.

Atomic Energy Act of 1954, as amended. 42 U.S.C. § 2011 et seq.

Bald and Golden Eagle Protection Act of 1940, as amended. 16 U.S.C. § 668 et seq.

Barnthouse LW. 2013. Impacts of entrainment and impingement on fish populations: A review of the scientific evidence. *Environmental Science and Policy* 31:149-156.

Barnthouse LW, Heimbuch DH, Mattson M, Young JR. 2009. Enclosure 6 to NL-09-036. Review of NRC's Impingement and Entrainment Impact Assessment for IP2 and IP3. March 16, 2009. Attachment to: [Entergy] Entergy Nuclear Northeast. 2009. Letter from F. Dacimo, Vice President, License Renewal, to Chief, Rulemaking, Directives and Editing Branch, NRC. Subject: Comments on NREG-1437, Draft Supplement 38. April 18, 2009. ADAMS Accession No. ML091040133.

Barnthouse LW, van Winkle W. 1988. Analysis of impingement impacts on Hudson River fish populations. *American Fisheries Society Monographs* 4:182-190.

Boehlert GW, Mundy BC. 1988. Roles of behavioral and physical factors in larval and juvenile fish recruitment to estuarine nursery areas. *American Fisheries Society Symposium* 3:51-57.

Carpenter SR, Brock WA. 2006. Rising variance: a leading indicator of ecological transition. *Ecology Letters* 9:311-318.

- [CHGE et al.] Central Hudson Gas & Electric Corporation, Consolidated Edison Company of New York, Inc., New York Power Authority, and Southern Energy New York. 1999. Draft Environmental Impact Statement for State Pollutant Discharge Elimination System Permits for Bowline Point, Indian Point 2 & 3, and Roseton Steam Electric Generating Stations. December 1999. ADAMS Accession No. ML083400128.
- Chase BC, Ayer MH, Elzey SP. 2009. Rainbow smelt population monitoring and restoration on the Gulf of Maine Coast of Massachusetts. American Fisheries Society Symposium 69:899–901.
- Daniels RA. 1995. “Long-term change in the nearshore fish assemblage of the tidal Hudson River.” Pages 260–263 in LaRoe ET, Farris GS, Puckett CE, Doran PD, Mac MJ, eds. 1995. Our Living Resources: A Report to the Nation on the Distribution, Abundance, and Health of U.S. Plants, Animals, and Ecosystems. U.S. Department of the Interior, National Biological Service, Washington, DC. 530 p. Available at <http://webharvest.gov/peth04/20041019015728/http://biology.usgs.gov/s+t/index.htm> (accessed 1 March 2017).
- Daniels RA, Limburg KE, Schmidt RE, Strayer DL, Chambers RC. 2005. Changes in fish assemblages in the tidal Hudson River, New York. American Fisheries Society Symposium 45: 471–503.
- DeChillo S. 1986a. “As Striped Bass Run Up Hudson the Pace Quickens at Hatchery.” *The New York Times*. June 8, 1986. Available at <http://www.nytimes.com/1986/06/08/nyregion/asstripedbassrunuphudsonthepacequickensathatchery.html?pagewanted=all&pagewanted=print> (accessed 13 June, 2016).
- DeChillo S. 1986b. “Hatchery’s Stripers Sent on Their Way.” *The New York Times*. November 23, 1986. Available at <http://www.nytimes.com/1986/11/23/nyregion/hatcherysstriperssentontheirway.html?pagewanted=all&pagewanted=print> (accessed June 13, 2016).
- Delisle C. 1969. Bimonthly progress of a non-lethal infection by *Glugea hertwigi* in young-of-the-year smelt *Osmerus eperlanus mordax*. *Canadian Journal of Zoology* 47(5):871-876.
- [DOI] U.S. Department of the Interior. 2016. Letter from A. Raddant, Regional Environmental Officer, to J. Danna, Chief, Project Branch 2, Division of License Renewal, NRC. Subject: COMMENTS, Draft supplement (DSEIS) to Supplement 38 to the *Generic Environmental Impact Statement (GEIS) for Renewal of Operating Licenses for Indian Point Generating Units 2 and 3*, Westchester County, New York, NRC-2008-0672. March 2, 2016. ADAMS Accession No. ML16067A375.
- [EA] EA Engineering, Science, and Technology, Inc. 1984. Indian Point Generating Station Entrainment Abundance and Outage Evaluation 1983 Annual Report. Prepared for Consolidated Edison Company of New York, Inc. and New York Power Authority. September 1984. ADAMS Accession No. ML083101084.
- [EA] EA Engineering, Science, and Technology, Inc. 1985. Indian Point Generating Station Entrainment Abundance and Outage Evaluation 1984 Annual Report. Prepared for Consolidated Edison Company of New York, Inc. and New York Power Authority. July 1985. ADAMS Accession No. ML083101091.
- [EIA] U.S. Energy Information Administration. 2016. Annual Electric Utility Data—EIA-906/920/923 Data File. Updated April 28, 2016, for February 2016 data. Available at <http://www.eia.gov/electricity/data/eia923/index.html> (accessed May 10, 2016).

Appendix B

Endangered Species Act of 1973, as amended. 16 U.S.C. § 1531 et seq.

[Entergy] Entergy Nuclear Operations, Inc. 2007. Letter from F. Dacimo, Vice President, License Renewal, Entergy, to NRC Document Control Desk. Subject: Supplement to License Renewal Application (LRA)—Environmental Report References. December 20, 2007. Entergy Nuclear Operations Inc., Indian Point Nuclear Generating Unit Nos. 2 & 3, Docket Nos. 50-247 and 50-286, ADAMS Accession No. ML080080205.

[Entergy] Entergy Nuclear Operations, Inc. 2013. Letter from J.A. Ventosa, Site Vice President, to NRC Document Control Desk. Subject: Entergy's required response for NTTF Recommendation 2.1: Flooding—Hazard Re-evaluation Report, Indian Point Unit Numbers 2 and 3, Docket Nos. 50-247 and 50-286, License Nos. DPR-26 and DPR-64, NL-13-156. December 23, 2013. ADAMS Accession Nos. ML13364A006, ML13364A007, ML13364A008, and ML13364A009.

[Entergy] Entergy Nuclear Operations, Inc. 2014a. Letter from F. Dacimo, Vice President, Operations License Renewal, to L. James, Environmental Project Manager, Division of License Renewal, NRC. Subject: Final Supplemental Environmental Impact Statement, Indian Point Nuclear Generating Unit Nos. 2 & 3, Docket Nos. 50-247 and 50-286, License Nos. DPR-26 and DPR-64. February 19, 2014. ADAMS Accession No. ML14063A528.

[Entergy] Entergy Nuclear Operations, Inc. 2014b. *Indian Point Unit 2, Updated Final Safety Analysis Report*. Chapter 2, Site and Environment. Revision 25, September 2014. ADAMS Accession No. ML14287A295.

[Entergy] Entergy Nuclear Operations, Inc. 2015. *2014 Annual Radioactive Effluent Release Report, Indian Point Nuclear Generating Unit Nos. 1, 2, and 3*. April 28, 2015. ADAMS Accession No. ML15124A715.

[Entergy] Entergy Nuclear Operations, Inc. 2016a. Letter from F. Dacimo, Vice President, Operations License Renewal, Entergy, to C. Bladey, Chief, Rules, Announcements, and Directives Branch, NRC. Subject: Comments on Second Draft Supplement to Final Supplemental Environmental Impact Statement for Indian Point License Renewal Indian Point Nuclear Generating Unit Nos. 2 and 3, Docket Nos. 50-247 and 50-286, License Nos. DPR-26 and DPR-64. March 4, 2016. ADAMS Accession Nos. ML16070A053 and ML16070A054.

[Entergy] Entergy Nuclear Operations, Inc. 2016b. Appendix 2G: Atlantic Menhaden HRBMP Data. March 4, 2016. Submitted as an attachment to Entergy 2016a.

[Entergy] Entergy Nuclear Operations, Inc. 2016c. Attachment 1 to NL-16-044. Letter from F. Dacimo, Vice President, Operations License Renewal, Entergy to C. Bladey, Chief, Rules, Announcements, and Directives Branch, NRC. Re: Entergy's Corrections and Clarifications in Response to Third-Party Comments on the NRC Staff's Draft Second Supplement to the Final Supplemental Environmental Impact Statement for Indian Point Nuclear Generating Units 2 and 3 License Renewal, Indian Point Nuclear Generating Unit Nos. 2 and 3, Docket Nos. 50-247 and 50-286, License Nos. DPR-26 and DPR-64. April 25, 2016. ADAMS Accession No. ML16123A173.

[Entergy] Entergy Nuclear Operations, Inc. 2016d. *2015 Annual Radioactive Effluent Release Report, Indian Point Nuclear Generating Unit Nos. 1, 2 and 3*. April 28, 2016. ADAMS Accession No. ML16131A637.

[Entergy] Entergy Nuclear Operations, Inc. 2016e. *2015 Annual Radiological Environmental Operating Report, Indian Point Nuclear Generating Unit Nos. 1, 2 and 3*. May 12, 2016. ADAMS Accession No. ML16145A185.

- [Entergy] Entergy Nuclear Operations, Inc. 2017a. *IPEC Quarterly Long-Term Groundwater Monitoring Report, Quarter Three, 2016 Report No. 32*. March 24, 2017. Available at <<http://www.safesecurevital.com/environment/reports.html>> (accessed 13 April 2017).
- [EPA] U.S. Environmental Protection Agency. 1999. *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*. April 21, 1999. Available at <<http://www.epa.gov/OUST/directiv/d9200417.pdf>> (accessed 15 September 2015).
- [EPA] U.S. Environmental Protection Agency. 2016a. Letter from J. Mitchell, Chief, Sustainability and Multimedia Programs Branch, to C. Bladey, Chief, Rules, Announcements, and Directives Branch, NRC. Subject: Docket ID NRC-2008-0672; *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 (NUREG–1437, Supplement 38, Volume 5) - Rating EC-2*. March 4, 2016. ADAMS Accession No. ML16082A272.
- [Entergy] Entergy Nuclear Operations, Inc. 2017b. *IPEC Quarterly Long-Term Groundwater Monitoring Report, Quarter Three, 2016 Report No. 32*. March 24, 2017. Available at <<http://www.safesecurevital.com/environment/reports.html>> (accessed 13 April 2017).
- [EPA] U.S. Environmental Protection Agency. 2016b. *Do maximum contaminant levels (MCLs) apply to drinking water at a free flowing tap*. 2016. Available at <<https://safewater.zendesk.com/hc/en-us/articles/211399788-Do-maximum-contaminant-levels-MCLs-apply-to-drinking-water-at-a-free-flowing-tap>> (accessed 28 March 2016).
- [EPRI] Electric Power Research Institute. 2010. *Estimation of Carbon-14 in Nuclear Power Plant Gaseous Effluents*. Available at <<https://www.epri.com/#/pages/product/000000000001021106/>> (accessed 29 June 2017).
- Ernest SKM, Brown JH. 2001. Homeostasis and compensation: the role of species and resources in ecosystem stability. *Ecology* 82:2118-2132.
- Federal Water Pollution Control Act of 1972 (also referred to as the CWA), as amended. 33 U.S.C. § 1251 et seq.
- [FEMA] U.S. Federal Emergency Management Agency. 2008. *National Response Framework, Nuclear/Radiological Incident Annex*. June 2008. Available at <https://www.fema.gov/pdf/emergency/nrf/nrf_nuclearradiologicalincidentannex.pdf> (accessed 29 June 2017).
- [FERC] U.S. Federal Energy Regulatory Commission. 2016. *ORDER ON RECONSIDERATION AND STAY*. 154 FERC 61,236. March 25, 2016. Available at <<http://www.ferc.gov/CalendarFiles/20160325130515-CP14-96-000.pdf>> (accessed 7 July 2016).
- [FWS] U.S. Fish and Wildlife Service. 2015. Letter from D. Stilwell, New York Field Supervisor, FWS, to D. Wrona, Chief, Environmental Review and Guidance Update Branch, NRC. Subject: Concurrence with determination that Indian Point license renewal is not likely to adversely affect the Indiana bat or northern long-eared bat. July 14, 2015. ADAMS Accession No. ML15196A013.
- Health Physics Society. 2004. "Radiation Risk in Perspective—Position Statement of the Health Physics Society." August 2004. Available at <<https://hps.org/documents/radiationrisk.pdf>> (accessed 4 August 2016).

Appendix B

[IUCN] International Union for the Conservation of Nature. 2001. IUCN Red List Categories and Criteria. Version 3.1. Species Survival Commission, Gland, Switzerland. Available at <http://www.iucnredlist.org/static/categories_criteria_3_1> (accessed 1 March 2017).

[IPCC] Intergovernmental Panel on Climate Change. 2007a. *Climate Change 2007: Synthesis Report*. Contribution of Working Groups I, II, and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri RK, Reisinger A (eds.)]. IPCC, Geneva, Switzerland. Available at <https://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf> (accessed 30 June 2016).

[IPCC] Intergovernmental Panel on Climate Change. 2007b. *Climate Change 2007: Working Group I: The Physical Science Basis*. Solomon S, Qin SD, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL, editors. Available at <https://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg1_report_the_physical_science_basis.htm> (accessed 4 August 2016).

Lantry BF, Stewart DJ. 1993. Ecological energetics of rainbow smelt in the Laurentian Great Lakes: An interlake comparison. *Transactions of the American Fisheries Society* 122:951-976.

Magnuson–Stevens Fishery Conservation and Management Reauthorization Act of 1976. 16 USC 1801 et seq.

[MDH] Minnesota Department of Health. 2015. *Sulfate in Well Water*. May 29, 2015. Available at <<http://www.health.state.mn.us/divs/eh/wells/waterquality/sulfate.pdf>> (accessed 6 June 2016).

National Cancer Institute (NCI). 1990. *Cancer in Populations Living Near Nuclear Facilities*. Bethesda, Maryland.

National Environmental Policy Act of 1969, as amended. 42 USC 4321 et seq.

[NEI] Nuclear Energy Institute. 2007. Industry Ground Water Protection Initiative—Final Guidance Document. NEI 07-07 [Final]. August 2007. ADAMS Accession No. ML072610036.

[NMFS] National Marine Fisheries Service. 2010. Letter from P. Colosi, Assistant Regional Administrator for Habitat Conservation, NMFS, to B. Holian, Director, and D. Wrona, Chief Projects Branch 2, Division of License Renewal, NRC. Regarding: Indian Point Generating Unit Nos. 2 & 3 License Renewal; Docket Nos. 50-247 and 50-268; Essential Fish Habitat Consultation. October 12, 2010. ADAMS Accession No. ML102930012.

[NMFS] National Marine Fisheries Service. 2013. Endangered Species Act Section 7 Consultation Biological Opinion: Continued Operation of the Indian Point Nuclear Generating Station, Units 2 and 3, Pursuant to Existing and Proposed Renewed Operating Licenses, NER 2012-25252. January 30, 2013. ADAMS Accession No. ML13032A256.

[NMFS] National Marine Fisheries Service. 2017. Endangered Species Act Section 7 Consultation Biological Opinion: Tappan Zee Bridge Replacement, NER-2016-13822. January 4, 2017. Available at <https://pcts.nmfs.noaa.gov/pcts-web/dispatcher/trackable/NER-2016-13822?overrideUserGroup=PUBLIC&referrer=%2fpcts-web%2fpublicAdvancedQuery.pcts%3fsearchAction%3dSESSION_SEARCH> (accessed 23 February 2017).

[Normandeau] Normandeau Associates, Inc. 1987a. Indian Point Generating Station Entrainment Abundance Program 1985 Annual Report. Prepared for Consolidated Edison Company of New York, Inc. and New York Power Authority. Report R-332-1062. April 1987. ADAMS Accession No. ML090580419.

- [Normandeau] Normandeau Associates, Inc. 1987b. Indian Point Generating Station Entrainment Abundance Program 1986 Annual Report. Prepared for Consolidated Edison Company of New York, Inc. and New York Power Authority. Report R-220. June 1987. ADAMS Accession No. ML090580425.
- [Normandeau] Normandeau Associates, Inc. 1988. Indian Point Generating Station Entrainment Abundance Program 1987 Annual Report. Prepared for Consolidated Edison Company of New York, Inc. and New York Power Authority. Report R-1110. May 1988. ADAMS Accession No. ML083360798.
- [Normandeau] Normandeau Associates, Inc. 2016. Appendix 2B: Hudson River Rainbow Smelt Infestation by the Microsporidian Parasite *Glugea hertwigi*. March 3, 2016. Submitted as an attachment to Entergy 2016a.
- [NRC] U.S. Nuclear Regulatory Commission. 1989. *Regulatory Analysis for the Resolution of Generic Issue 82, "Beyond Design Basis Accidents in Spent Fuel Pools."* NUREG-1353. April 1989. ADAMS Accession No. ML082330232.
- [NRC] U.S. Nuclear Regulatory Commission. 2001. *Technical Study of Spent Nuclear Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants.* NUREG-1738. February 2001. ADAMS Accession No. ML010430066.
- [NRC] U.S. Nuclear Regulatory Commission. 2008. *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.* NUREG-1437, Supplement 38, Volumes 1 and 2. December 2008. ADAMS Accession Nos. ML083540594 and ML083540614.
- [NRC] U.S. Nuclear Regulatory Commission. 2009. *Safety Evaluation Report Related to the License Renewal of Indian Point Nuclear Generating Unit Nos. 2 and 3.* NUREG-1930, Volumes 1 and 2. November 2009. ADAMS Accession Nos. ML093170451 and ML093170671.
- [NRC] U.S. Nuclear Regulatory Commission. 2010. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants: Supplement 38, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3.* Washington, DC: NRC. NUREG-1437, Supplement 38. December 10, 2010. ADAMS Accession No. ML102990043.
- [NRC] U.S. Nuclear Regulatory Commission. 2011. *Safety Evaluation Report Related to the License Renewal of Indian Point Nuclear Generating Unit Nos. 2 and 3.* NUREG-1930, Supplement 1. August 2011. ADAMS Accession No. ML11242A215.
- [NRC] U.S. Nuclear Regulatory Commission. 2013a. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Revision 1.* Washington, DC. NUREG-1437, 3 Volumes. June 19, 2013. ADAMS Accession No. ML13107A023.
- [NRC] U.S. Nuclear Regulatory Commission. 2013b. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants: Supplement 38, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3.* Washington, DC: NRC. NUREG-1437, Suppl. 38, Vol. 4. June 2013. ADAMS Accession No. ML13162A616.
- [NRC] U.S. Nuclear Regulatory Commission. 2013c. *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal. Revision 1.* Washington, DC: NRC. NUREG-1555. June 19, 2013. ADAMS Accession No. ML13106A246.

[NRC] U.S. Nuclear Regulatory Commission. 2013d. *Procedural Guidance for Preparing Categorical Exclusions, Environmental Assessments, and Considering Environmental Issues*. LIC-203, Revision 3. July 1, 2013. ADAMS Accession No. ML12234A708.

[NRC] U.S. Nuclear Regulatory Commission. 2013e. *Staff Evaluation and Recommendation for Japan Lessons-Learned Tier 3 Issue on Expedited Transfer of Spent Fuel*. COMSECY-13-0030, November 12, 2013. ADAMS Accession Nos. ML13273A601 and ML13273A628.

[NRC] U.S. Nuclear Regulatory Commission. 2014a. Memorandum from R.C. Baval to M.A. Satorius dated May 23 2014, "Staff Requirements—COMSECY-13-0030—Staff Evaluation and Recommendation for Japan Lessons-Learned Tier 3 Issue on Expedited Transfer of Spent Fuel." May 2014. ADAMS Accession No. ML14143A360.

[NRC] U.S. Nuclear Regulatory Commission. 2014b. *NRC Emergency Preparedness and Incident Response Programs*. NUREG-0728, Rev. 5. August 2014. Not publically available.

[NRC] U.S. Nuclear Regulatory Commission. 2014c. *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel*. Washington, DC: NRC, Office of Nuclear Material Safety and Safeguards. NUREG-2157, Vols. 1 and 2. September 2014. ADAMS Accession Nos. ML14196A105 and ML14196A107.

[NRC] U.S. Nuclear Regulatory Commission. 2014d. *Addendum to Enclosure 1 of COMSECY-13-0030, "Regulatory Analysis for Japan Lessons-Learned Tier 3 Issue on Expedited Transfer of Spent Fuel."* September 2014. ADAMS Accession No. ML14252A708.

[NRC] U.S. Nuclear Regulatory Commission. 2014e. "Indian Point Nuclear Generating—NRC Integrated Inspection Report 05000247/2014004 and 05000286/2014004." November 7, 2014. ADAMS Accession No. ML14314A052.

[NRC] U.S. Nuclear Regulatory Commission. 2015a. *Biological Assessment on the Northern Long-Eared Bat (Myotis septentrionalis) and Indiana Bat (Myotis sodalis) for the Indian Point Nuclear Generating Units 2 and 3 Proposed License Renewal*. July 2015. ADAMS Accession No. ML15161A086.

[NRC] U.S. Nuclear Regulatory Commission. 2015b. *Safety Evaluation Report Related to the License Renewal of Indian Point Nuclear Generating Plant, Units 2 and 3*. NUREG-1930, Supplement 2. July 2015. ADAMS Accession No. ML15188A383.

[NRC] U.S. Nuclear Regulatory Commission. 2015c. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants: Supplement 38, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3*. NUREG-1437, Suppl. 38, Vol. 5. Draft Report for Comment. December 2015. ADAMS Accession No. ML15351A422.

[NRC] U.S. Nuclear Regulatory Commission. 2016. Letter from G.T. Dentel, Chief, Reactor Projects Branch 2, Division of Reactor Projects, NRC, to L. Coyle, Site Vice President, Entergy. Subject: Indian Point Nuclear Generating—Integrated Inspection Report 05000247/2016001 and 05000286/2016001. May 12, 2016. ADAMS Accession No. ML16133A597.

[NYSDEC] New York State Department of Environmental Conservation. 2003. *Final Environmental Impact Statement Concerning the Applications to Renew New York State Pollutant Discharge Elimination System (SPDES) Permits for the Roseton 1 and 2, Bowline 1 and 2, and Indian Point 2 and 3 Steam Electric Generating Stations, Orange, Rockland and Westchester Counties. Hudson River Power Plants FEIS*. June 25, 2003. ADAMS Accession No. ML083360752.

[NYSDEC] New York State Department of Environmental Conservation. 2009. New York State Department of Environmental Conservation Comments on the NRC Staff's Draft Supplemental Environmental Impact Statement for the License Renewal of Indian Point Units 2 and 3, Buchanan, New York. March 18, 2009. ADAMS Accession No. ML090780782.

[NYSDEC] New York State Department of Environmental Conservation. 2010. *DER-10/Technical Guidance for Site Investigation and Remediation*. May 3, 2010. Available at http://www.dec.ny.gov/docs/remediation_hudson_pdf/der10.pdf (accessed 22 September 2016).

[NYSDEC] New York State Department of Environmental Conservation. 2016. Letter from K. Moser, Deputy Commissioner, NYSDEC, to C. Bladey, Office of Administration, NRC. Re: Comments on the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 38, Volume 5, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3, Draft 6 Report for Comment* (NUREG-1437). March 4, 2016. ADAMS Accession No. ML16069A379.

[NYSDEC] New York State Department of Environmental Conservation. 2017c. State Pollutant Discharge Elimination System (SPDES) Discharge Permit NY0004472. Issued April 24, 2017. Effective May 1, 2017. ADAMS Accession No. ML17138A236

[NYSDEC] New York State Department of Environmental Conservation (NYSDEC). 2017b. "Fact Sheet. New York State Pollutant Discharge Elimination System (SPDES) Draft Permit Renewal with Modification, Indian Point Electric Generating Station, Buchanan, NY." January 2017. Available at http://www.dec.ny.gov/docs/permits_ej_operations_pdf/ipspdesfctsht.pdf (accessed 8 March 2017).

[NYS DOS] New York State Department of State. 2012. Significant Coastal Fish & Wildlife Habitats, Coastal Fish and Wildlife Rating Form, Hudson Highlands. Office of Planning and Development. Updated August 15, 2012. Available at http://www.dos.ny.gov/opd/programs/consistency/Habitats/HudsonRiver/Hudson_Highlands_FLNAL.pdf (accessed 14 March 2016).

[NYS et al.] New York State Governor, New York State Department of Environmental Conservation, New York State Department of Health, New York State Department of State, Office of the Attorney General of the State of New York, New York State Department of Public Service, Entergy Nuclear Indian Point 2 LLC, Entergy Nuclear Indian Point 3 LLC, Entergy Nuclear Operations Inc. 2017. Indian Point Agreement. January 8, 2017. ADAMS Accession No. ML17180A396.

Oak Ridge National Laboratory. 1979. Letter from L. Barnhouse, Research Associate, Oak Ridge National Laboratory, to J. Golumbek, U.S. Environmental Protection Agency. September 28, 1979.

O'Grady JJ, Reed DH, Brook BW, Frankhan R. 2004. What are the best correlates of predicted extinction risk. *Biological Conservation* 118:513–520.

Petraitis P. 2013. *Multiple Stable States in Natural Ecosystems*. Oxford University Press. Oxford, England.

[PHASE] Public Health and Sustainable Energy. 2016. NRC Public Comments, Re: *Docket Number 2008-0672: The Nuclear Regulatory Commission (NRC) Notice: Entergy Nuclear Operations, Inc.; Indian Point Nuclear Generating Unit Nos. 2 and 3; Draft Supplemental Environmental Impact Statement; Request for Comment*. *Federal Register Number: 2015-32777*. March 4, 2016. ADAMS Accession No. ML16069A335.

Appendix B

[Pisces] Pisces Conservation, Ltd. 2015. The Status of Fish Populations and the Ecology of the Hudson. June 2015. ADAMS Accession No. ML16069A366.

[Pisces] Pisces Conservation, Ltd. 2016. Notes on *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 38, Volume 5, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3, Draft Report for Comment* (NUREG-1437). Memo from Richard Seaby to Jim Bacon and Mark Lucas—Riverkeeper, Re: The NRC supplemental information of the Indian Point GEIS. 04 March 2016. ADAMS Accession No. ML16069A366.

Pimm SL, Jones HL, Diamond J. 1988. On the risk of extinction. *The American Naturalist* 132(6):757-785.

[Riverkeeper] Riverkeeper, Inc. 2016. Letter from J. Bacon, Attorney for Riverkeeper, to Rulemakings and Adjudications Staff, NRC. Re: Comments of Riverkeeper, Inc. on *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 38, Volume 5, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3, Draft Report for Comment* (NUREG-1437) ID NRC-2008-0672. March 4, 2016. ADAMS Accession No. ML16069A366.

Riverkeeper Inc. Llc v. EPA. 2007. 475 F.3d 83, 2nd Circuit Court.

Safe Drinking Water Act (SDWA). 42 USC 300F et seq.

Scheffer M. 2009. *Critical Transitions in Nature and Society*. Princeton University Press. Princeton, New Jersey.

[UMA] UMA Engineering Pacific, Inc. 1974. *Feasibility Study and Design Development Striped Bass Fish Hatchery Hudson River, New York for Consolidated Edison Company of New York, Inc. New York, New York*. December 15, 1974. ADAMS Accession No. ML100221977.

[USGCRP] U.S. Global Change Research Program. 2009. *Global Climate Change Impacts in the United States*. Karl TR, Melillo JM, Peterson TC, editors. ADAMS Accession No. ML100580077.

[USGCRP] U.S. Global Change Research Program. 2014. *Climate Change Impacts in the United States: The Third National Climate Assessment*. Melillo JM, Richmond TC, Yohe GW, editors. ADAMS Accession No. ML14129A233.

[USGS] U.S. Geological Survey. 2016a. USGS Surface-Water Monthly Statistics for the Nation, USGS 01358000 Hudson River at Green Island NY. Available at http://waterdata.usgs.gov/nwis/monthly/?format=sites_selection_links&search_site_no=01358000&agency_cd=USGS&referred_module=sw (accessed 1 March 2017).

[USGS] U.S. Geological Survey. 2016b. Quality of Ground Water. June 20, 2016. Available at <http://pubs.usgs.gov/gip/gw/quality.htm> (accessed 6 June 2016).

Young JR. 2016a. Appendix 2C: Biological Examination of Spatial and Temporal Distribution and Abundance of Early Life Stages of River Herring With Respect to IPEC Entrainment Impacts. Prepared for Entergy Nuclear Operations, Inc. March 2016. Submitted as an attachment to Entergy 2016a.

Young JR. 2016b. Appendix 2E to Entergy: Review of NRC's Strength of Connection Calculations. March 2016. Submitted as an attachment to Entergy 2016a.

Zhang GJ, Cai M, Hu A. 2013. Energy consumption and the unexplained winter warming over northern Asia and North America. *Nature Climate Change* 3(5):466-470. Available at https://www.researchgate.net/publication/258807241_Energy_consumption_and_the_unexplained_winter_warming_over_northern_Asia_and_North_America#pf5 (accessed 30 June 2016).

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Docket Nos. 50-247 and 50-286

11. ABSTRACT (200 words or less)

This second supplement to the final supplemental environmental impact statement (FSEIS) for the proposed renewal of the operating licenses for Indian Point Nuclear Generating Unit Nos. 2 and 3 incorporates new information that the U.S. Nuclear Regulatory Commission (NRC) staff has obtained since the publication of the first supplement to the FSEIS in June 2013.

This supplement includes the NRC staff's evaluation of revised engineering project cost information for severe accident mitigation alternatives (SAMAs), additional sensitivity analysis of SAMAs, newly available aquatic impact information, the additional environmental issues associated with license renewal resulting from the June 2013 revision to Table B-1 in Appendix B to Subpart A of Title 10 of the Code of Federal Regulations (10 CFR) Part 51 and NUREG-1437, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants," and incorporates the impact determinations of NUREG-2157, "Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel," in accordance with the requirements in 10 CFR 51.23(b). Additionally, this supplement describes the reinitiation of consultation under Section 7 of the Endangered Species Act regarding the Northern Long-Eared Bat (*Myotis Septentrionalis*). This supplement also provides and update on the status of the operating licenses for Indian Point Nuclear Generating Unit Nos. 2 and 3.

12. KEY WORDS/DESCRIPTORS (List words or phrases that will assist researchers in locating the report.)

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