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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

Office of Nuclear Reactor Regulation

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For additional information or copies of this document contact:

Division of License Renewal
U.S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Mail Stop O-11F1
11555 Rockville Pike
Rockville, Maryland 20852
Phone: 1-800-368-5642, extension 6459
Fax: (301) 415-2002
Email: michael.wentzel@nrc.gov

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 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, 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*) and provides an update on the status of the operating licenses for Indian Point Nuclear Generating Unit Nos. 2 and 3.

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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 1to 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.

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 regarding the northern long-eared bat (*Myotis septentrionalis*).

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 license:

> 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 3216 megawatts thermal (MW(t)) (core power) with a design net electrical capacity of 1078 megawatts electric (MW(e)). IP3 is currently licensed to generate 3216 MW(t) (core power) with a design net electrical capacity of about 1080 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.**

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 a license renewal application, 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)
ADAMS	Agencywide Documents Access and Management System
AEC	Atomic Energy Commission
AFW	auxiliary feedwater
AREOR	Annual Radiological Environmental Operating Report
ASMFC	Atlantic States Marine Fisheries Commission
ASLB	Atomic Safety and Licensing Board
BCG	Biota Concentration Guide
BLS	Bureau of Labor Statistics
BMPs	best management practices
BSS	Beach Seine Survey
CAA	Clean Air Act of 1970
CFR	Code of Federal Regulations
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
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DPS	distinct population segment
EIA	Energy Information Administration
EIS	environmental impact statement
EMR	entrainment mortality rate

Entergy	Entergy Nuclear Operations, Inc.
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
FLIGHT	Facility Level Information on GreenHouse gases Tool
FR	Federal Register
FSEIS	final supplemental environmental impact statement
FSS	Fall Shoals Survey
ft	foot (feet)
Fukushima Dai-ichi	Fukushima Dai-ichi Nuclear Power Plant
FWS	U.S. Fish and Wildlife Service
GEIS	NUREG-1437, “Generic Environmental Impact Statement for License Renewal of Nuclear Plants”
GHG	greenhouse gas
gpm	gallon(s) per minute
Gy/d	gray per day
ha	hectare(s)
HCFC	hydrochlorofluorocarbons
I&E	impingement and entrapment
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^3/min	cubic meter(s) per minute

m^3/s	cubic meter(s) per second
mrem	millirem
MCL	maximum contaminant level(s)
MMT	million metric tons
MT	metric ton(s)
MWe	megawatt electric
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
NHPA	National Historic Preservation Act of 1966
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
NRC	U.S. Nuclear Regulatory Commission
NYB	New York Bight
NYCRR	New York Codes, Rules, and Regulations
NYSDEC	New York State Department of Environmental Conservation
OTR	ozone transport region
PCB	polychlorinated biphenyl
pCi/L	picocurie(s) per liter
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
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
SEIS	supplemental environmental impact statement
SOC	strength of connection
SPDES	State Pollutant Discharge Elimination System
SRM	Staff Requirements Memorandum
USACE	U.S. Army Corps of Engineers
USCB	U.S. Census Bureau
USGCRP	U.S. Global Change Research Program
USGS	U.S. Geological Survey
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.

Four 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.

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 (Volume 78 of the *Federal Register* (FR), page 37282 (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 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.

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 regarding the northern long-eared bat (*Myotis septentrionalis*). Chapter 2 of this supplement updates the information in the FSEIS pertaining to the expiration date of the IP2 and IP3 licenses. Chapter 7 of this supplement discusses the status of consultation regarding the northern long-eared bat.

Where appropriate, **bold** text indicates specific text corrections or additions to the FSEIS, and **bold strikeout** indicates deletions from the text.

2.0 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. 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 under its existing license until the NRC reaches a decision on the license renewal request. The operating license of IP3 is set to expire on December 12, 2015.

Based on the change in status for the IP2 license, 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.**

3.0 REVISED SAMA ENGINEERING PROJECT COST ESTIMATES

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.

Notwithstanding the acceptability of the SAMA analysis described in the 2010 final supplemental environmental impact statement (FSEIS), 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's letter dated May 6, 2013, discussed deferring the consideration of certain cost-beneficial SAMAs pending implementation of action items related to the U.S. Nuclear Regulatory Commission's (NRC's) comprehensive safety assessment in response to the events affecting the Fukushima Dai-ichi Nuclear Power Plant (Fukushima Dai-ichi) (Entergy 2013b). The NRC staff's assessment of Entergy's revised cost estimates and the deferral of certain cost-beneficial SAMAs are discussed below.

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 require implementation of cost-beneficial SAMAs before issuing a renewed license or provide its rationale for not requiring their implementation.

In June 2010, the Atomic Safety and Licensing Board Panel (ASLBP) issued Order LBP-10-13 granting admission of NYS-35 and consolidating it with NYS-36 (ASLBP 2010). In its decision, the ASLBP 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 ASLBP 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 ASLBP granted New York State's Motion for Summary Disposition (and denied Entergy's and the NRC's motions) regarding contention NYS-35/36 (ASLBP 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 ASLBP's decision to the Commission; however, in December 2011, the Commission found that the appeal was interlocutory (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.

By letter dated May 6, 2013 (Entergy 2013b), Entergy submitted the results of completed, refined engineering project cost estimates for those SAMAs that it previously determined to be potentially cost beneficial. As a result of the refined cost estimation, Entergy determined that 6 of the 22 SAMAs were no longer cost beneficial. Entergy also stated that it has elected to voluntarily implement four 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 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).

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;
- 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 (AACE) International (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 provided by Entergy 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 noting 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, 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	$4,1000,000	$1,738,982	$1,741,724
IP2-021 – Install additional pressure or leak monitoring instrumentation for inter-system 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 V switchgear room	$11,772,170	$200,000	$456,985	$458,843
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

SAMAs Previously Determined To Be Cost Beneficial	Benefit with Uncertainty	Estimated Cost (2009)	Refined Estimated Cost (2013)	Corrected Estimated Cost (2014)
IP2-060 – Provide added protection against flood propagation from stairwell 4 into the 480 V 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 V switchgear room	$5,799,982	$192,000	$933,981	$943,792
IP2-062 – Provide a hard-wired connection to a safety injection (SI) pump form 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 V switchgear room	$6,317,929	$196,800	$494,175	$496,071
IP3-GAG – Steam Generator safety gagging device (To be Implemented)	$19,000,000	$50,000	$458,617	$453,745

Source: 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, 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 amongst 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 amongst 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 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 intersystem 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, 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 appears to be large 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 non-destructive 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's 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 5l (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 evaluations; 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 appears to be large 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 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's 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 large uncertainty in the cost estimate, 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's 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 (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 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 International'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 International'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 International'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 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

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 that were 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 AACE International 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 AACE International 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.

According to AACE International's RP No. 18R-97, estimated costs for a Class 5 estimate can be high by as much as 100 percent or low by as much as 50 percent. Based on this large range of uncertainty, the 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 that have been determined to be potentially cost beneficial should be deferred due to 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 reevaluated 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 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 that were 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 Revisions to the 2010 FSEIS Resulting from Entergy's Completed Engineering Project Cost Estimates for SAMAs Previously Identified as Potentially Cost Beneficial

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 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-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 reevaluated 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 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.

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-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 reevaluated 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 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 ENTERGY'S REPORTEDLY NEW INFORMATION FOR ENTRAINMENT AND IMPINGEMENT IMPACTS

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. Entergy asserted that this new information and analysis indicated that potential impacts to certain aquatic species as a result of projected entrainment and impingement 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 those 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.

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 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.

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 Indian Point Nuclear Generating Unit Nos. 2 and 3 (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 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 resource impact assessment in Entergy (2007b), a December 2007 supplement to its license renewal application. 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 says that, as a result of the new information and the AKRF report, which relies on different data than that what 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 2008 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 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.

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 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 and important species (RIS) addressed by the NRC's assessment of the effects of the entrainment and impingement at IP2 and IP3 on Hudson River aquatic resources. 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:

(1) The National Marine Fisheries Service's (NMFS's) listing determination for blueback herring (Volume 78 of the *Federal Register* (FR), page 48944 (FR 78 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 CWIS [cooling water intake system], and therefore suggest that reconsideration of that finding is warranted;"

(2) a New York State Department of Environmental Conservation (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

(3) 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 Endangered Species Act of 1973, as amended (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 postponed the listing decision until certain data deficiencies could be resolved and further analysis could be completed. Indeed, NMFS (2015) presently considers river herring to be a "Species of Concern" and "Candidate Species" for future listing.

In late 2013, NMFS and the ASMFC formed a River Herring Technical Expert Working Group to assist them in developing more complete information on the species and invited participants in this Working Group from Federal Government agencies, State fish and wildlife agencies, East Coast Native American Tribes and First Nations, academic and scientific groups, fishery management councils, conservation and environmental groups, industry (e.g., hydropower and fishing), and recreational groups. The Technical Expert Working Group set up a web page on NMFS's web site, (http://www.greateratlantic.fisheries.noaa.gov/protected/riverherring/tewg/index.html), where it posts its activities and information.

In its letter, Entergy (2014b) stated that "NMFS and ASMFC ranked all cooling water intake structure impacts, such as I&E [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 (undated) 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 "Alter water withdrawal rates or water intake velocities to reduce alosine mortality. Locate 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 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 are summarized in Section 4.3.

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).

Hatalla et al. (2011) assessed the information from the Hudson River utilities'' Beach Seine Survey (BSS, 1974 through 2009) and Fall Shoals Survey (FSS, 1979 through 2009) monitoring programs, the same sampling programs that were analyzed by the NRC staff 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). They 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 was 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 deleted.]

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.

This information from NYSDEC contradicts Entergy's (2014) 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 I&E [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 representative important species (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), Fall Shoals Survey (FSS), and Beach Seine Survey (BSS) in 1995, 1998 (one fish), and 1993, respectively, roughly midway through the period analyzed here. 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 essentially disappeared from the river after 1995 (Daniels et al. 2005). When present, the largest abundances of eggs and YSL 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) note that in the period 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 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.

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 does not warrant changing the finding from Moderate-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 information that Entergy submitted in support of the AKRF report, the NRC staff reassessed impacts to rainbow smelt and other species. The results of the NRC staff's independent analysis are summarized in Section 4.3.

4.3 NRC Staff's Independent Analysis of the AKRF (2014, 2015) Reports and Updated Field Data

The AKRF (2014, 2015) reports update the NRC staff's FSEIS 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 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 analysis, 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 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.

Table 4–1. Differences in Methodology among the FSEIS (NRC 2010, 2013b), Entergy (2015c; AKRF 2014, 2015), and the Present Analysis.

Method	Analysis Feature	FSEIS (NRC 2010,2013b)	Entergy (2015c; AKRF 2014, 2015)	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 young-of year caught within designated weeks/volume sampled	Total young-of-year 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

Method	Analysis Feature	FSEIS (NRC 2010,2013b)	Entergy (2015c; AKRF 2014, 2015)	Present Analysis
	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
Weight of Evidence	Impact levels	Small, Moderate, and Large	Small, Moderate, and Large	Small, Moderate, Large, Unresolved, and results from NMFS (2015) biological opinion for threatened and endangered species.

In the FSEIS, the population trend analysis conducted by the NRC staff applies 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. Indian Point Nuclear Generating Unit No.1 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 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 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; ASMFC 2007AS; O'Connor et al. 2012). As a result, in the present analysis more RIS population trends were analyzed using the LRS data than had been 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. 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 for the population trend line of evidence. 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 strength of connection (SOC) analysis, AKRF used the parameter values from the NRC staff's 2010 FSEIS (2010) rather than the updated values from the 2013 FSEIS supplement (2013b). The NRC staff's independent analysis updates the 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 (2010) or 2013 FSEIS supplement (2013b). In the present analysis, the NRC staff also included a category, "Unresolved" for those RIS for which a Population Trend line of evidence (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 analysis differs from AKRF's in these ways.

The NRC staff finds that four species had 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 impact of IP2 and IP3 cooling system operation 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 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 unresolved strength of connection, impacts could not be 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 WOE impact of "Low." Here, the lack of resolution in both LOEs is assigned a WOE impact value of "Unresolved" 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 staff described the unresolved impacts to Atlantic and shortnose sturgeon as "Small." No information has been received by the NRC staff that would further resolve the impact levels. In June 2013, the NRC (2013a) updated NUREG–1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. Based on the guidance contained in the GEIS update, the NRC now expresses results for ESA-listed species not as Small, Moderate, or Large, but in language prescribed by the ESA. To be consistent with the NRC's updated practice, the NRC staff's new analysis incorporates the conclusions of NMFS's biological opinion concerning the effects of IP2 and IP3 cooling water system operation on the endangered Atlantic and Shortnose sturgeon. As such, the biological opinion (NMFS 2013) concludes that the continued effects of impingement and entrainment at IP2 and IP3 are likely to adversely affect, but not jeopardize the continued existence of, both species, and the NRC staff incorporates the biological opinion conclusion in the WOE results for the two Federally listed species.

Table 4–2. Impacts of Impingement and Entrainment at IP2 and IP3 on Hudson River Representative Important Species in FSEIS, Entergy's Analysis, and the Present Analysis

Species	FSEIS (NRC 2013b)	Entergy (2015)	Present Analysis
Alewife	Moderate	Small	Small [d]
American Shad	Small	Small	Small
Atlantic Menhaden	Small[a][b]	Small[a][b]	Unresolved[a][b]
Atlantic Sturgeon	Small[a][b]	Small[a][b]	Likely to adversely affect[a][b][c]
Atlantic Tomcod	Small	Small	Small
Bay Anchovy	Small	Small	Small
Blueback Herring	Large	Small	Large
Bluefish	Small	Small	Small

Species	FSEIS (NRC 2013b)	Entergy (2015)	Present Analysis
Gizzard Shad	Small[(a)(b)]	Small[(a)(b)]	Unresolved[(a)(b)]
Hogchoker	Large	Moderate	Moderate
Rainbow Smelt	Moderate-Large	Moderate	Large
Shortnose Sturgeon	Small[(a)(b)]	Small[(a)(b)]	Likely to adversely affect[(a)(b)(c)]
Spottail Shiner	Small	Small	Small
Striped Bass	Small	Moderate	Small
Weakfish	Moderate	Small	Small[(d)]
White Catfish	Small	Small	Small
White Perch	Large	Small	Small[(d)]
Blue Crab	Small[(a)(b)]	Small[(a)(b)]	Unresolved[(a)(b)]

(a) Population Trend LOE could not be established.

(b) Strength of Connection could not be established using Monte Carlo simulation.

(c) From NMFS's (2013) biological opinion. In Supplement 1 to the FSEIS, the NRC staff described the unresolved impacts to Atlantic and shortnose sturgeon as "Small." No information has been received by the NRC staff that would further resolve the impact levels.

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

5.0 NEW ENVIRONMENTAL ISSUES RESULTING FROM THE REVISION TO 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 (Volume 78 of the *Federal Register* (FR), page 37282 (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 2009). 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 permit~~s~~, 3-5522-00011/00026 ~~**and 3-5522-00105/00009, respectively**~~ (Entergy ~~**2007a**~~ **2015**).

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 (AQCR) include inter/intrastate counties that share a common airshed. With respect to NAAQS, Westchester County is designated a nonattainment area for ozone (O_3) 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 (O_3) 8-hour standard~~,~~ **and** particulate matter less than 10 microns in diameter (PM_{10}),~~ **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*—O_3 and $PM_{2.5}$**~~
> - ~~**Litchfield—O_3**~~
>
> ~~**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*—O_3 and $PM_{2.5}$**~~
> - ~~**Sussex*—O_3**~~

~~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*—O_3 and $PM_{2.5}$~~
- ~~Dutchess and Putnam—O3~~
- ~~New York*—O_3, PM_{10}, 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	PM2.5
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 $PM_{2.5}$

State	County	Designation	
		Nonattainment Area	Maintenance Area
	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 (NOx) 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 diesel generators, gas turbines, diesel fire pumps, 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).

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 (SO_2), 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. Permitted air emission sources at IP2 and IP3 include diesel generators, gas turbines, diesel fire pumps, and heating boilers. These 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 (NYSEDC 2015a). Over the previous 5 years (2010 to 2014), there have been no notices of violations associated with IP2 and IP3 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 (O_3) 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 PM_5. 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 with 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. 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 because the soils are not considered to be suitable for prime farmland. 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 Mable 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 reevaluate 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 reevaluated 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 RAIs 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 downstream fresh water flow, Hudson River water at the IP2 and IP3 site is usually either saline or brackish (Entergy 2007a).

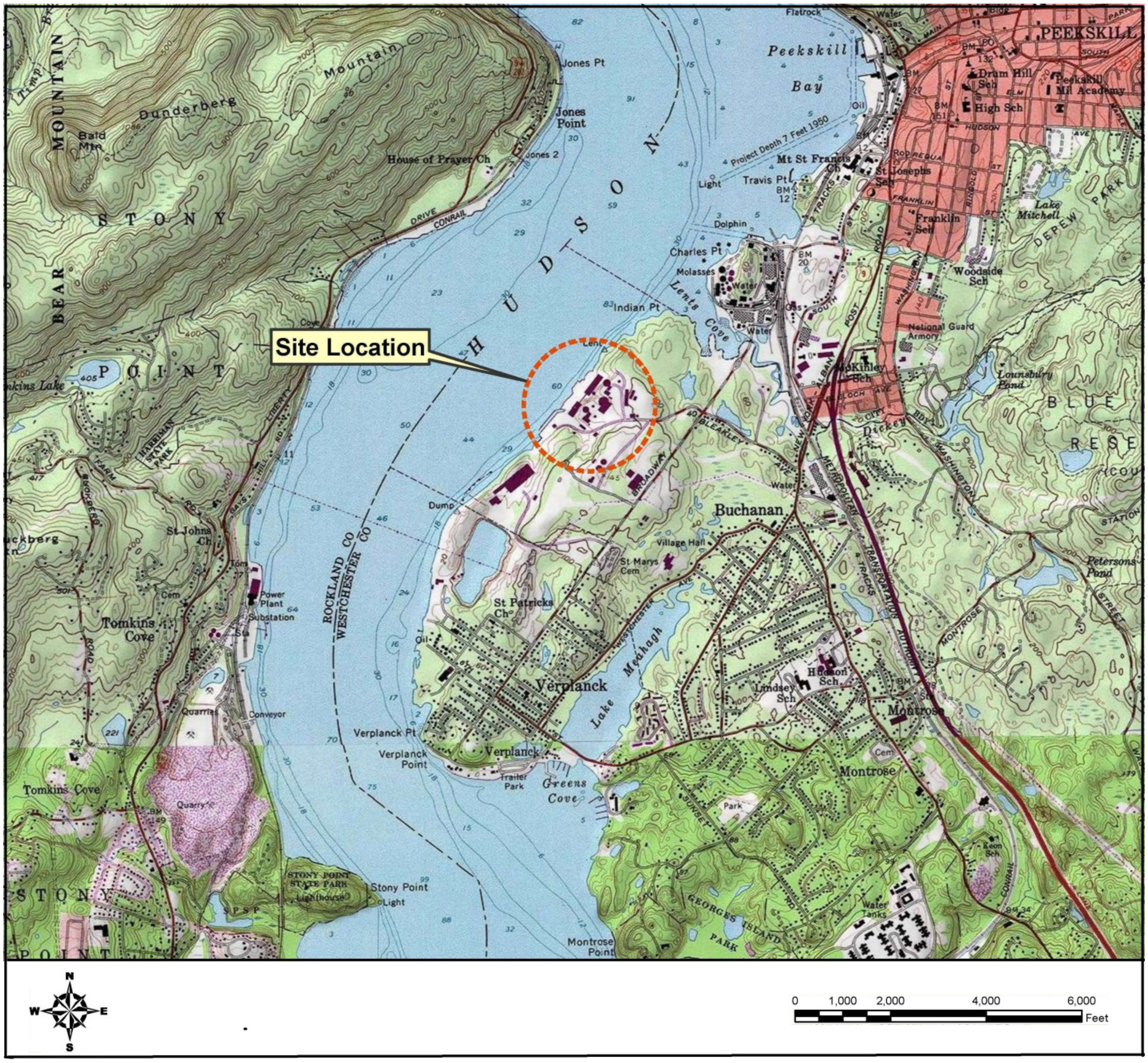
5.4.1.2 Groundwater

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) that 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).

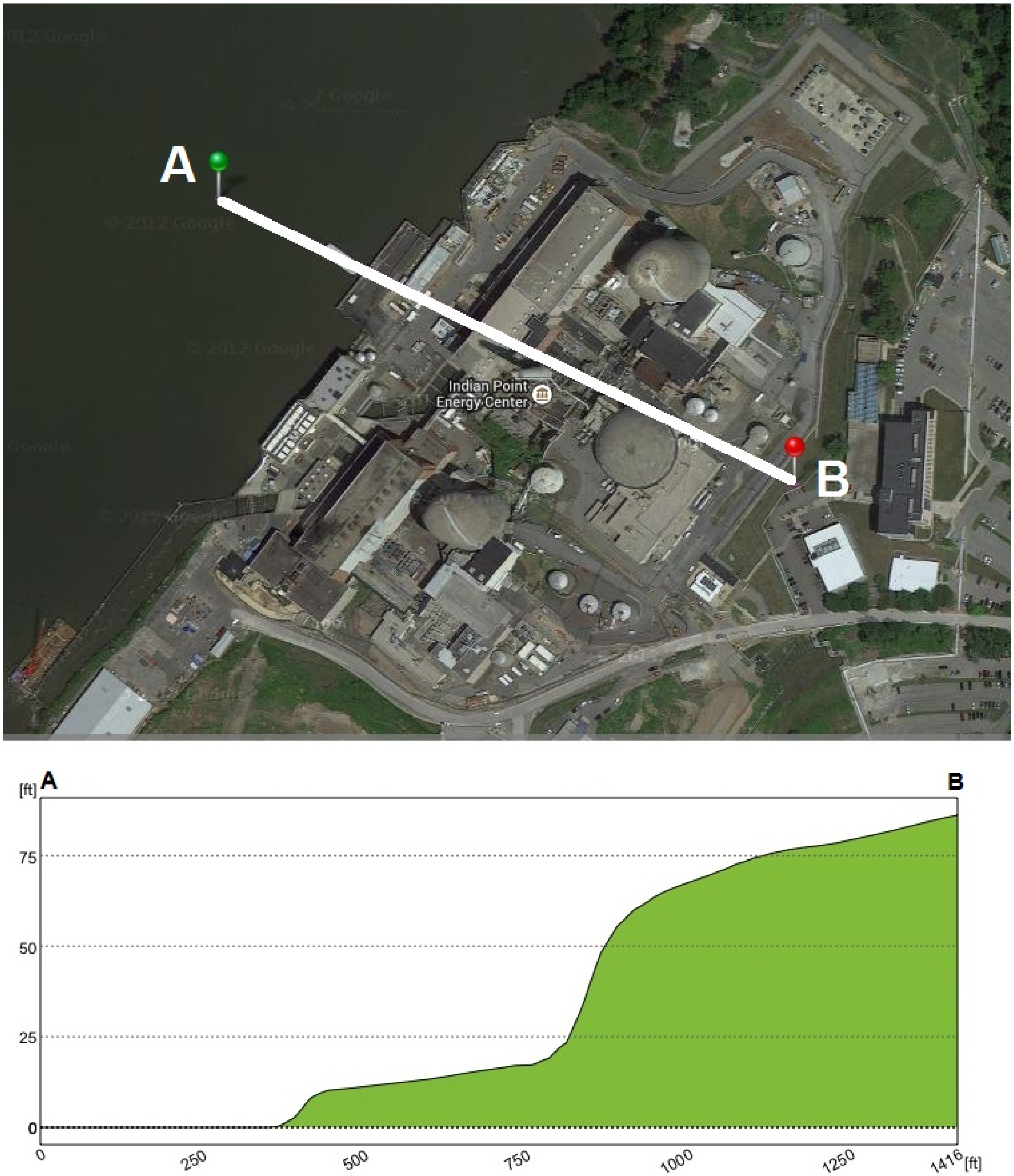
The IP2 and IP3 site is bordered on the northwest by the Hudson River. At the river, the elevation of the land surface is 10 ft (3 m) above the National Geodetic Vertical Datum of 1929 (NGVD-29). Moving east from the river, the land surface rises up to approximately 140 ft (43 m) NGVD-29 near the eastern 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).

1 **Figure 5–1. Site Location and Topography**



2 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 (7- 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 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). United Water has proposed to construct and operate a desalination facility in the town of Haverstraw, approximately 4 mi (6.5 km) south-southwest downstream of the IP2 and IP3 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. As discussed in Section 5.14.4, the operations of IP2 and IP3 are not expected to adversely affect operation of the proposed facility.

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). Onsite, 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 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 associated with the IP2 spent fuel pool and its associated fuel transfer canal created another plume of tritium contamination (GZA 2008; NRC 2012e). The radionuclides cesium-137, nickel-63, and cobalt-60 have been sporadically identified in the groundwater on site. How these radionuclides got into the groundwater has not been determined, but no discrete plumes of contamination have been found for these radionuclides (Entergy 2008c, 2009a, 2010a, 2011a, 2012b, 2013a, 2014f, 2014h, 2015b, 2015f; 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; GZA 2008; and 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).

IP2 Spent Fuel Pool Leaks

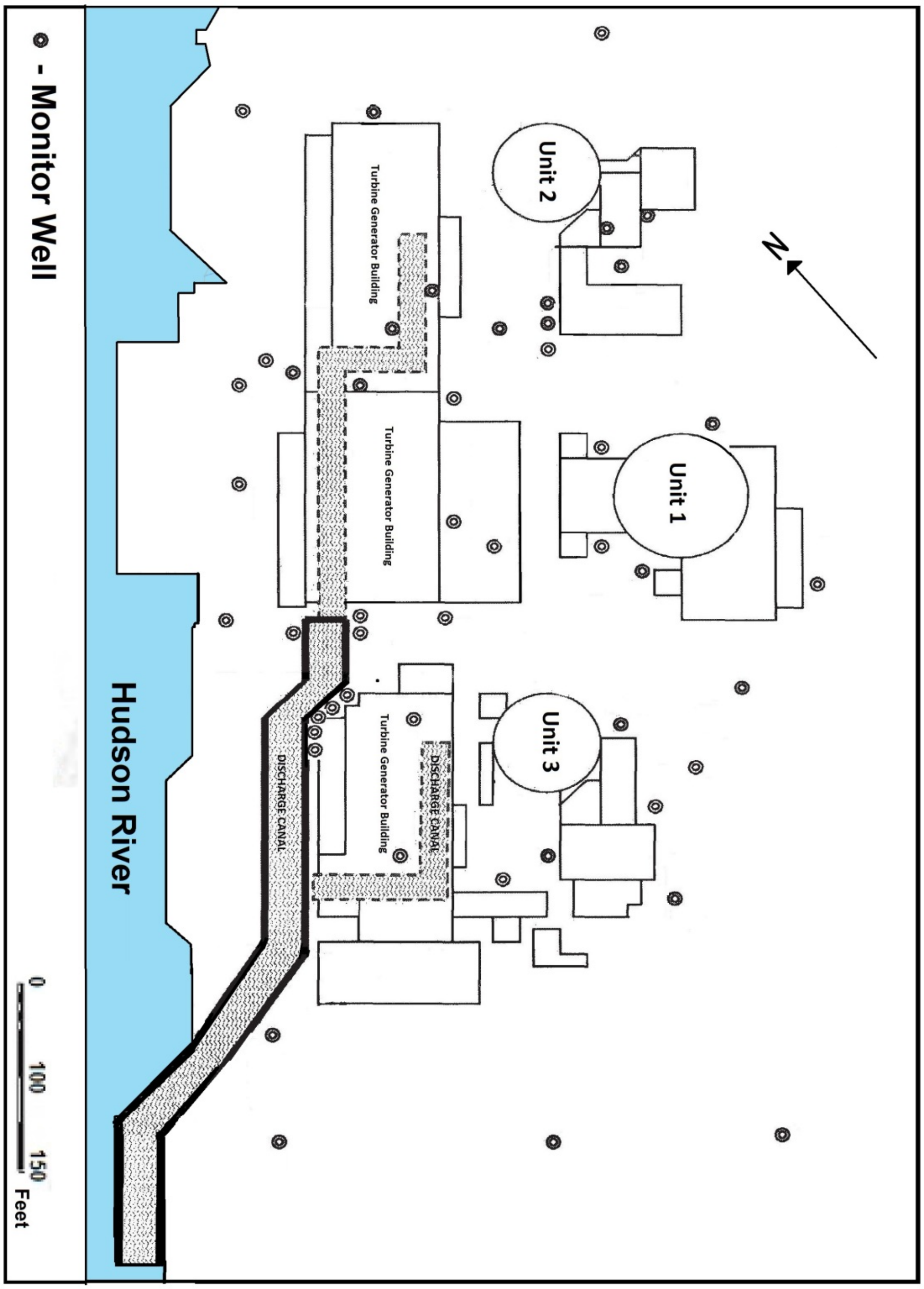
In 1990, a small hole was detected in the IP2 spent fuel pool stainless steel liner. An estimated 50 gallons (189 liters) per day had been leaking through this hole. An epoxy seal was installed to plug the hole. Later in 1992, a steel box was welded over the epoxy-sealed hole to permanently seal the 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 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 2015a).

5.4.2.2 Extent of Groundwater Contamination

Entergy established 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.

Figure 5–3. Monitor Wells Located near Plant Buildings



Sources: Modified from Entergy 2008c, 2015b

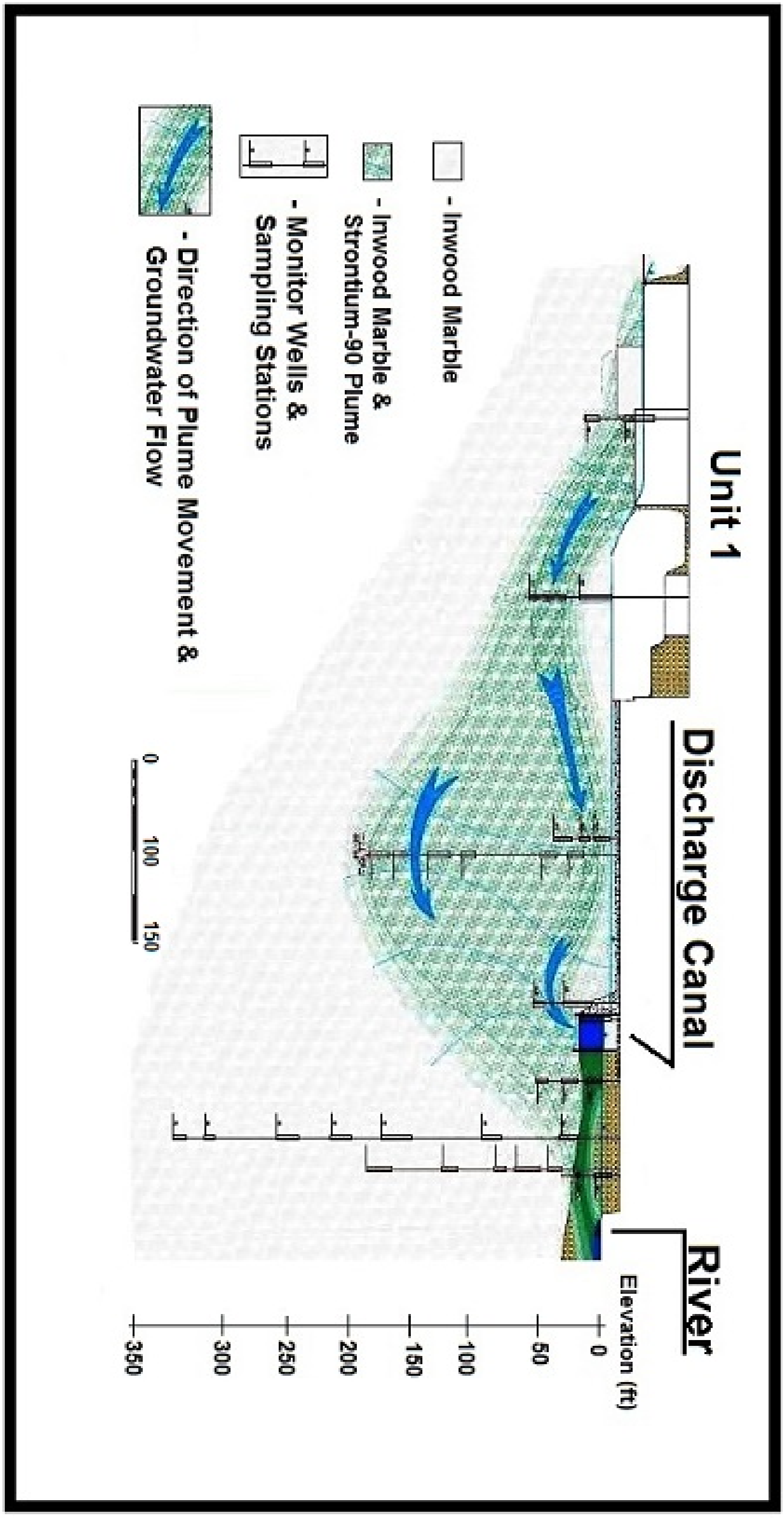
Radionuclide contamination is found above and in the water table. When contaminated water leaked into the Inwood Marble, it first flowed through the fractures of the Inwood Marble above the water table. As the contaminated water moved downward under gravity, it moved both vertically and laterally. As a result, it is believed the leaks from the IP2 spent fuel pool contaminated a small area of the Inwood Marble 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 from the IP2 spent fuel pool, (2) a tritium plume from the IP1 spent fuel pool, and (3) a strontium-90 plume from the IP1 spent fuel pool. These plumes comingle 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.

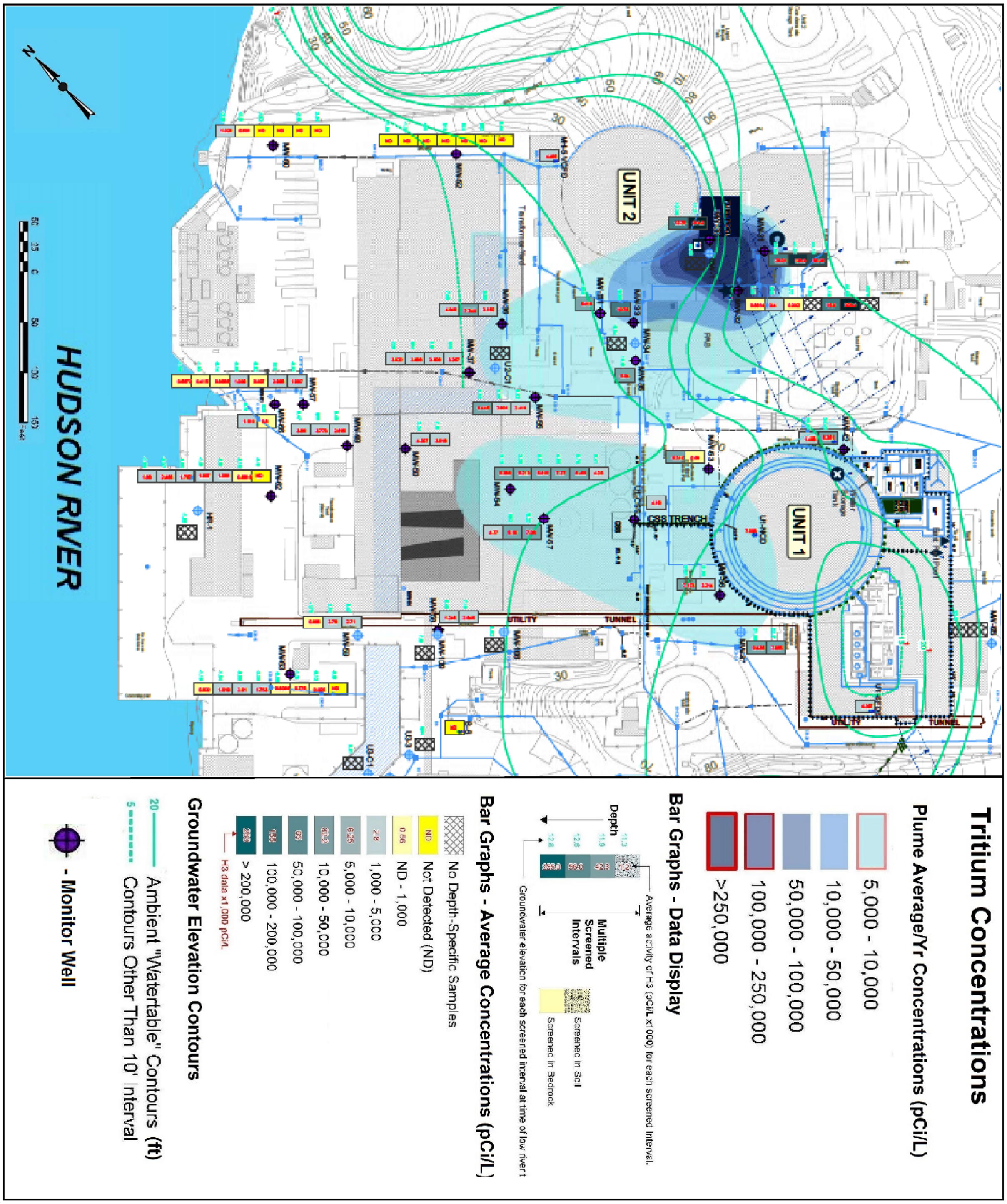
Groundwater contamination plume maps show the lateral extent of the plumes from their points of origin to their discharge locations near the Hudson River. Figure 5–5 shows the lateral extent of both the IP2 and IP1 tritium plumes in the 4th quarter of 2014. Figure 5–6 shows the lateral extent of the strontium-90 plume in the 4th quarter of 2014. Groundwater monitoring data confirm that tritium and strontium-90 groundwater contamination moves toward and into the Hudson River. Contamination has not been detected moving off the site in any other direction (Entergy 2014h, 2014k, 2015b, 2015f).

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



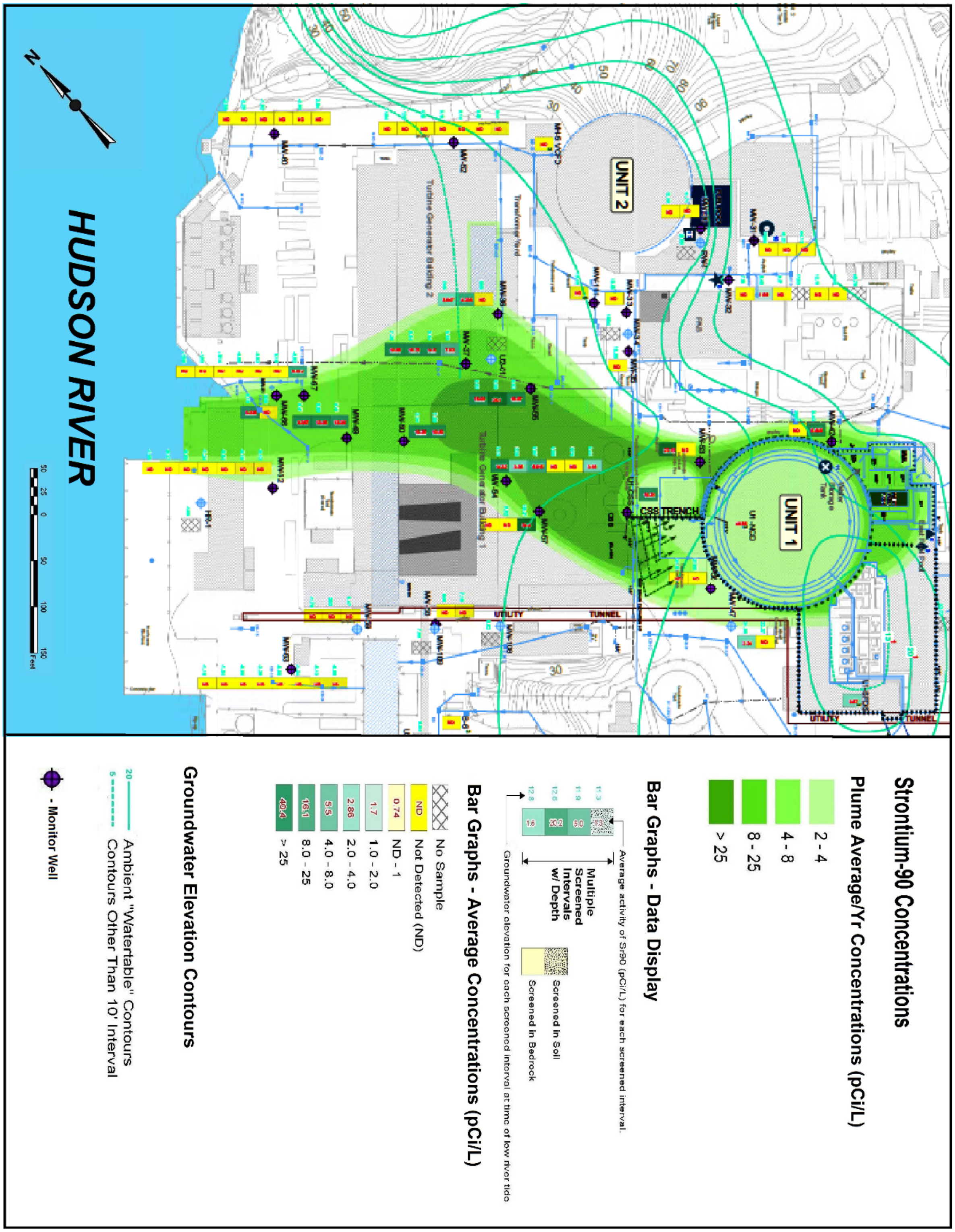
2 Source: Modified from Entergy 2015b

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



2 Source: Modified from Entergy 2015f

Figure 5–6. Strontium-90 Plume in the 4th Quarter of 2014



Source: Modified from Entergy 2015f

For short periods of time, from 2007 through June of 2014, 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).

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 cesium-137, cobalt-60, nickel-63, strontium-90, and tritium. The MCL represents the sum of all radionuclides, 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 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 Levels/Limits

Radionuclide	Concentration (pCi/L)[a]
Cesium-137	200
Cobalt-60	100
Nickel-63	50
Strontium-90	8
Tritium	20,000

[a] Concentration for this radionuclide to produce a dose of 4 mrem per year.

Sources: EPA 2002a, 2002b, 2002c, 2002d, 2002e

In the third quarter of 2014, tritium concentrations in the plume from the IP2 spent fuel pool were below the concentration in Table 5–2 over much of the area of the plume but exceed the concentration 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 are all below the concentration in Table 5–2 over the entire plume length. Concentrations of strontium-90 usually exceeded the Table 5–2 limit over much of the plume area. For cesium-137, cobalt-60, and nickel-63, only cesium-137 and nickel-63 exceeded their limits in Table 5–2, and that was at sample location MW-42-49. From 2003 through 2013, routine monitoring of tritium in Hudson River water has been conducted. Concentrations in the river water did not exceed 800 picocuries per liter (pCi/L). This is a very low-level concentration relative to the concentration in Table 5–2 (Entergy 2014g).

5.4.2.3 *Monitoring Groundwater 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.

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 Annual Radiological Environmental Operating Report (AREOR). These reports are publicly available on the NRC Web site at http://www.nrc.gov/reactors/operating/ops-experience/tritium/plant-specific-reports/ip2-3.html.

Entergy committed to the following conditions as part of a settlement with Riverkeeper, Inc., Hudson and River Sloop Clearwater, Inc. (Riverkeeper, Inc., Hudson and River Sloop Clearwater, Inc., and Entergy Nuclear Operations 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 http://www.safesecurevital.com/environment/reports.html.

5.4.2.4 Independent Evaluations

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 its final 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 New York State Department of Health 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 the New York State Department of Health 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 (NYDEC 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 the New York State Department of Health 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 New York State Department of Health 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 contaminates 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 colbalt-60 by approximately 93 percent, but it would only reduce cesium-137 by 32 percent and nickel-63 by 13 percent. 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 a radiological contaminants decreases, the concentration of that 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, and it behaves chemically like an ordinary hydrogen atom. 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 to 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 (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 Quarter 2 of 2007 through Quarter 1 of 2014, the radioactivity in the tritium plume from the IP2 spent fuel pool has decreased by 80 percent (Entergy 2014h). However, the April 2014 release near IP2 (described above) has increased the radioactivity in the tritium plume. As a result, the amount of radioactivity in the tritium plume in Quarter 4 of 2014, while still less than 2007, contained only 46 percent less radioactivity (Entergy 2015f).

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 Quarter 4 of 2008—when the IP1 spent fuel pools were defueled and strontium radioactivity values were at their highest reported levels in the groundwater—until Quarter 3 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).

To illustrate the rate of attenuation, Figure 5–7 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 5–8 shows the extent of the strontium-90 plume in 2007, and Figure 5–6 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. 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 at monitor wells MW-66 and MW-67. These sampling stations are located near the river and within the plumes (Entergy 2008c, 2009a, 2010a, 2011a, 2012b, 2013a, 2014f, 2015d). Well locations MW-66 and MW-67 are shown on Figure 5–5 through Figure 5–8. From 2007 through 2014, tritium concentrations 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. Because of this process, the 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.

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	1116	1500	8	7

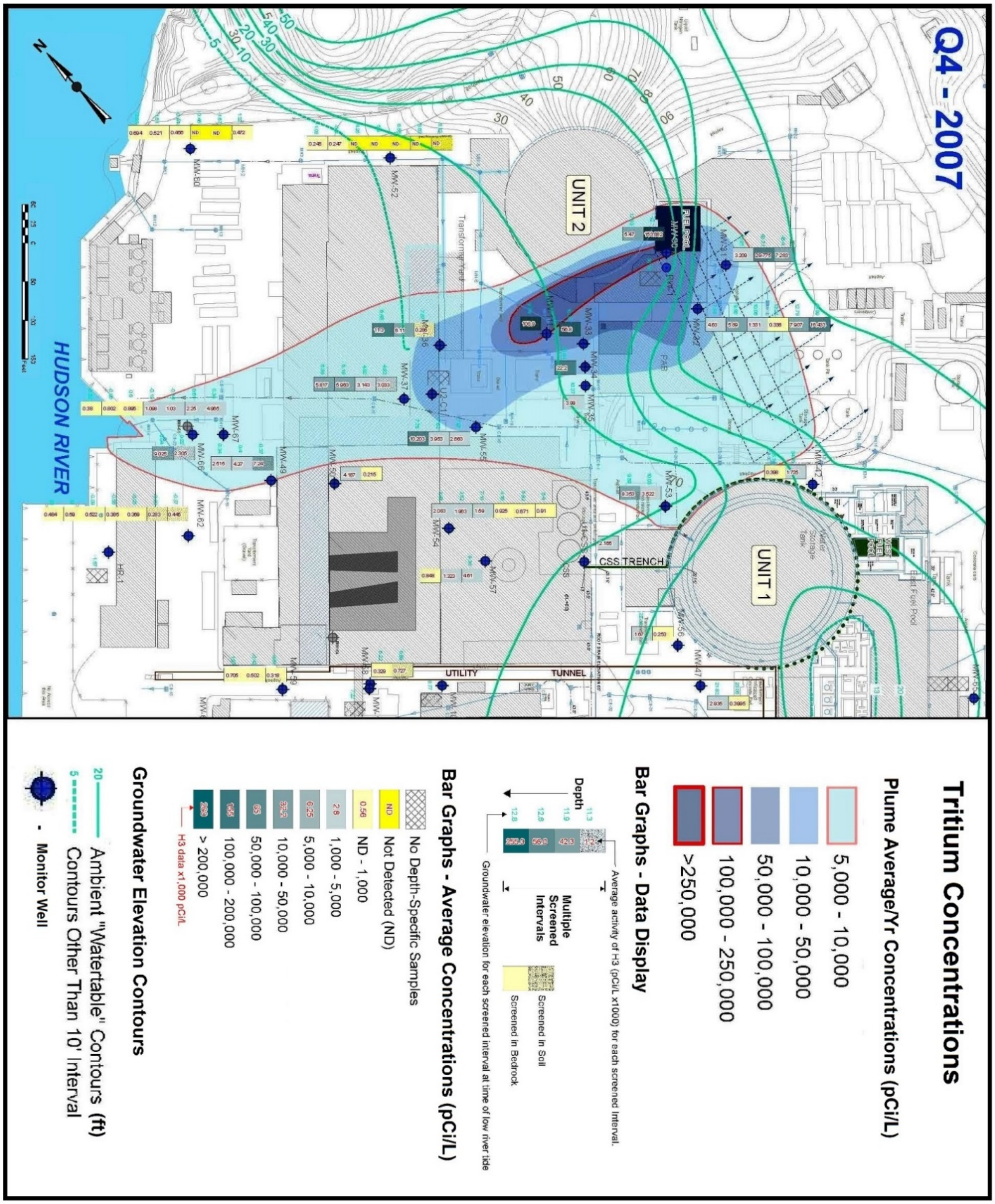
Sources: Entergy 2008c, 2009a, 2010a, 2011a, 2012b, 2014f, 2015d

In addition, from 2007 through 2013, tritium concentrations in Table 5–3 were at low levels relative to the concentration in Table 5–2 of 20,000 pCi/L, whereas strontium-90 concentrations in the same two wells were above the concentration in Table 5–2 of 8 pCi/L (Entergy 2014g). 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 0.0002 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 stated in Section 5.4.2, the radionuclides cesium-137, nickel-63, and cobalt-60 have been sporadically identified at local areas within the IP2 and IP3 site, but no plumes of contamination have been identified for these radionuclides. In September 2014, no cobalt-60 was found above the lower limit of detection in any sample stations, but cesium-137 and nickel-63 were detected above the lower limit of detection at groundwater sample station MW-42-49. However, 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 groundwater sample station MW-42-49 and should not reach the Hudson River.

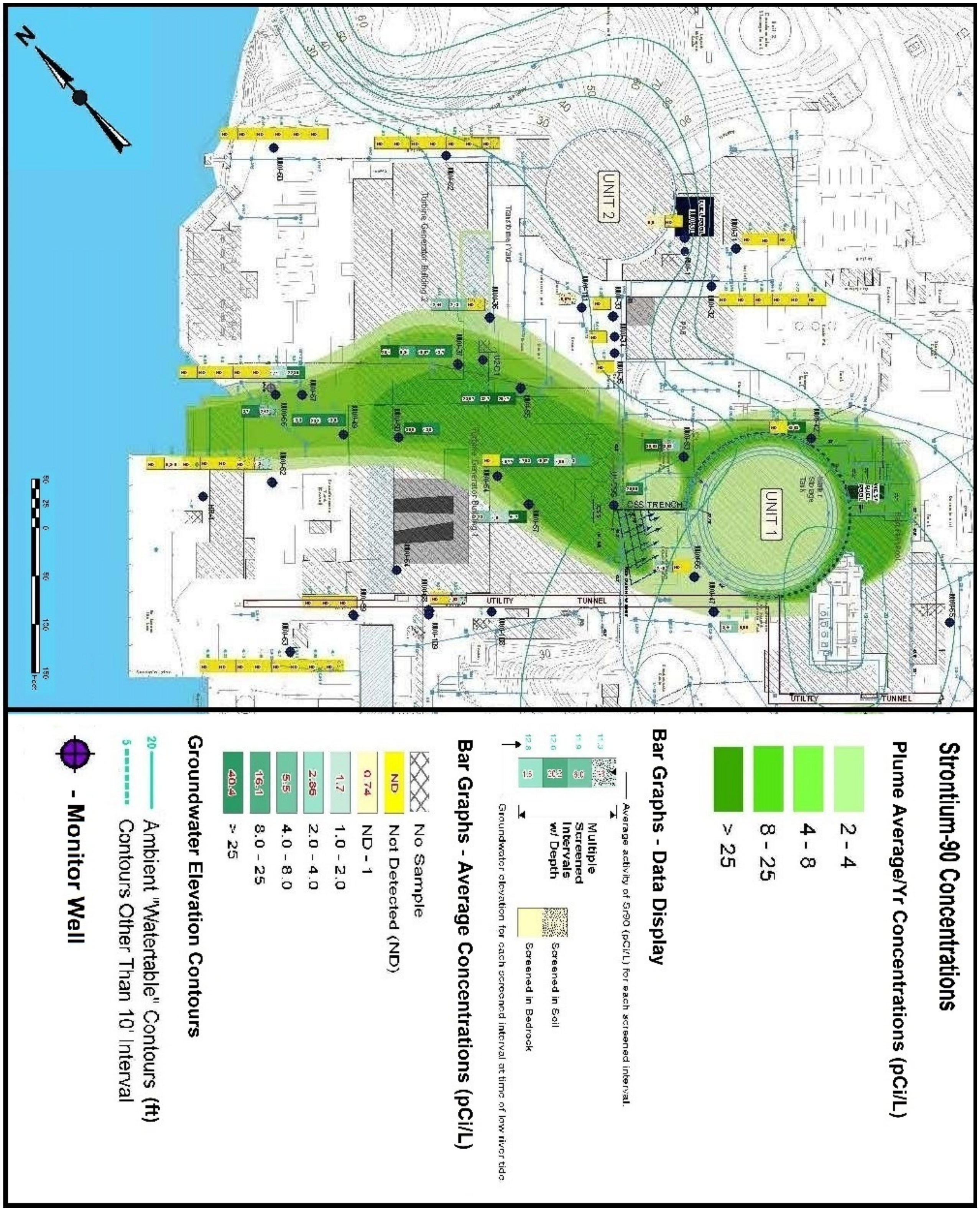
Should onsite groundwater contamination remain after the period of license renewal, Entergy would be required to address any residual contamination during decommissioning of the facility, as necessary.

Figure 5–7. IP2 Tritium Plume in 2007



Source: Modified from Entergy 2015b

1 **Figure 5–8. Strontium-90 Plume in 2007**



2 Source: Modified from Entergy 2008d

5.4.3 Environmental Consequences

This section evaluates the impact of inadvertent releases of radionuclides on groundwater and 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 previously stated, the radionuclides cesium-137, nickel-63, and cobalt-60 have been sporadically identified at local areas within the IP2 and IP3 site, but no plumes of contamination have been identified for these radionuclides. Over the period of license renewal, groundwater contamination from these radionuclides are expected to remain small in area extent and should not reach the Hudson River. Entergy would be required to address any residual contamination during decommissioning of the facility, as necessary.

The sealing of leaks associated with the IP2 spent fuel pool has stopped the leakage of tritium into the groundwater from those sources. The groundwater monitoring program quickly detected the April 2014 leaks of tritium 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 concludes that groundwater contamination will either remain onsite, or be discharged into the Hudson River. Therefore, off-site groundwater supplies should continue to be unaffected by ongoing operations. At the IP2 and IP3 site, the hydraulic properties of the Inwood Marble will not support large yields of water to wells. The onsite groundwater quality in the Inwood Marble has been noticeably altered relative to the concentrations in Table 5–2. Therefore, the NRC staff concludes the current impact on the onsite groundwater quality is MODERATE.

However, 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. 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. Therefore, the overall impacts to groundwater due to the IP2 and IP3 license renewal would be SMALL to MODERATE.

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 (see Section 5.14.4 for the impacts to the proposed Haverstraw Water Supply Project). 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 (Noncooling System Impacts)

In the 2013 GEIS (NRC 2013a), the NRC staff determined that noncooling 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, noncooling 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) (NYDSEC 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 with the potential for spills of oil or other regulated substances under a 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 effects to terrestrial resources from pollutants carried by stormwater would be minimized 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) (0.001Gy/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 2007a), are as follows:

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

The maximum estimated dose rate calculated for 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) at which level 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 IP2 and IP3 site (which includes IP1) are based on the site's 2006 REMP results reported in Entergy's AREOR as follows:

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

The total calculated dose to aquatic biota at the IP2 and IP3 site of 5.01×10^{-2} rad/d (5.01 x $^{-4}$ 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 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 a water discharge permit 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 12898, 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 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 (CO_2); methane (CH_4); nitrous oxide (N_2O); water vapor (H_2O); and fluorinated gases, such as hydrofluorocarbons (HFC), perfluorocarbons (PFC), and sulfur hexafluoride (SF_6). 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 2007, 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 lifetime[1] (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

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[1] 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.

chlorofluorocarbons and hydrochlorofluorocarbons (HCFC), but these substances are typically 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}),[2] 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 (CO_{2eq} (MT/year))[(a)]	Worker Vehicles (CO_{2eq} (MT/year))	Electrical Equipment Related Sources (CO_{2eq} (MT/year))[(b)]	Total (CO_{2eq} (MT/year))[(c)]
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,

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[2] 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.

heavy precipitation, and minimum and maximum temperatures (IPCC 2007a; USGCRP 2009, 2014; EPA 2014b).

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 to1.4 °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 zones[3] 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

[3] 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.

estuary. For example, Seekell and Pace (2011) documented a long-term warming trend in the 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 or 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 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 20-year 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 20-year 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 20-year 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	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	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)
Water Supply and Treatment Facilities			
Haverstraw Water Supply Project	Proposed water treatment plant, intake pumping station, and transmission and distribution mains. It would provide up to 7.5 million gallons of potable water per day to Rockland County.	4 mi (6.5 km) south-southwest of the IP2 and IP3 site with water intake on Hudson River	Undetermined (FERC 2015; HWSP 2012)
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

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). While the Haverstraw Water Supply Project would be located outside the geographic area of analysis, it is considered in this air quality cumulative impact analysis because of its proximity to IP2 and IP3 (approximately 5 miles) and Westchester County. Operation of the water treatment plant will emit pollutants as a result of testing and operation of emergency diesel generators and mobile sources (e.g., delivery trucks and employee vehicles); however, emissions from the generators are anticipated to be a minor air source that will not exceed major air source thresholds. Further, mobile source emissions were concluded to not have a significant impact on air quality (HWSP 2012). 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 (river kilometer (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 2013 is 14,380 cubic feet per second (cfs) (406 cubic meters per second (m^3/s)). The lowest average annual mean flow recorded over the period of record is 6,386 cfs (180 m^3/s). The mean 90-percent exceedance flow is 4,410 cfs (125 m^3/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 2014).

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 (m^3/min)), which is equivalent to a flow of about 178,000 cfs (5,030 m^3/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 m^3/min), which is equivalent to 20,000 cfs (560 m^3/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 40 million gallons per day (mgd) (61 cfs (1.7 m^3/s)) of water, with peak daily withdrawals of 52 mgd (80 cfs (2.3 m^3/s)) (NYDEC 2015f; Wheelabrator Technologies 2015). 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 227 mgd (351 cfs (9.9 m^3/s)) of water, with a peak daily withdrawal of 979 mgd (1,515 cfs (42.8 m^3/s)) (NYSDEC 2015f).

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 m^3/s)), or a total volume of about 2,490 mgd (3850 cfs (109 m^3/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 m^3/s), or about 39 mgd (60 cfs (1.7 m^3/s)) (NRC 2010). This estimate reflects a consumptive water use of less than 2 percent. In 2013, reported withdrawals for IP2 and IP3 averaged 2,029 mgd (3,139 cfs (88.7 m^3/s)), with a maximum daily withdrawal of 2,477 mgd (3,832 cfs (108.2 m^3/s)) (NYDEC 2015f).

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. Nevertheless, 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 2,296 mgd (3,552 cfs (100.4 m^3/s)). This is approximately 2 percent of the normal tidal flow of the river (i.e., 178,000 cfs (5,030 m^3/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 m^3) or more of surface water or groundwater. Previously, this law applied only to public water supplies (NYSDEC 2015g; 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 Haverstraw Water Supply Project or 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. The NRC staff continues to review Entergy's flooding hazard reevaluation for IP2 and IP3 (Entergy 2013d) that was submitted in response to the NRC's RAI under Recommendation 2.1 of the Japan Lessons Learned Near-Term Task Force (NRC 2012a). The NRC staff will use the information collected during its review and inspection to determine whether Entergy should be required to update the design basis and plant structures, systems, and components important to safety. Meanwhile, Entergy has taken interim actions to protect structures, systems, and components up to flood levels of more than 17 ft (5.2 m) (Entergy 2013d).

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 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.

It is unlikely that the proposed Haverstraw Water Supply Project would be adversely affected by contaminated groundwater discharging to the Hudson River at the IP2 and IP3 site. This is because of the extremely low levels of contamination in the Hudson River that might result from the flow of groundwater into the river. 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 (NRC 2012e).

Considering ongoing activities and reasonably foreseeable actions, the NRC staff concludes that the cumulative impacts on groundwater quality and, indirectly, on surface water quality 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. 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 on the direct and indirect impacts of impingement and entrainment to aquatic resources does not substantially change the overall finding of the 2010 FSEIS 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 proposed Haverstraw Water Supply Project (2012) includes a water treatment plant, intake pumping station, and transmission and distribution mains that would provide up to 7.5 million gallons (34 million liters) of potable water per day to Rockland County, New York. It would have a water intake structure on the Hudson River 4 miles (6.5 km) south-southwest of the IP2 and IP3 site where impingement and entrainment of fish and aquatic invertebrates would occur. The draft environmental impact statement (EIS) prepared by United Water, the applicant for the project, finds that use of a wedge-wire screen as mitigation to minimize impingement and reduce entrainment would minimize losses to the target fish species and "would not result in significant adverse impacts on regional target species populations, or to regional populations of other fish, plankton or macroinvertebrates" (Haverstraw Water Supply Project 2012, Chapter 9A).

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 2015) finds that about 13 acres (5.25 hectares) of oyster habitat would be adversely impacted by construction operations (discussed in NYSDOT and NYSTA 2015, Chapter 18, "Construction Impacts"), some or all of which may be permanently lost. Compensatory mitigation for the project includes the restoration of 13 acres (5.25 hectares) 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 2015, 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, as documented in the 2010 FSEIS (NRC 2010). The level of impact to aquatic resources considering the updated information is bounded by the NRC staff's previous assessment, which concluded that the cumulative impacts to aquatic resources is 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 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 is 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 CO_2 (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 2012, EPA issued a final GHG Tailoring Rule (77 FR 41051) 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. On June 25, 2013, the Climate Action Plan was established to reduce carbon pollution (EOP 2013). The Climate Action Plan will reduce carbon pollution, prepare the United States for the impacts of climate change, and lead international efforts to combat global climate change. Under the Climate

Action Plan, EPA has proposed rules to reduce carbon pollution from new and existing power plants. The Clean Power Plan Final Rule (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 (870 million tons (789 MMT) less). 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 emission 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 or expansion of nuclear plants to attain GHG reduction goals (New York State Climate Action Council 2010).

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 through 2033 and 2015 through 2035, respectively) is noticeable but not destabilizing. The NRC staff concludes that the incremental impact from the contribution of GHG emissions from continued operation of IP2 and IP3 on climate change would be SMALL. The cumulative impacts on climate change from the proposed license renewal and other past, present, and reasonably foreseeable projects would be MODERATE.

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."[4] 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 (Volume 61 of the *Federal Register* (FR), pages 28467 and 28495 (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

[4] 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).

identified in the Court's decision are appropriately addressed by the Commission. In CLI-12-16, 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 (EIS) 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.

6.1 Issuance of the 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,[5] 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 license renewal SEIS.

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

[5] 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."

fuel and high-level waste disposal)."[6] Although NUREG–2157 (the technical basis for 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.

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[6] 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).

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 Indian Point Nuclear Generating Unit Nos. 2 and 3 (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:[7]

> 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**~~

[7] 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.

> ~~**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.**

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)the environmental impacts of the continued storage of spent fuel, as stated in 10 CFR 51.23**
- pursuant to 10 CFR 51.**2353**(c)(3)(iii) 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; 6.6~~**4.11.1.3**[(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; 6.6~~**4.11.1.2**[(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 SECTION 7 CONSULTATION

7.1 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.) (Volume 80 of the *Federal Register* (FR) (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). 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.

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 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 National Marine Fisheries Service and determined that the level of impact for aquatic special status species remained SMALL.

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 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*) and provides an update on the status of the operating licenses for IP2 and IP3.

8.1 Environmental Impacts of License Renewal from Issues Considered in this Supplement

Based on its review of the engineering cost estimates provided by Entergy Nuclear Operations, Inc. (Entergy), the NRC staff concludes that the approach used and costs 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. 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. 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.

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 decision makers 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 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 entrainment and impingement 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, entrainment, and impingement**, and water use and quality, which includes the issue of radionuclides released to groundwater**. Chapter 4 of this SEIS describes the MODERATE impacts of plant operation on aquatic ecology through impingement and entrainment (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**~~ **MODERATE**. **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 New Closed-Cycle Cooling	NGCC[d]	
	License Renewal	Plant Shutdown		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	**SMALL to** 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
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)

Impact Category	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
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

	Conservation/Energy Efficiency	Combination of Alternatives	
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~~.

(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.

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10.0 LIST OF PREPARERS

Members of the NRC's Office of Nuclear Reactor Regulation prepared this 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

Name	Affiliation	Function or Expertise
NRC		
Russell Chazell	Nuclear Reactor Regulation	Human Health
James Danna	Nuclear Reactor Regulation	Branch Chief
Kevin Folk	Nuclear Reactor Regulation	Surface Water
William Ford	Nuclear Reactor Regulation	Groundwater
Briana Grange	Nuclear Reactor Regulation	Ecology
Kimberly Green	Nuclear Reactor Regulation	Severe Accident Mitigation Alternatives
Robert Hoffman	Nuclear Reactor Regulation	Cumulative Impacts
Steve Klementowicz	Nuclear Reactor Regulation	Radioactive Waste
Dennis Logan	Nuclear Reactor Regulation	Ecology
Nancy Martinez	Nuclear Reactor Regulation	Air Quality, Greenhouse Gases
John Parillo	Nuclear Reactor Regulation	Severe Accident Mitigation Alternatives
Michael Wentzel	Nuclear Reactor Regulation	Project Manager
David Wrona	Nuclear Reactor Regulation	Branch Chief
Contractor		
Valerie Cullinan	Pacific Northwest National Laboratory	Statistics, Ecology

APPENDIX A

REVISED IMPINGEMENT AND ENTRAINMENT IMPACT ANALYSIS FOR INDIAN POINT NUCLEAR GENERATING UNIT NOS. 2 AND 3

A. REVISED IMPINGEMENT AND ENTRAINMENT IMPACT 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 2013). 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. 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 for the license renewal of IP 2 and IP 3.

The IP2 and IP3 site is located on the Hudson River estuary at River Kilometer 67 (River Mile 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 Barnthouse 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 (2013):

- 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.
- 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 adapted 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, 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, 2013) 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 is population trends of representative important species (RIS), with decreasing trends in population size of crabs and young-of-the-year fish (together referred to as YOY) across the 27 years of monitoring data being 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 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 developed by EPA for evaluating 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.

A.2 Methods

The NRC staff's present analysis differs somewhat from the analyses in the FSEIS (NRC 2010, 2013), Entergy's (2014) and AKRF's (2014) submissions, and Entergy's (2015) and AKRF's (2015) submissions in response to NRC staff (2015) 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 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 and the NRC staff's analyses is that AKRF selected periods of consistent sampling based on sample week number, while the NRC staff uses month designations, due to 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 FSEIS supplement. Except where it is necessary to differentiate between volumes, the NRC staff collectively refers to the 2010 FSEIS, as modified by the 2013 FSEIS supplement, as the FSEIS in this appendix.

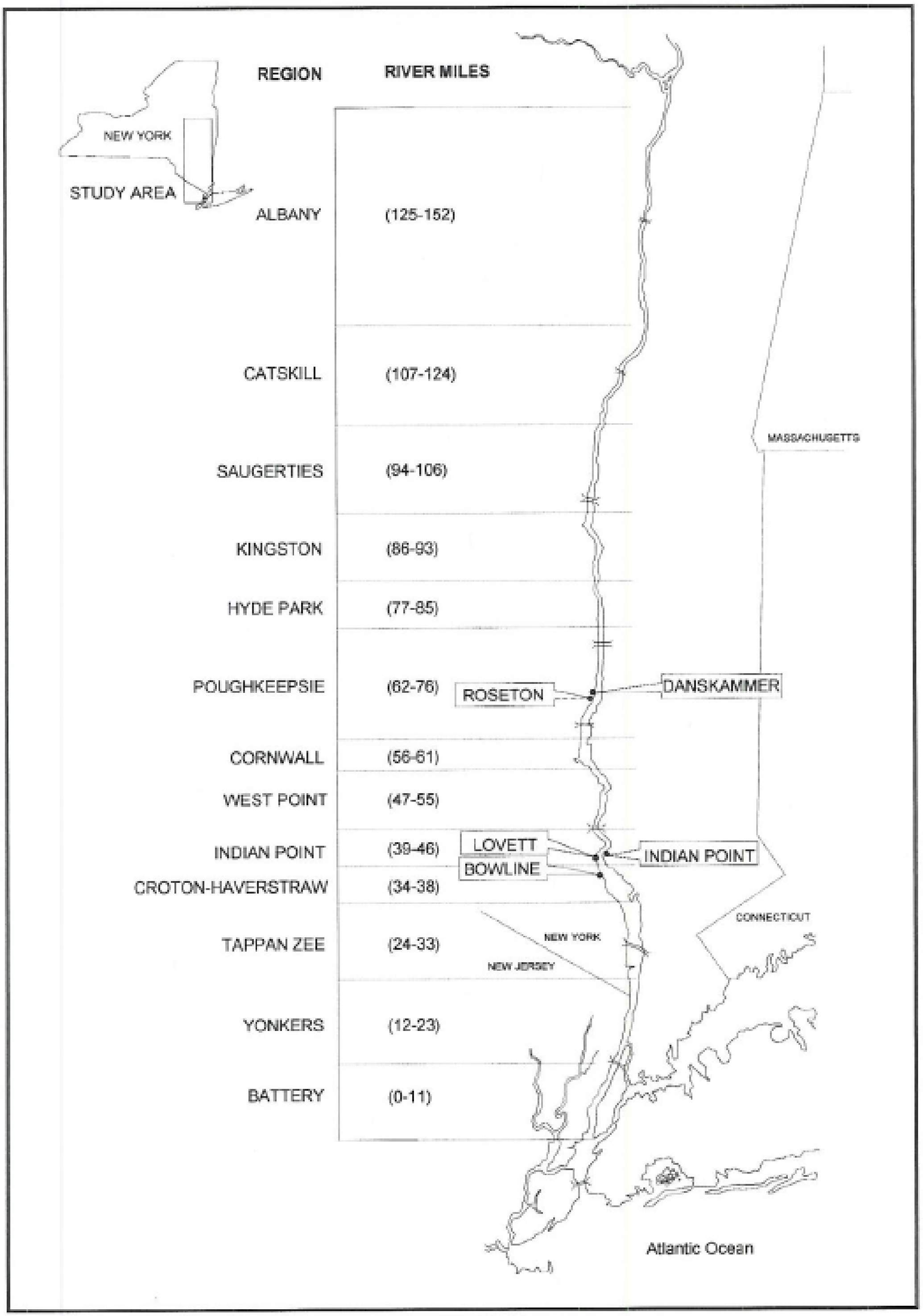
Data sources

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 (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 feet (6 m) at mean low tide (sampled by the LRS and FSS) on both sides of the river. The stratum bottom extends upward from the bottom to 10 feet (3 m) above the river bottom where the water depth is greater than 20 feet (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 feet (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.

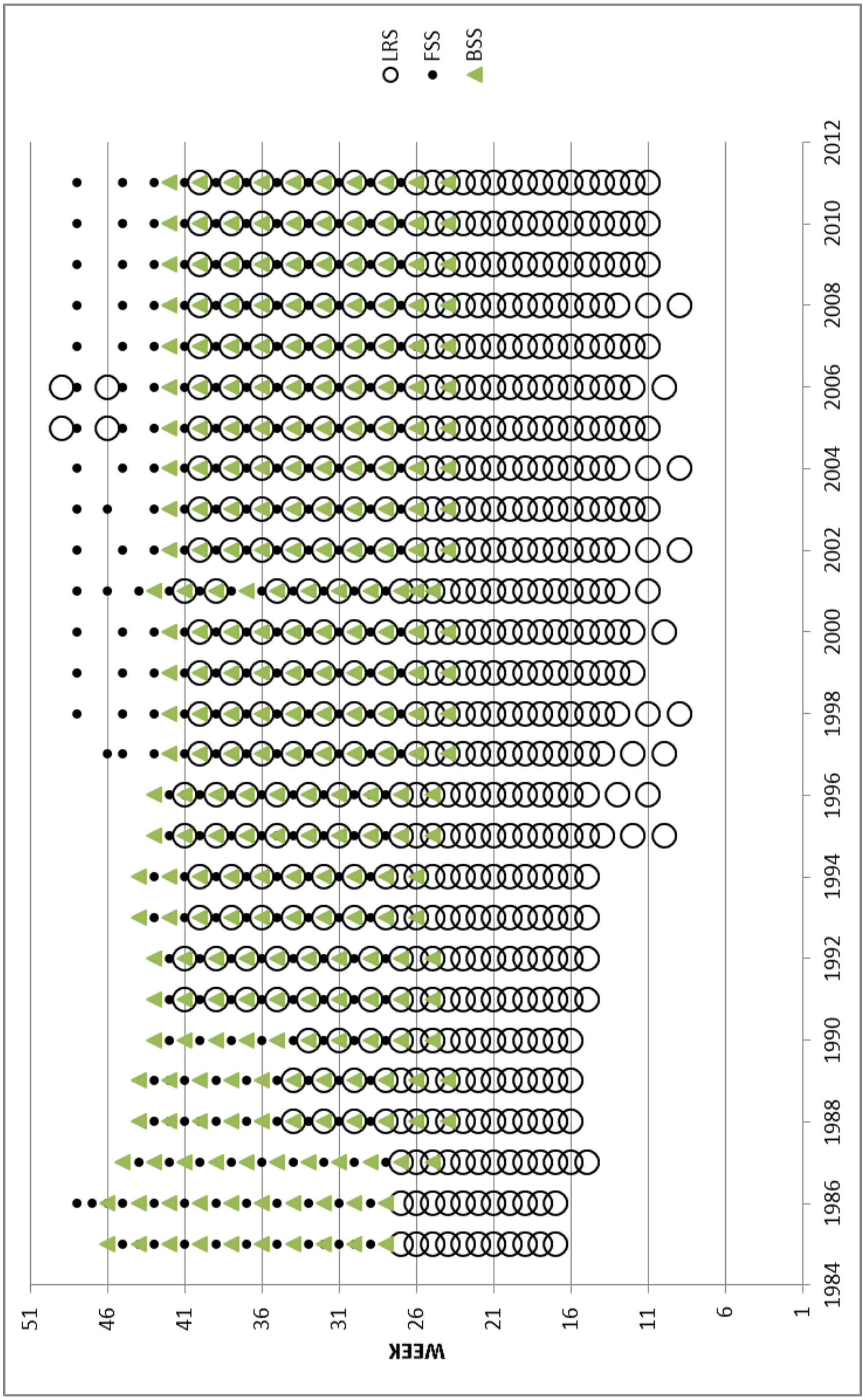
Sampling methods varied somewhat in the early years of the Program until 1985. The FSS between 1974 and 1984 employed a 1-square meter (m^2) (1-yard $(yd)^2$) Tucker trawl with a 3-millimeter (mm) (1/8-in.) mesh to sample the channel and a 1-m^2 (1-yd^2) epibenthic sled with a 3-mm (1/8-inch (in.)) mesh to sample the bottom and shoal strata. From 1985 to present, a 3-m (1-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 sampled bay anchovy, American shad, and weakfish 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 from 1985 through 2011 by the Three Hudson River Monitoring Program Surveys: the Long River Survey (LRS), Fall Shoals Survey (FSS), and Beach Seine Survey (BSS)



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 entrainment and impingement 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 that were not verified after new Ristroph screens were installed at IP2 and IP3 in 1991. The present analysis uses I&E data from these studies, including impingement survival estimates. Table A–1 summarizes relevant aspects of the monitoring studies used here to assess impacts.

Table A–1. Hudson River Monitoring Studies Used To Assess Impacts

Study	Study Dates	Information Available
Impingement Abundance[1]	1975–1990	Number of fish impinged at IP2 and IP3.
Entrainment Abundance[1]	1981 1983–1987	Entrainment density by species and life stage for IP2 and IP3 combined.
Longitudinal River Ichthyoplankton or Long River Survey (LRS)[2]	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)[2]	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)[2]	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.

[1] Data provided by Entergy (2007)

[2] Data provided by Entergy (2015)

Entergy (2014, 2015) provided the annual Hudson River Estuary Monitoring Program Year Class Reports for 2006 through 2011 (ASA 2008-2013), 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. Population Trends 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 and is used here.

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. 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, and National Marine Fishery Service's (NMFS's) (2013) biological opinion on the effect of the IP2 and IP3 cooling water intake systems on Atlantic sturgeon and shortnose sturgeon.

<u>Representative Important Species (RIS)</u>

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 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 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 (Barnthouse 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	*Alosa pseudoharengus*	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	*Brevoortia tyrannus*	Permanent or seasonal resident	Juveniles and adults eat phytoplankton, zooplankton, copepods, and detritus. Species is prey of bluefish and striped bass.
American shad	*Alosa sapidissima*	Anadromous	Juveniles and adults primarily eat zooplankton, small crustaceans, copepods, mysids, small fish, and fish eggs. Species is prey of oceanic species.
Atlantic sturgeon	*Acipenser oxyrinchus*	Anadromous Protected	Juveniles and adults are bottom feeders, subsisting on mussels, worms, shrimp, and small fish.
Atlantic tomcod	*Microgadus tomcod*	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	*Anchoa mitchilli*	Estuarine	Species primarily eats zooplankton and is prey of YOY bluefish and striped bass.
Blueback herring	*Alosa aestivalis*	Anadromous	Species' diet includes insect larvae and copepods. It is prey of bluefish, weakfish, and striped bass.
Bluefish	*Pomatomus saltatrix*	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	*Dorosoma cepadianum*	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	*Trinectes maculates*	Estuarine	Adults are generalists and eat annelids, arthropods, and tellinid siphons. Species is prey of striped bass.
Rainbow smelt	*Osmerus mordax*	Anadromous	Larval and juvenile smelt eat planktonic crustaceans; larger juveniles and adults feed on crustaceans, polychaetes, and fish.

Common Name	Scientific Name	Occurrence and Status	Predator/Prey Relationships
			Adults eat anchovies and alewives. Species is prey of striped bass and bluefish.
Shortnose sturgeon	*Acipenser brevirostrum*	Federally endangered; permanent or seasonal resident	Juveniles feed on benthic insects and crustaceans.
Spottail shiner	*Notropis hudsonius*	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	*Morone saxatilis*	Anadromous	Species eats menhaden river herring, tomcod, and smelt. Larvae are prey of spottail shiner, white perch, striped bass, bluegill, and white catfish.
Weakfish	*Cynoscion regalis*	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	*Ameiurus catus*	Freshwater	Juveniles eat midge larvae. Adults are omnivores, feeding on anything from fish to insects to crustaceans.
White perch	*Morone americana*	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	*Callinectes sapidus*	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.

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. A measure of local effects examines trends from 1985 through 2011 within only River Segment 4 (the Indian Point segment). 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 provided by Entergy. The Riverwide data are the utilities' Abundance Index (1974 through 2011) and the LRS, FSS, and BSS 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 (all river regions) scales for each RIS.

The annual River Segment 4 estimate of the population response is 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 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).

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 Young-of-Year (YOY) Catch-per-Unit-Effort (CPUE) Among Hudson River Estuary Monitoring Surveys, 1985-2011

RIS	Data used for YOY and Yearling Abundance Index in Year Class Reports	FSS (no./1000 m^3)	LRS (no./1000 m^3)	BSS[b] (no./1000 m^3)	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 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	0.119	1.217	0.000	LRS
Spottail shiner	FSS-Channel	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 m^3

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 detectible, 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. Impingement and/or entrainment 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. 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 used 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 = 1000 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:

$$N_t = N_0 e^{rt} + (\delta N_0 e^{rt})\varepsilon_t \quad (1)$$

where

t = 1 to 20 (number of years associated with relicensing) or 27 years (number of years for trend analysis: 1985 through 2011);

N_0 = the initial juvenile population abundance at the beginning of the YOY life stage set to either 1000 or $1\text{x}10^8$;

r = the population growth rate estimated from the slope from the linear model of standardized YOY River Segment 4 (Indian Point) LRS, FSS, or BSS density data (1985 through 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_t = 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 entrainment and impingement implicit in the parameters N_0 and r. Annual abundance of YOY RIS without losses of eggs, larvae, and juveniles from entrainment and impingement was estimated using the same model form but with an independent ε_t ,and N_0 and r replaced with

$$N_0^* = N_0(1 + EMR) \text{ and } r^* = r_{\text{UL}}(1 - IMR)/\max(1,\text{CV}) \quad (2)$$

where

EMR [entrainment mortality rate] and *IMR* [impingement mortality rate] are conditional mortality rates (CMRs) for entrainment and impingement;

r_{UL} is the upper limit of the linear slope defined as the estimated slope plus one standard error of the estimated slope; and

CV is the coefficient of variation of the annual 75th percentiles from the weekly catch density.

The growth rate divided by the CV in the density data provides an alternative growth rate closer to zero for negative values of *r* and a slightly larger growth rate for positive values of *r* with the amount of increase dependent on the magnitude of the variability. The divisor is set to 1 (allowing a maximum increase in growth rate) when the CV is greater 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 estimated from published conditional impingement mortality rates (CIMRs) (CHGEC 1999). Estimates for *EMR* assume 100 percent mortality, and the *IMR* incorporates impingement survival rates.

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 (Indian Point) obtained from the LRS, FSS, and BSS 1981 and 1983 through1987 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 Jan.–March	Season 2 April–June	Season 3 July–Sept.	75th Percentile of Abundance over Years[a]
EGG	**3%**	**20%**	**78%**	**210,801 x 10^3**
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%**	**23,140 x 10^3**
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%**	**618,393 x 10^3**
Atlantic Tomcod	100%	< 1%	0%	
Alosa species	0%	37%	< 1%	
Bay Anchovy	0%	11%	58%	
Anchovy Family	0%	2%	39%	
White Perch	0%	12%	1%	

Life Stage	Season 1 Jan.– March	Season 2 April– June	Season 3 July– Sept.	75th Percentile of Abundance over Years[a]
Striped Bass	0%	17%	1%	
Herring Family	0%	20%	< 1%	
JUVENILE	**2%**	**44%**	**54%**	**10,989 x 10^3**
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%**	**4,469 x 10^3**
Atlantic Tomcod	100%	< 1%	0%	
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 through 1987). No entrainment sampling occurred in October through December.

Table A–5. Method for Estimating Taxon-Specific Entrainment Mortality Rate (EMR) Based on River Segment 4 Standing Crop for the Strength-of-Connection Analysis

Property or Method		Number Entrained	River Segment 4 Standing Crop
Input Data	Variables	Mean density organisms entrained by IP2 and IP3 (number per 1000 m^3)	LRS density (by life stage) FSS density of YOY (number per 1000 m^3) BSS density of YOY (# per haul)
		Volume of cooling water withdrawn by IP2 and IP3 (1000 m^3/min)	River Segment 4 volume (m^3) River Segment 4 shore zone surface area (m^2)
	Frequency	Per week of sampling	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

Property or Method	Number Entrained	River Segment 4 Standing Crop
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)
Taxonomic Substitutions	Alewife, blueback herring, and unidentified alosids are treated collectively as river herring "Unidentified anchovy spp." are allocated to bay anchovy "Unidentified *Morone* spp." are allocated proportionally to the identified striped bass and white perch in entrainment samples.	

The number of RIS by life stage (*I* = 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 through1987) as

$$E_{ijk} = \overline{d_{ijk}}\,(V_{IP2} + V_{IP3})(60 \times 24 \times 7 \times 1000) \qquad (3)$$

where $\overline{d_{ijk}}$ is the input mean weekly density entrained (number/1000 m^3) for a given RIS (Table A–5) along with the associated volume of water withdrawn (1000 m^3/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, so that the number of fish entrained during that season was added 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 m^3; 168,901 acre-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 m^2; 1,025 acres) divided by the area of a seine sample (450 m^2; 4,844 ft^2). 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 CHGEC (1999) (Table A–8).

Table A–6. Estimated Annual Standing Crop of Eggs, Larvae, and Juvenile RIS within River Segment 4 (thousands of fish)

Taxon	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

Taxon	1981	1983	1984	1985	1986	1987
Atlantic Menhaden	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Atlantic Sturgeon	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
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

Table A–7. Annual Estimated Number of RIS Entrained at IP2 and IP3 (thousands of fish)

Taxa	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	0	0	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
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

Table A–8. Estimate of the River Segment 4 Entrainment Mortality Rate (EMR) and the 95 Percent Confidence Limits for the Riverwide Entrainment CMR (1974–1997)

Taxa	75th Percentile Annual Number Entrained (number x 10^6)	75th Percentile of Number at Risk (number x 10^6)	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	NA	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

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 cumulativeCIMR (1984 through1990; CHGEC 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 entrainment and impingement is estimated as the sum of the annual differences divided by N_0 (1000 or 10^8) and the number of years of data (20 or 27). One realization of a simulation using t = 27, N_0 = 1000 highlights the annual difference achieved in the YOY population abundance with and without entrainment and impingement 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 entrainment and impingement mortality, shown in black in Figure A–3). If the model included no variation (δ = 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 entrainment and impingement 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 = 1000 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 entrainment and impingement 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%	
Rainbow Smelt	10%	18%	1%	12%	
Hogchoker	< 1%	20%	6%	16%	
Alosa species	< 1%	< 1%	< 1%	16%	

[a] 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, 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 Conditional Impingement Mortality Rate Estimated by Year Class for Indian Point[1] Used to Estimate the Taxon-Specific Impingement Mortality Rate[2] (IMR) for the Strength of Connection Analysis

RIS	1984	1985	1986	1987	1988	1989	1990	Maximum = IMR
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

[1] CHGEC (1999) Appendix VI

[2] IMR estimates include a correction for partial survival

NA = Not available

Figure A–3. One Realization of the Monte Carlo Simulation Using Parameter Estimates for White Perch

Gray and black shading represents positive and negative annual differences in abundance between the two models.

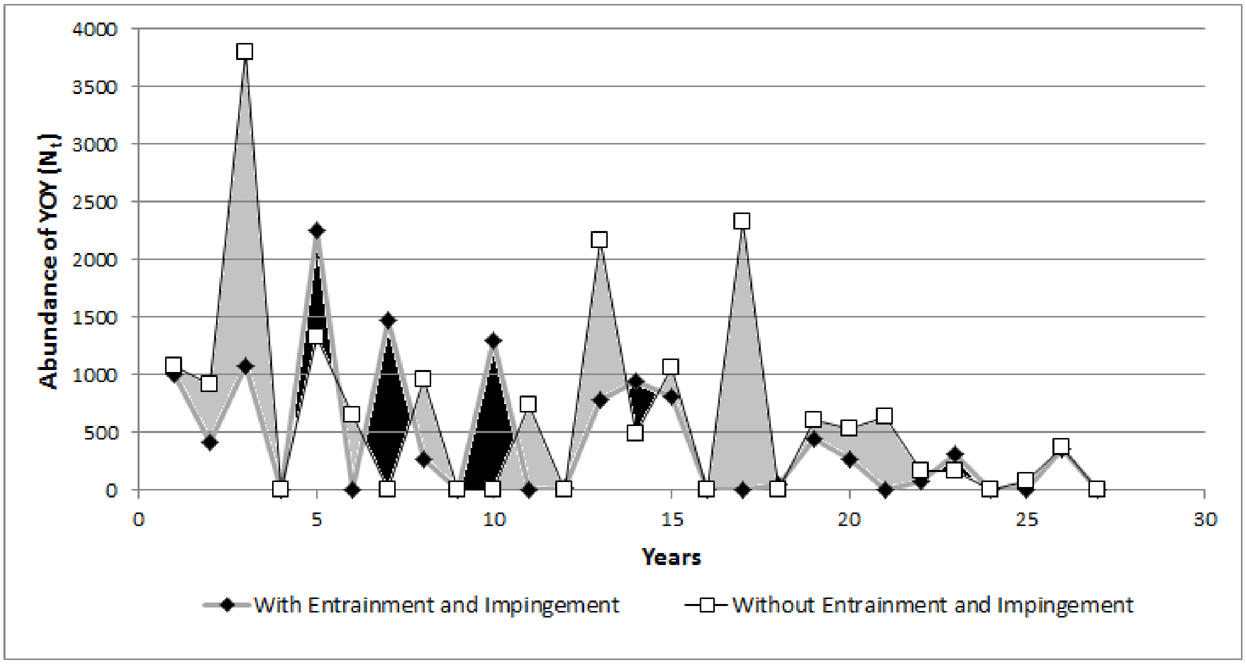
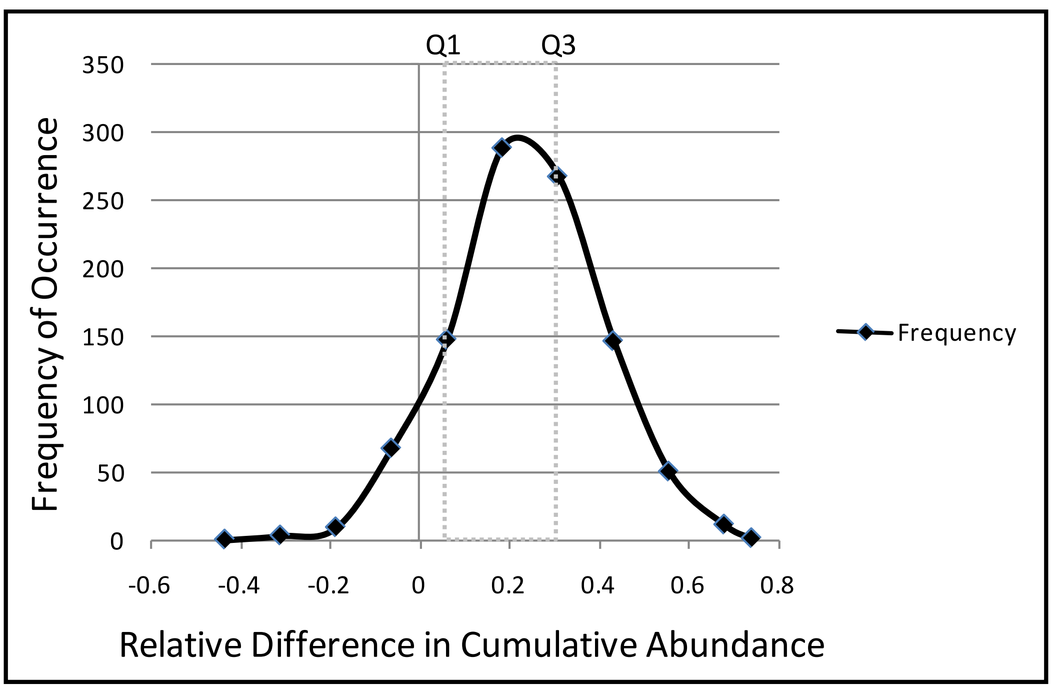


Figure A–4. Example Frequency Distribution of the Relative Difference in Cumulative Abundance from the Monte Carlo Simulation (*n* = 1000). Dashed lines indicate the first and third quartiles (Q1 and Q3) of the distribution



Weight of Evidence

To classify impacts as small, moderate, or large, a WOE approach combined the results of 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, which includes IP2 and IP3, 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 had slopes that are significantly greater than or not significantly different from zero (i.e., detectible population increase or an undetectable population trend). Trends satisfying this description receive a score of 1.
- RIS populations are declining if population trends had negative slopes that are significantly different from zero (i.e., detectible 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 three investigators (Table A–11), and overall use and utility scores are the averages of the individual attribute scores. The overall scores characterize the overall 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

Use and Utility Attribute	River Segment 4 RIS Trends	Riverwide RIS Trends
Temporal Representativeness	3	3
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 to the number of measurements; the overall utility score ^{i} is defined in Table A–11;

and the 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, three 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 impingement and entrainment 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 precludes differentiating the effect of I&E on the population trend or not), 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 entrainment, impingement, 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 entrainment and impingement, 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 entrainment, impingement, and loss of prey did not include zero for any of the simulation runs. That is, the effects of entrainment and impingement 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.

A.3 Results

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 through E1) 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. In River Segment 4 (Addendum A–1, Figures F1 through K1), plots show consistent decreases for American shad, Atlantic tomcod, and rainbow smelt. Plots show either flat or decreasing trends for blueback herring, bluefish, weakfish, white catfish, and white perch. Alewife have an increasing trend for all riverwide measures of abundance. Spottail shiner and striped bass had mixed results in riverwide population measures. Overall, a consistent pattern of decreasing trends in YOY fish abundance occurs in River Region 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 (Figure A–5), Atlantic tomcod (Figure A–6), blueback herring (Figure A–7), and rainbow smelt (Figure A–8) for all or most sampling programs.

Figure A–5. Estimated Linear Slopes and Confidence Intervals (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each American Shad Population Measure of Abundance

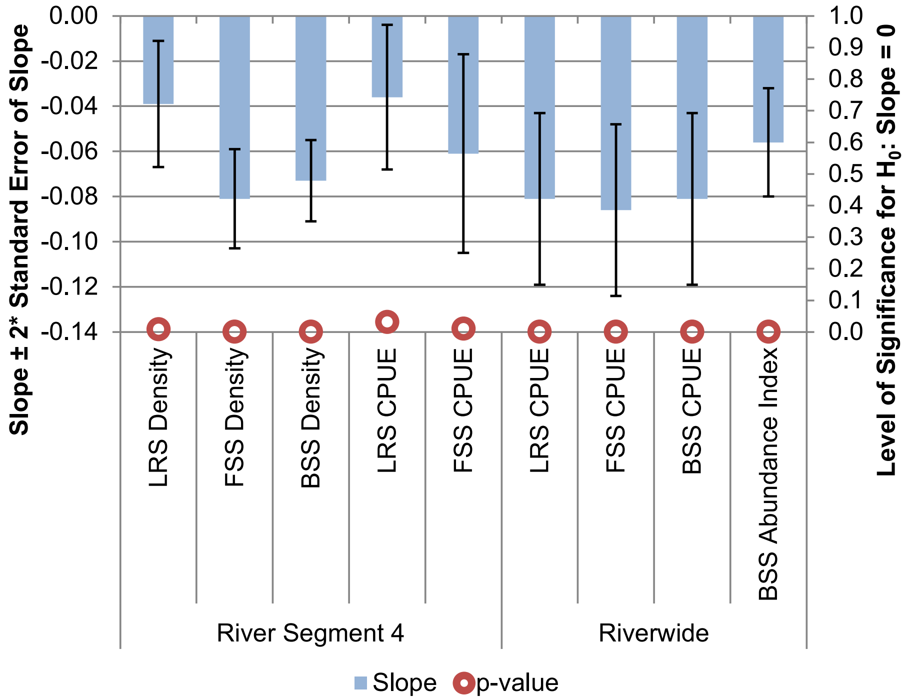


Figure A–6. Estimated Linear Slopes and Confidence Intervals (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Atlantic Tomcod Population Measure of Abundance

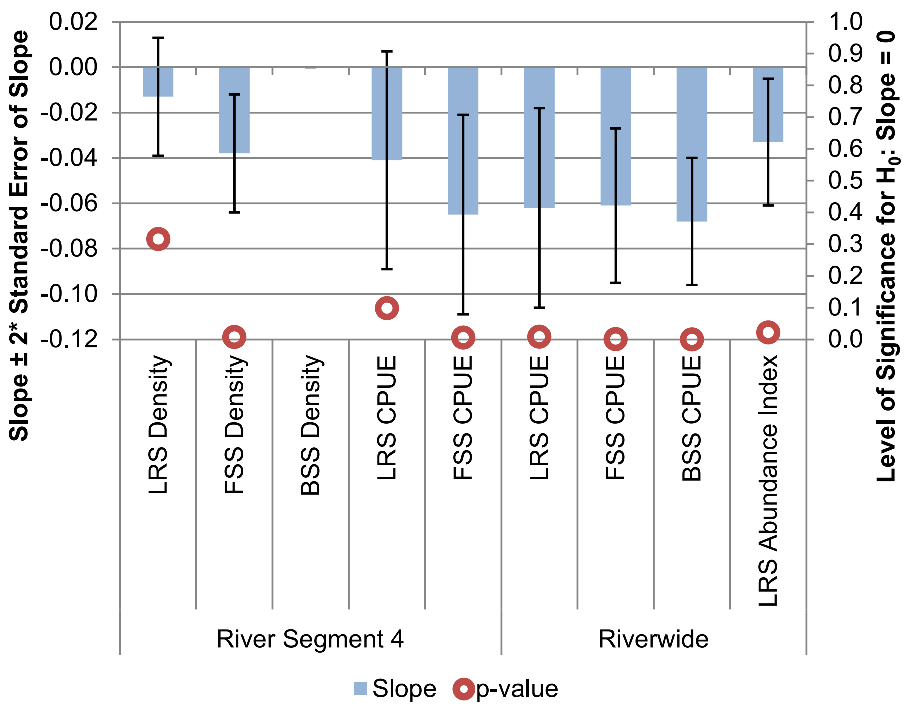


Figure A–7. Estimated Linear Slopes and Confidence Intervals (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Blueback Herring Population Measure of Abundance

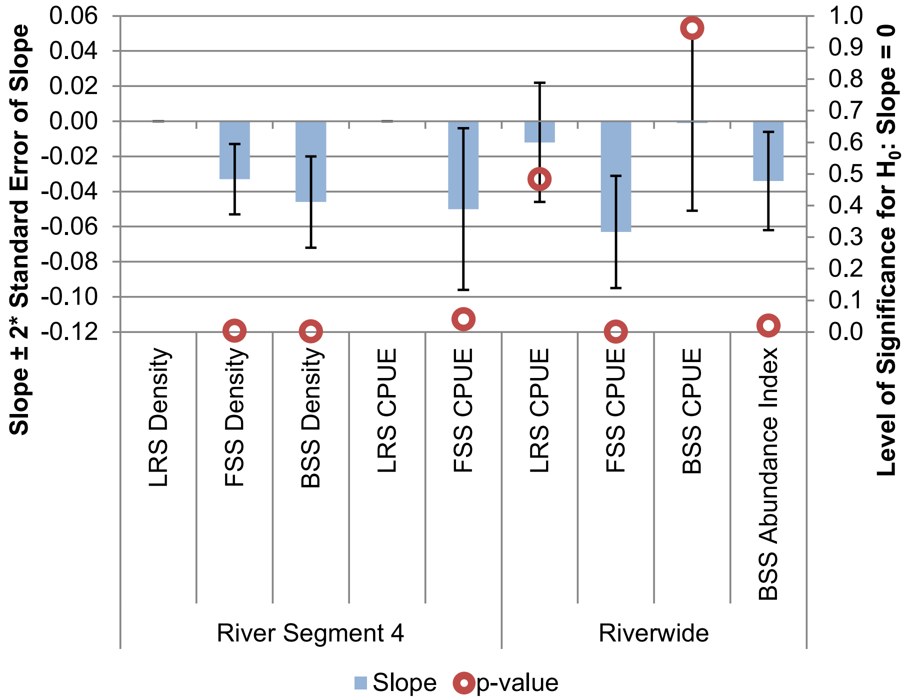
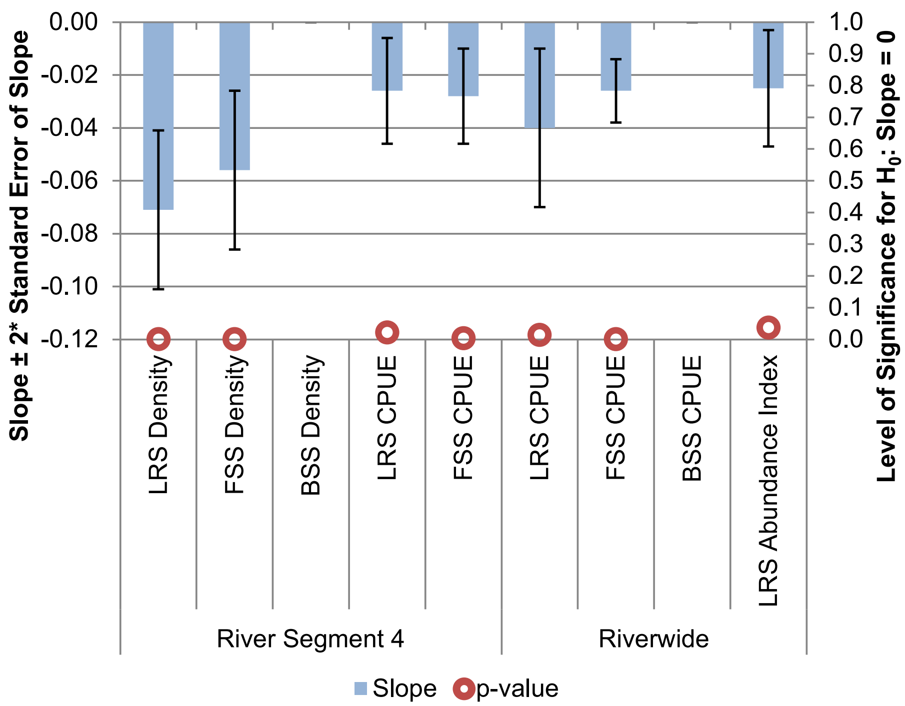


Figure A–8. Estimated Linear Slopes and Confidence Intervals (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Rainbow Smelt Population Measure of Abundance



Less consistency of trend results among measures of abundance and geographic scales occurs for bluefish, hogchoker, striped bass, and white catfish. For bluefish (Figure A–9), three of the five negative slopes in River Segment 4 are significant and two are not, while riverwide results are more mixed. Hogchoker (Figure A–10) and striped bass (Figure A–11) 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 (Figure A–12), and the results are inconsistent.

Figure A–9. Estimated Linear Slopes and Confidence Intervals (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Bluefish Population Measure of Abundance

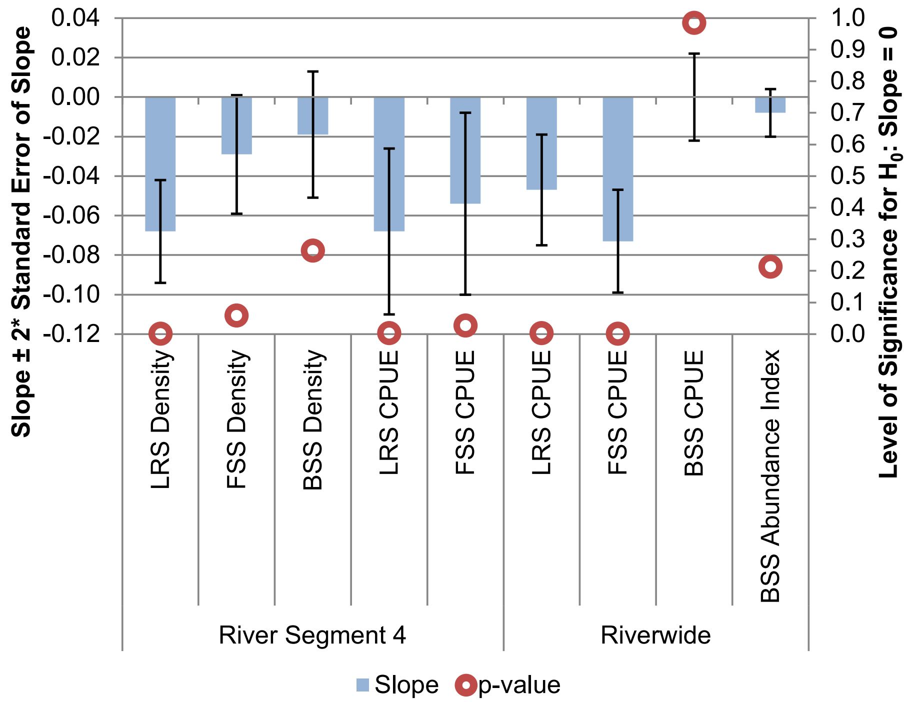


Figure A–10. Estimated Linear Slopes and Confidence Intervals (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Hogchoker Population Measure of Abundance

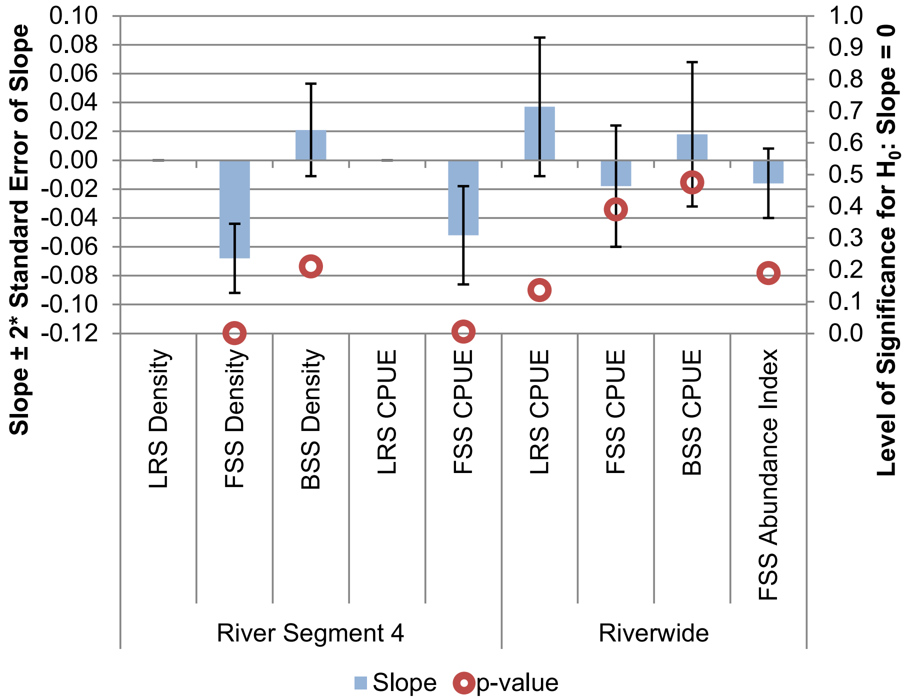


Figure A–11. Estimated Linear Slopes and Confidence Intervals (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Striped Bass Population Measure of Abundance

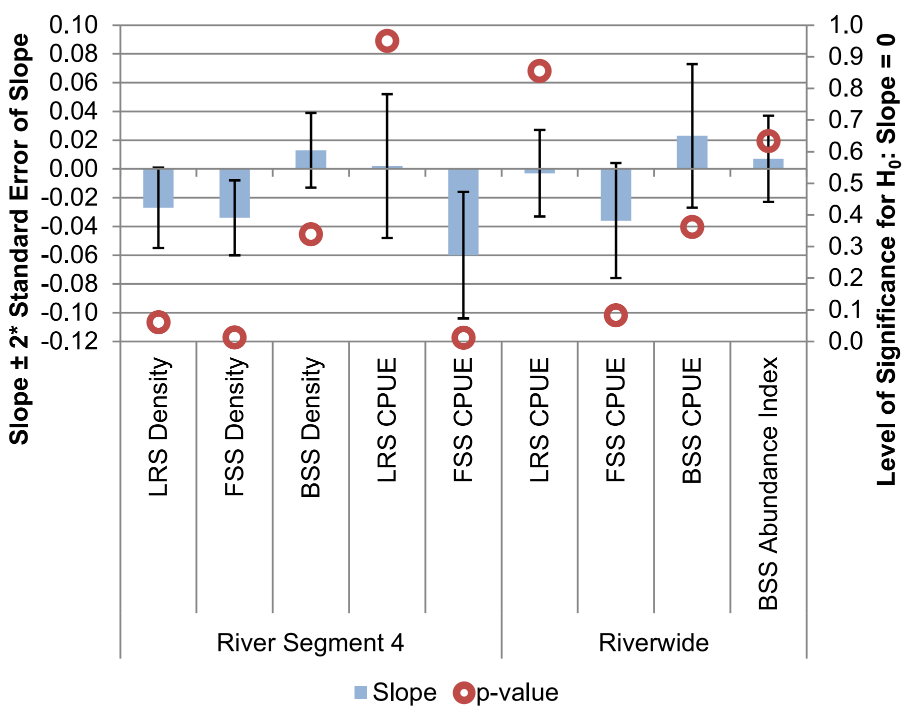
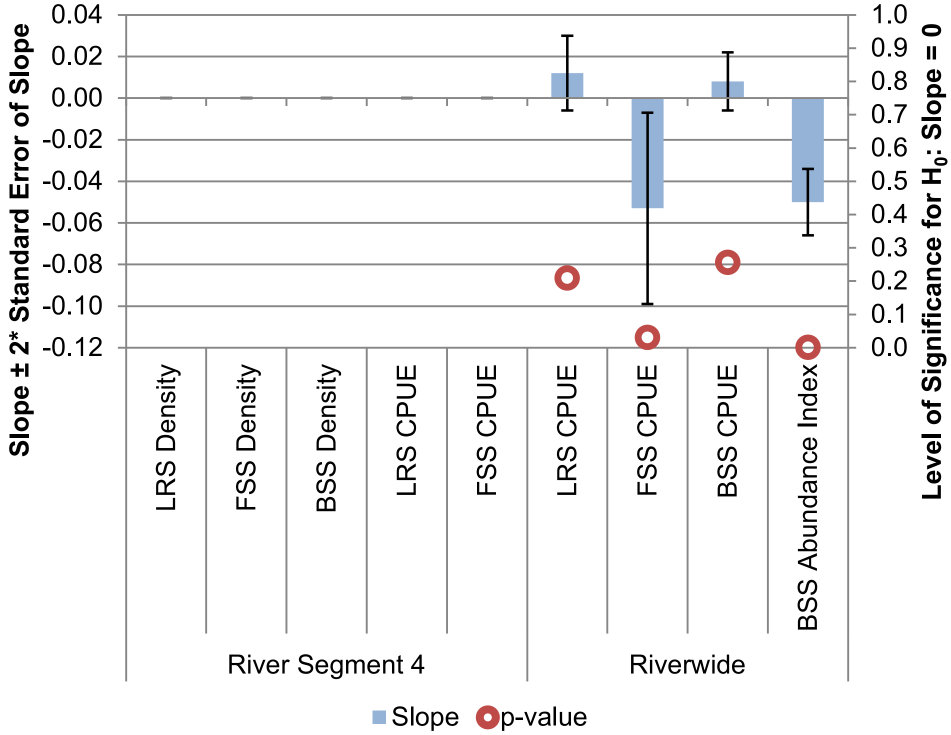


Figure A–12. Estimated Linear Slopes and Confidence Intervals (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each White Catfish Population Measure of Abundance



Population Trend LOE

For each measure of abundance and RIS, application of scoring and decision rules to the trend results produced a River Segment 4 assessment score (Table A–12) and a Riverwide assessment score (Table–13). Insufficient catches for some RIS resulted in some unknown assessments. Although all measures of abundance for any RIS derive from samples from the same YOY population, trend scores can differ, probably due to different sampling efficiencies, different distributions of populations in relation to sampling locations, etc.

Table A–12. Assessment of Population Impacts for IP2 and IP3 River Segment 4

	Density			Catch-per-Unit Effort		River Segment
Species	**LRS**	**FSS**	**BSS**	**LRS**	**FSS**	**Assessment**
Alewife	N/A[a]	4	1	N/A	1	2.0
American Shad	4	4	4	4	4	4.0
Atlantic Menhaden	N/A	N/A	N/A	N/A	N/A	Unknown
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

Species	Density			Catch-per-Unit Effort		River Segment Assessment
	LRS	FSS	BSS	LRS	FSS	
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] N/A: not applicable; YOY not present in samples.

Note: 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.

1 **Table A–13. Assessment of Riverwide Population Impacts**

Species	CPUE			Abundance Index			Riverwide Assessment
	LRS	FSS	BSS	LRS	FSS	BSS	
Alewife	1	1	1	N/A[a]	N/A	1	1.0
American Shad	4	4	4	N/A	N/A	4	4.0
Atlantic Menhaden	N/A	N/A	N/A	N/A	N/A	N/A	Unknown
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] N/A: not applicable; YOY not present in samples

Note: Tabled 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.

2 The NRC staff combined the River Segment 4 and Riverwide population assessments to yield
3 an overall population trend conclusion (Table A–14). Several RIS (Atlantic menhaden, Atlantic
4 and shortnose sturgeon, and blue crab) had too few catches to make a population trend

assessment, and results 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 seven RIS (alewife, bay anchovy, gizzard shad, spottail shiner, striped bass, weakfish, and white perch) did not exhibit detectable declines.

Table A–14. Weight of Evidence Results for the Population Trend Line of Evidence

Measurement	River Segment Assessment Score	Riverwide Assessment Score	WOE Score[b]	Impact 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
Atlantic Menhaden	Unknown	Unknown	Unknown	Unresolved[c]
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] Use and 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

Strength of Connection LOE

For the SOC analysis, the NRC staff conducted four simulation series for each RIS using all possible pairs of the parameters t and N_0 (n = 1000 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 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 entrainment and impingement are consistently greater than the modeled variation.

Table A–15. Table A–15 Parameter Values Used in the Monte Carlo Simulation

RIS	Survey Used	Estimated Linear Slope (*r*)	Slope + Standard Error of the Slope Estimate (r_{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)

The results and SOC conclusions of the Monte Carlo simulations (n = 1000) for each pair of N_0 (1000 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 verses 27 years modeled (*t*) decreased with increasing initial abundance (N_0). For N_0 = 1000 and 1 x 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 SOC analysis assumes that the IP2 and IP3 cooling systems can affect aquatic resources both directly through impingement or entrainment 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 impingement and entrainment, the NRC staff could assess the effect of the IP2 and IP3 cooling systems on the River Segment 4 population trends (e.g., how strongly are the effects of the cooling system connected to the RIS of interest). The results of this analysis indicate a High SOC for seven species (Table A–17). For those species, the IP2 and IP3 cooling systems were 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 (minimal evidence of connection).

Table A–16. Quartiles of the Relative Difference in Cumulative Abundance and Conclusions for the Strength-of-Connection from the Monte Carlo Simulation

Taxa	Number of Years	N_0 = 1000			$N_0 = 1 \times 10^8$			Strength-of-Connection 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	
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	

Table A–17. Weight of Evidence for the Strength-of-Connection Line of Evidence for YOY RIS Based on the Monte Carlo Simulation

RIS	Strength of Connection	RIS	Strength of Connection
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
Gizzard Shad	Cannot be Modeled(a)	Blue Crab	Cannot be Modeled[a]

[a] Estimates for model parameters were unavailable or information was lacking.

The SOC for Atlantic menhaden, Atlantic and shortnose sturgeon, gizzard shad, and blue crab could not be modeled. Atlantic menhaden did not occur in entrainment samples (1981, 1983–1987) 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 to1987 to 56,600 annually from 1988 to1990. Despite the increase in impingement, gizzard shad and blue crab represent only about 1 percent of all RIS impinged.

<u>Integration</u>

The WOE integrates the population trend and SOE LOEs into final impact conclusions (Table A–18). Assignment of an NRC staff 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 the operation of the 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 the cooling system and RIS trend. Conversely, if an RIS exhibits a high SOC to the IP2 and IP3 cooling system operation but no statistically significant population decline, the final determination will be Small. If, for any RIS, the population trend is unresolved and the SOC could not be modeled, the WOE conclusion is “unresolved.”

Both Atlantic and shortnose sturgeon populations are listed under the Endangered Species Act (ESA). As discussed in the 2013 FSEIS supplement, the NRC staff and NMFS conducted a Section 7 consultation, and NMFS (2013) issued a biological opinion on the effects of impingement at IP2 and IP3, which concludes that continued operation of either IP2 or IP3 individually is likely to adversely affect but is not likely to jeopardize the continued existence of these species. This conclusion is used as a final impact conclusion.

Table A–18. Impingement and Entrainment Impact Summary for Hudson River YOY RIS

Species	Population Trend Line of Evidence	Strength of Connection Line of Evidence	Impacts of IP2 and IP3 Cooling System Operation
Alewife	Undetected Decline	Low	Small
American Shad	Detected Decline	Low	Small
Atlantic Menhaden	Unresolved[a]	Unresolved [b]	Unresolved
Atlantic Sturgeon	Unresolved[a]	Unresolved [b]	Likely to adversely affect but not jeopardize[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]	Likely to adversely affect but not jeopardize[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] From NMFS's (2013) biological opinion. In Supplement 1 to the FSEIS, the NRC staff described the unresolved impacts to Atlantic and shortnose sturgeon as "Small." No information has been received by the NRC staff that would further resolve the impact levels.

Uncertainty Analysis for Changing Years of Analysis

Both the population trend LOE and the SOC LOE were based on data collected nearly 10 years after the start of operation of the IP2 and IP3 cooling system. A nonparametric Mann-Whitney test of the equality of the median abundance pre- and post-1985 provides an indication of a change in status that would not be reflected in the 1985 through 2011 data used in the WOE analysis (Table A–19).

Table A–19. P-Values for Mann-Whitney Test of Equal Median Abundance Pre- and Post-1985 for Each Population Metric

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	Abundance Index	
Alewife	--	0.22	0.06	--	<0.01	NA	<0.01	0.50	NA	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 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	NA	NA	<0.01	NA	<0.01	0.19	0.14	0.38
Blueback Herring	--	0.01	0.15	--	<0.01	NA	<0.01	0.01	0.02	0.71
Bluefish	0.27	<0.01	0.02	0.49	<0.01	NA	<0.01	0.02	0.02	0.67
Gizzard Shad	--	--	--	--	--	--	NA	NA	--	0.00
Hogchoker	--	0.17	0.03	--	0.38	0.28	NA	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	--	--	NA	0.25	NA	0.44	0.00
Striped Bass	NA	NA	NA	NA	0.42	NA	NA	NA	NA	0.00
Weakfish	NA	0.01	--	NA	<0.01	NA	<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	NA	0.03	<0.01	<0.01	0.57

NA = Pre-1985 Median < Post-1985 Median; Highlighted cells are significant α = 0.05; and -- = Not enough data

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. Both American shad and rainbow smelt population trend conclusions were Detected Decline. 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 the 1985 through 2011 data affected the WOE impact conclusion 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. Of these RIS, alewife (Figure A–13), weakfish (Figure A–14), and white perch (Figure A–15) had a change in their WOE impact conclusions from that published earlier (NRC 2013). The years of monitoring data used to assess alewife, weakfish, and white perch population density trends used in the SOC analysis could affect the WOE impact conclusions.

Figure A–13. River Segment 4 Alewife Population Trends Based on the BSS Standardized Density for Two Subsets of Years of Monitoring Data

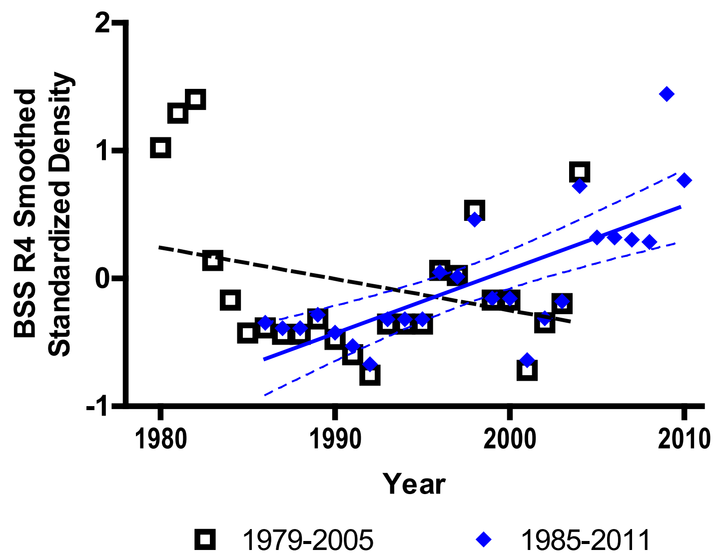


Figure A–14. River Segment 4 Weakfish Population Trends Based on the FSS Standardized Density for Two Subsets of Years of Monitoring Data

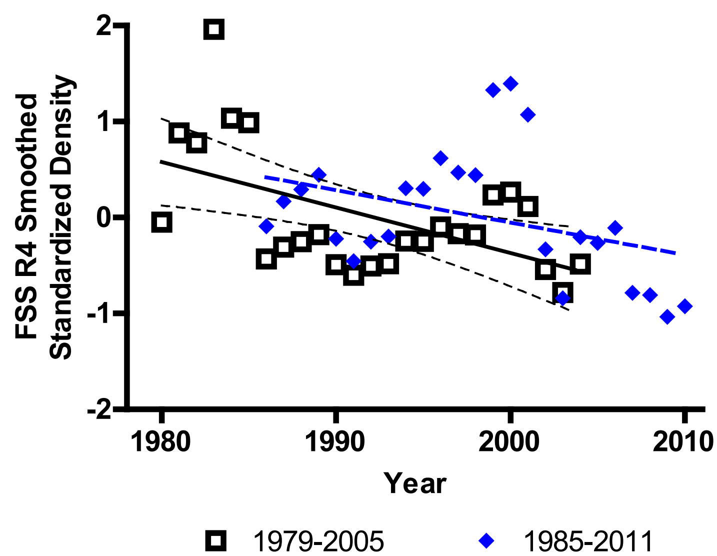
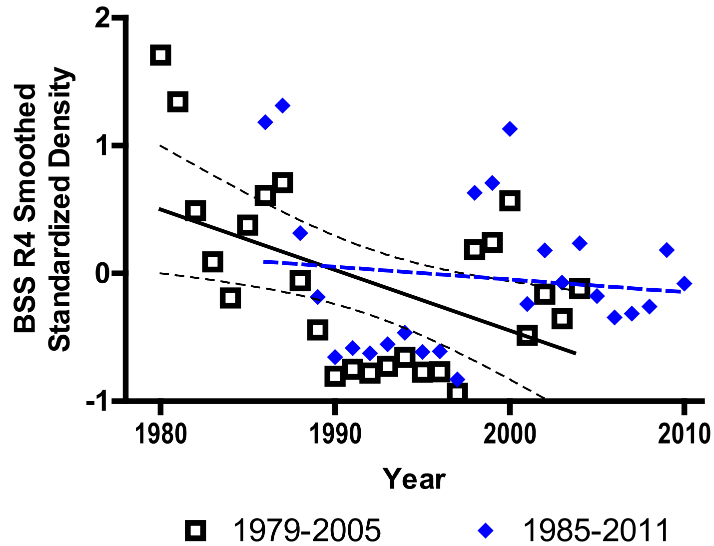


Figure A–15. River Segment 4 White Perch Population Trends Based on the BSS Standardized Density for Two Subsets of Years of Monitoring Data



A.4 Discussion

Across species, 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. Four species had statistically significant declines consistently across measures of abundance and geographic scales: American shad, Atlantic tomcod, blueback herring, and rainbow smelt.

American shad YOY population trends for all measures of abundance for both River Segment 4 and Riverwide scales are negative and statistically significant (Figure A–5). 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 stock since 1985 (Hattala and Kahnle 2009). The decline in American shad has generally been attributed principally 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 2009DE, 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 SOC for Hudson River American shad is Low (Table A–17), and so the impact of IP2 and IP3 operation is Small (Table A–18). 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 contributes to increased mortality rates (ASMFC 2009).

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 IP2 and IP3 impingement during the seaward migration.

The population trends LOE shows a decline in the blueback herring YOY population that was consistent in measures of abundance within River Segment 4 and less consistent Riverwide (Figure A–7, Table A–14). For alewife, however, results were mixed (Tables A–12 and A–13). Statistically significant trends in River Segment 4 are positive for BSS density and negative for FSS density (Addendum A–1, Figures B1 and C1), even though 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 while 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, and the mid-Atlantic blueback herring stock complex, which includes the Hudson River, is significantly decreasing (78 FR 48944). The population trends LOE (Tables A–12, A–13, and 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 SOC conclusion is Low for alewife and High for blueback herring (Table A–17), which, together with the population trends LOE, results in a level of IP2 and IP3 impact of Small for alewife and Large for blueback herring. 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 some uncertainty is introduced into the analysis. In its blueback herring factsheet, the Atlantic States Marine Fisheries Commission (ASMFC) (undated) 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." 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 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 trends 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 SOC is High (Table A–17), indicating that the effect of IP2 and IP3 on the population would be observable. The WOE conclusion is that the impact of IP2 and IP3 cooling system operation on rainbow smelt is High.

Large cooling water withdrawals may be a source of adverse impact to rainbow smelt coastwide. For example, NRC (2007) finds that the impingement impacts of Pilgrim Nuclear Power Station on rainbow smelt and winter flounder populations in the James River are Moderate, whereas effects on other fish species are 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 adverse impacts.

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, 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 (Figure A–6), with trends for 2 of 4 measures of abundance statistically significant for River Segment 4 (Table A–12) and 4 of 4 Riverwide (Table A–13), indicating an unstable population. 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. The SOC is Low (Table A–17), which indicates that the effect of IP2 and IP3 on the population would not be observable. The resulting impact conclusion is Small (Table A–18). 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.

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, and the EMR from IP2 and IP3 is 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 (Tables A–12, A–13, and A–14). The statistically significant trends, however, were all negative: FSS density and CPUE in River Segment 4 (Figure A–10). The SOC LOE was High, indicating that the effect of I&E at IP2 and IP3 would be observable. Considered together, the impact of IP2 and IP3 cooling water system operation was Moderate (Table A–18). 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.

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. Only 1 of 4 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 an undetected decline for the population trends LOE.

Bay anchovy EMR in River Segment 4 is relatively high, about 21 percent (Table A–15), and the SOC is High (Table A–17). That, together with undetectable population declines, yielded an impact conclusion of Small (Table A–18). 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.

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 L2). Only one trend is statistically significant (Riverwide FSS Abundance Index, Table A–13), and it is negative, which leads to a Population Trend LOE conclusion of an undetected decline (Table A–14). The CEMR is high (54.4 percent, Table A–15), and the SOC is High. Because the weakfish population is only seasonal in the Hudson River and spends much of the year offshore, the high EMR of fish that do reside in River Segment 4 does not appear to result in long-term population declines.

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 impingement and entrainment 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 were originally focused on this species. Population trends in 3 of 9 indices of abundance are statistically significant, all of them negative (Figure A–11): 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. The inconsistency of results yields an undetected decline for the Population Trends LOE (Table A–14). The NYSDEC also monitors the abundance of Hudson River YOY striped bass with a beach seine survey and calculates a riverwide abundance index. In reviewing the NYSDEC Striped Bass Young-of-Year 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 SOC is High, which suggests that effects of I&E may be observable, and combined with an undetected decline conclusion for the Population Trends LOE, results in a small level of impact from IP2 and IP3 (Table A–18).

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, are one of the few species that can tolerate the interannual transitions between limnetic and oligohaline conditions in River Segment 4 and are 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 N2), although only one trend was statistically significant, and so a white perch population decline was undetected (Table A–14). The EMR is 7.5 percent of the River Segment 4 YOY population annually (Table A–15) and the SOC was High (Table A–17), indicating that the effects of I&E could be observable. Because of the undetectable population trend, the impact level was Small (Table A–18).

Beside 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 SOC is Low. Adult bluefish are marine and pelagic, and the YOY are seasonal visitors to the estuary.

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 ppt) 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 were too few to calculate populations tends in River Segment 4 (Table A–12) or Riverwide (Table A–13) and so the impact was unresolved (Table A–18).

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 SOC could not be modeled, and the impact was unresolved (Table A–18). Spottail shiner trends were inconsistent, and the SOC was low (Table A–18). Too few white catfish were caught in River Segment 4 to assess trends (Table A–12). Trends could be calculated Riverwide, and the two statistically significant trends were both negative (Table A–13). The SOC is low (Table A–17). For both Spottail shiner and white catfish, the impact level was Small (Table A–18).

Atlantic and shortnose sturgeon were not captured often enough to determine trends. Although the present study 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. NYSDEC and Cornell (2015) report that, although the index has high interannual variability, the trend in abundance is increasing from 2006 through 2014 (the last year reported) 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 Section 7 consultation for protection of the species f at IP2 and IP3. Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) 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. NMFS (2013) issued a biological opinion on the effects of impingement at IP2 and IP3 and concluded that continued operation of either IP2 or IP3 individually 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 is designated in the action area. In accordance with the biological opinion, IP2 and IP3 are conducting monitoring studies to provide more information on the impacts to these species.

Blue crab were not captured often enough to determine River Segment 4 or Riverwide population trends or to determine SOC. This study could therefore not resolve the impact of I&E on this species.

A.5 Conclusions

The NRC staff used a WOE approach to combine a Population Trends LOE and an SOC LOE to assess the impact of impingement and entrainment 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 had consistent statistically significant declines among measures of abundance: American shad, Atlantic tomcod, blueback herring, and rainbow smelt.

A Monte Carlo-based assessment of SOC combined information on EMR, CMR, and population trends to indicate the degree to which the effects of impingement and entrainment at IP2 and IP3 would be observable. Species with high SOC included bay anchovy, blueback herring, hogchoker, rainbow smelt, striped bass, weakfish, and white perch.

The impact levels of operation of the IP2 and IP3 cooling water intakes are Moderate for one species (hogchoker) and Large for two species (blueback herring and rainbow smelt). The impact levels are Small for ten species: alewife, American shad, Atlantic tomcod, bay anchovy, bluefish, spottail shiner, striped bass, weakfish, white catfish, and white perch. Impacts could not be resolved for Atlantic menhaden, gizzard shad, and blue crab. The years of monitoring data used (1979 through 2005 vs. 1985 through 2011) to assess alewife, weakfish, and white perch population trends and used to estimate the parameters for the SOC analysis could affect the WOE impact conclusions for these RIS.

For Hudson River populations of Atlantic and shortnose sturgeon populations listed under the ESA, too few individuals were collected to determine either population trends or SOC. For these species, continued operation of either IP2 or IP3 individually is likely to adversely affect but is not likely to jeopardize the continued existence of these species (NMFS 2013).

A.6 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.

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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. 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 analysis are calculated with and without extreme observations defined as absolute standardized observations >3.

Figures A through C 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 D and E 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 F through H 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 I through K present the standardized riverwide annual YOY abundance index (provided by Entergy) for the LRS, FSS, and BSS 1974 through 2011 data.

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 H0: 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. 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)

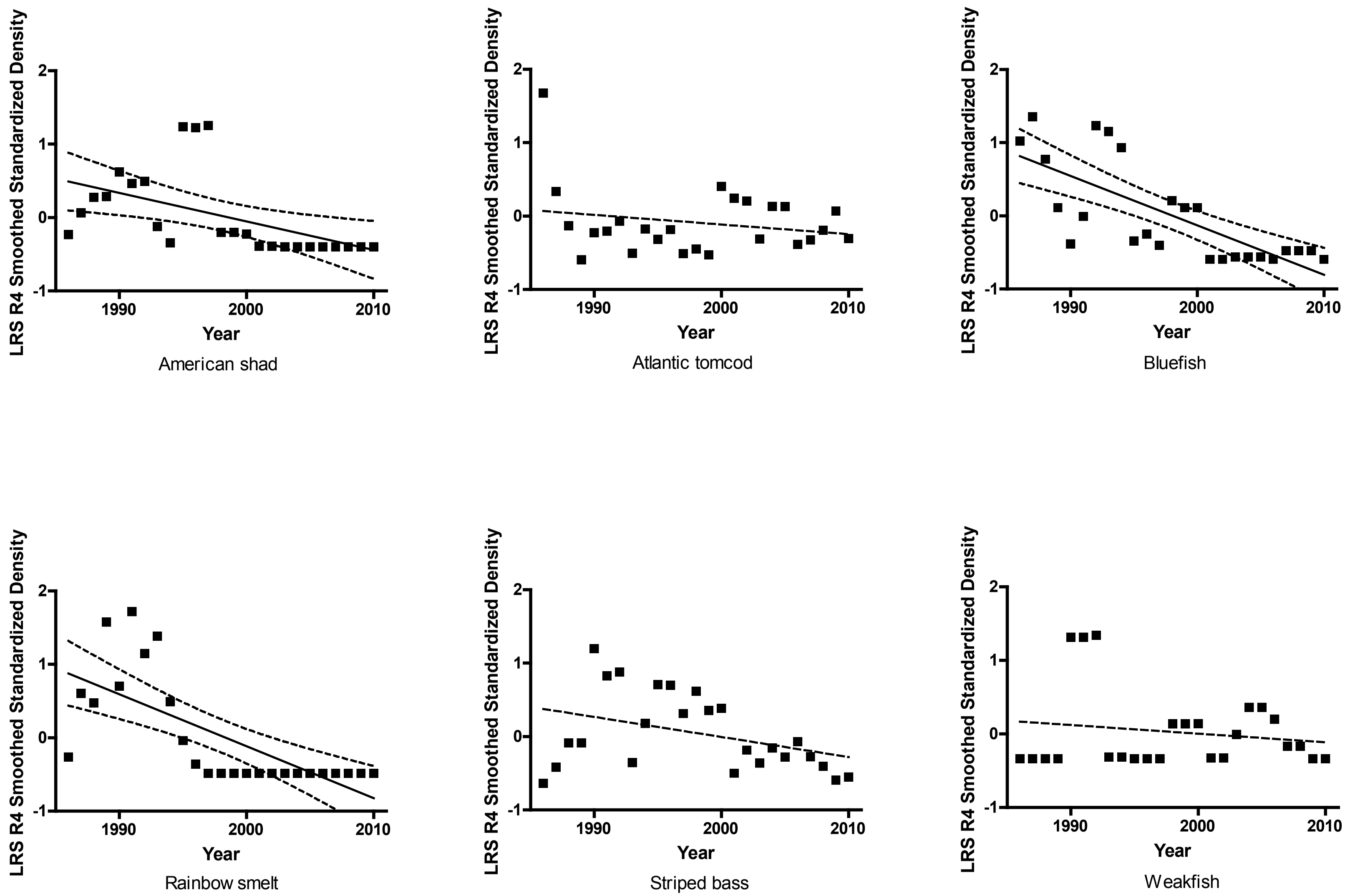


Figure B1. River Segment 4 FSS YOY Density (July–Oct Sampling Events, 1985–2011, with 3 yr. Moving Average Smoothing)

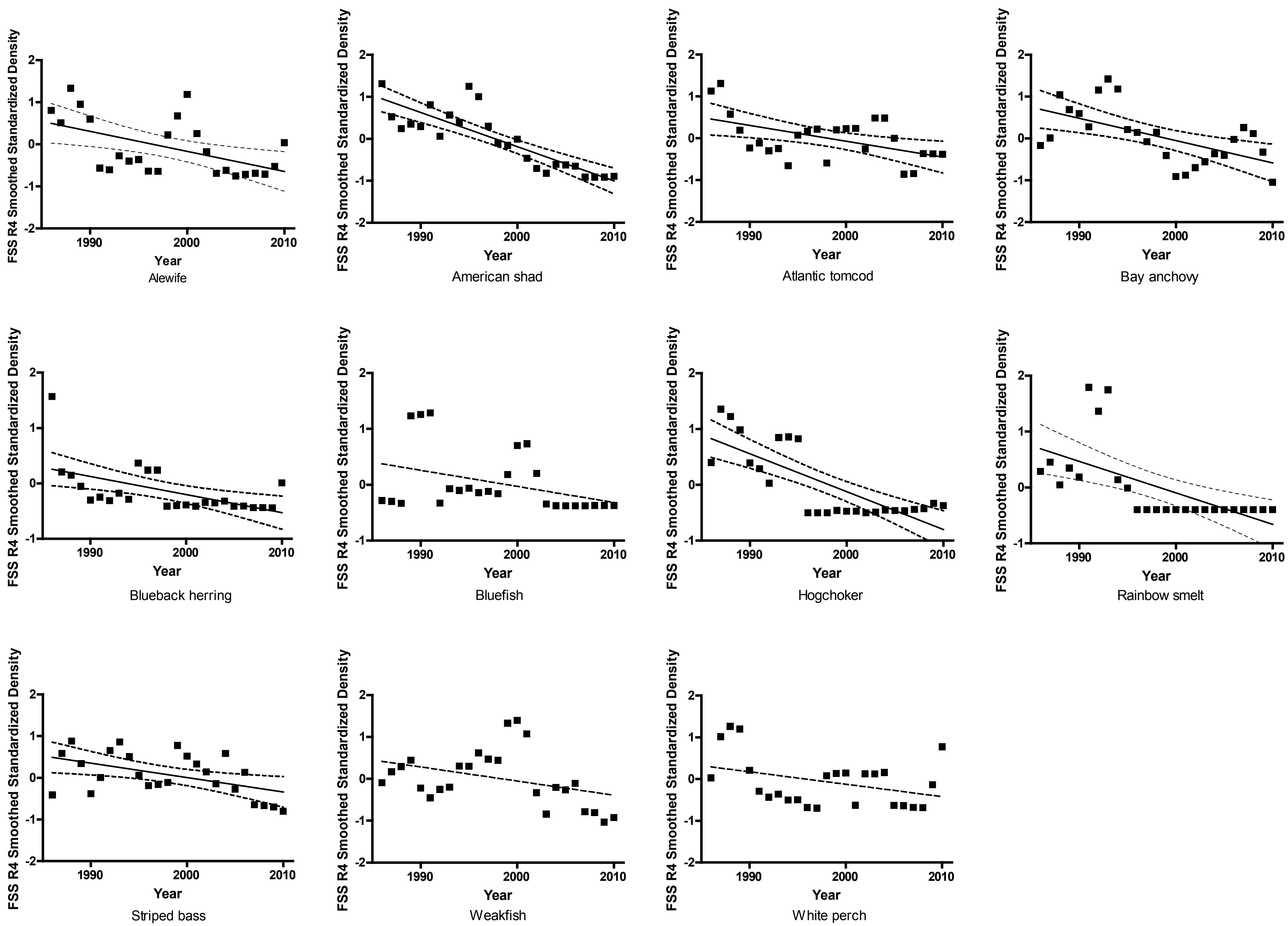


Figure C1. River Segment 4 BSS YOY Density (July–Oct Sampling Events, 1985–2011, with 3 yr. Moving Average Smoothing)

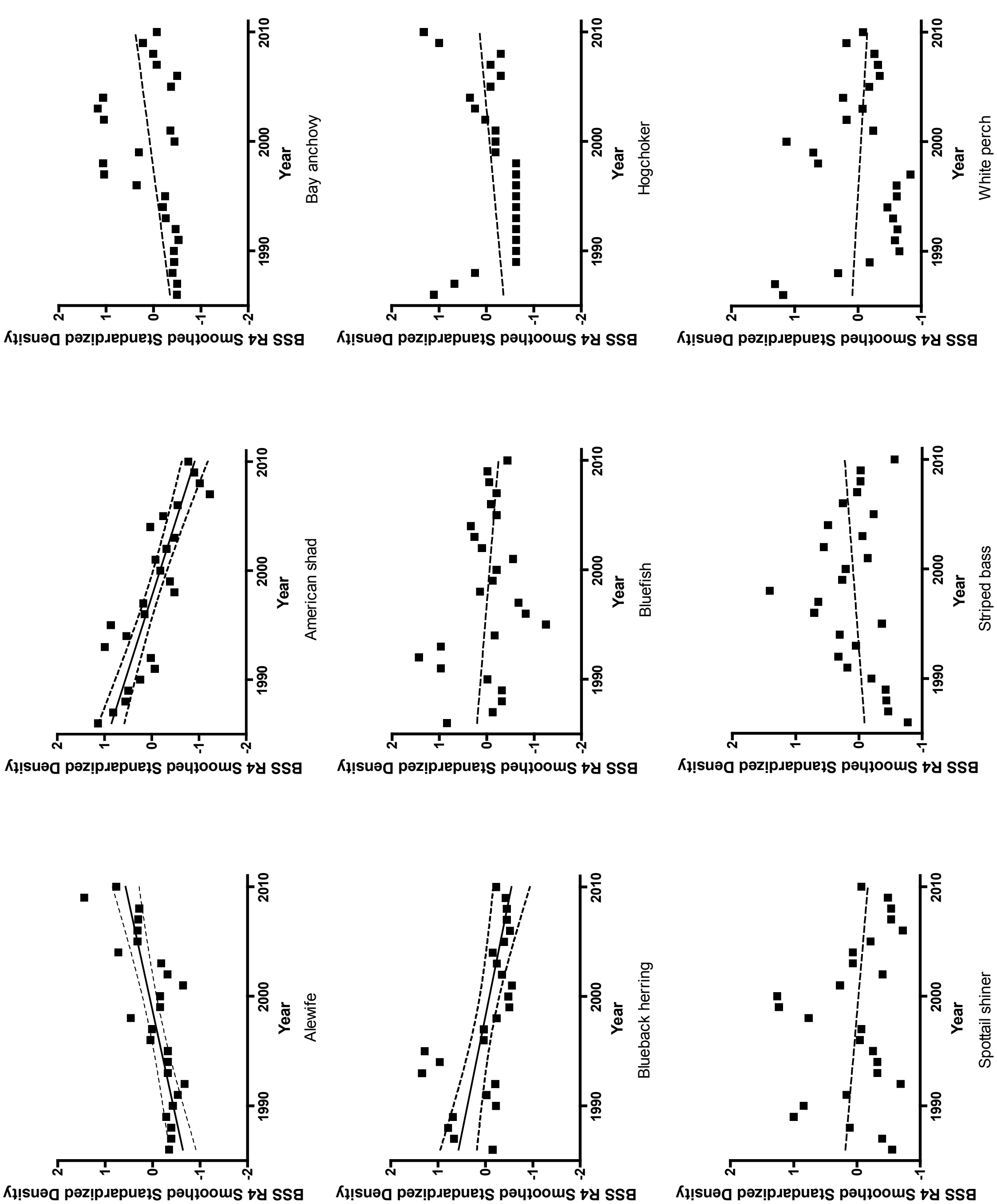


Figure D1. River Segment 4 LRS YOY CPUE (May–July Sampling Events, 1985–2011)

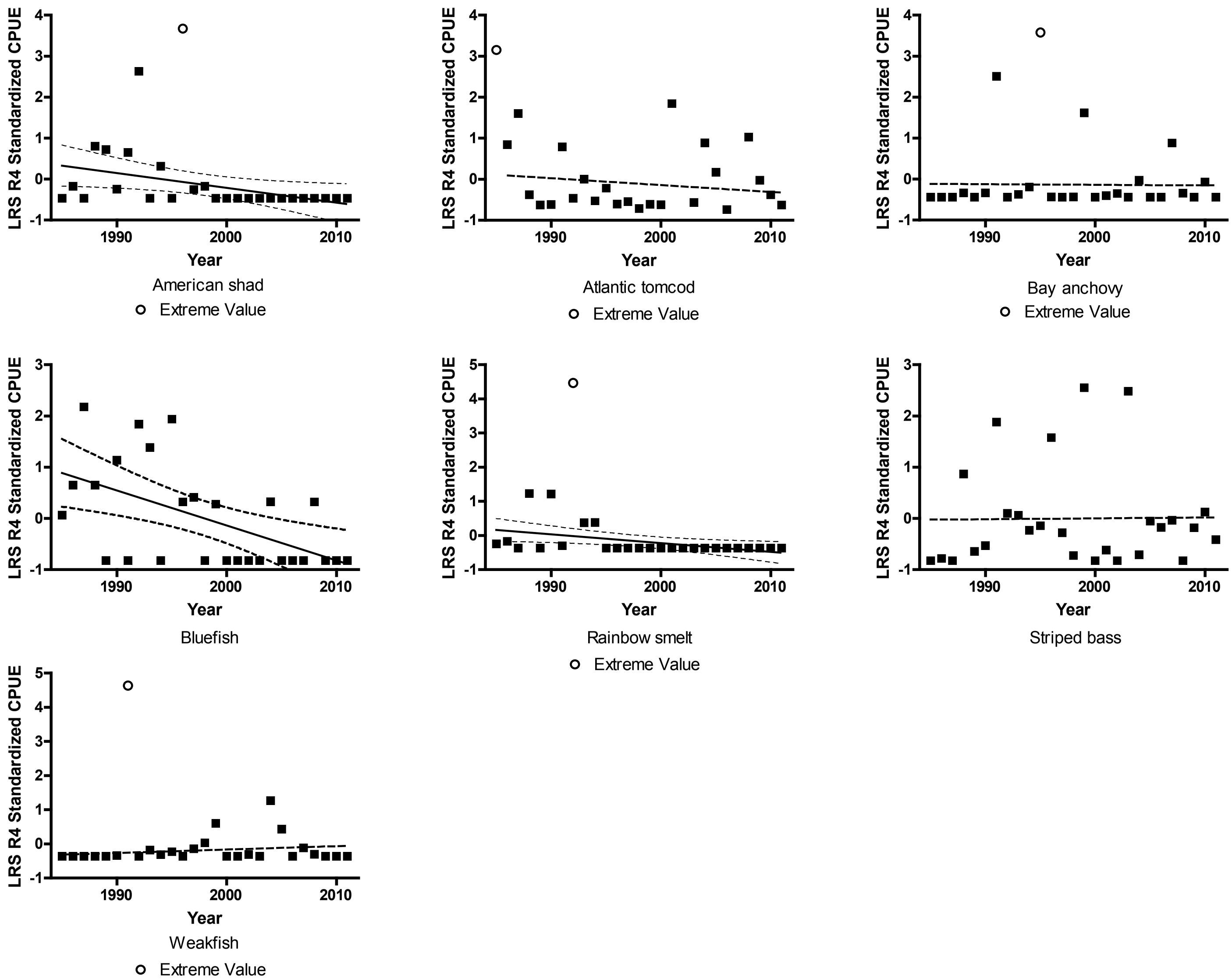


Figure E1. River Segment 4 FSS YOY CPUE (July–Oct Sampling Events, 1985–2011)

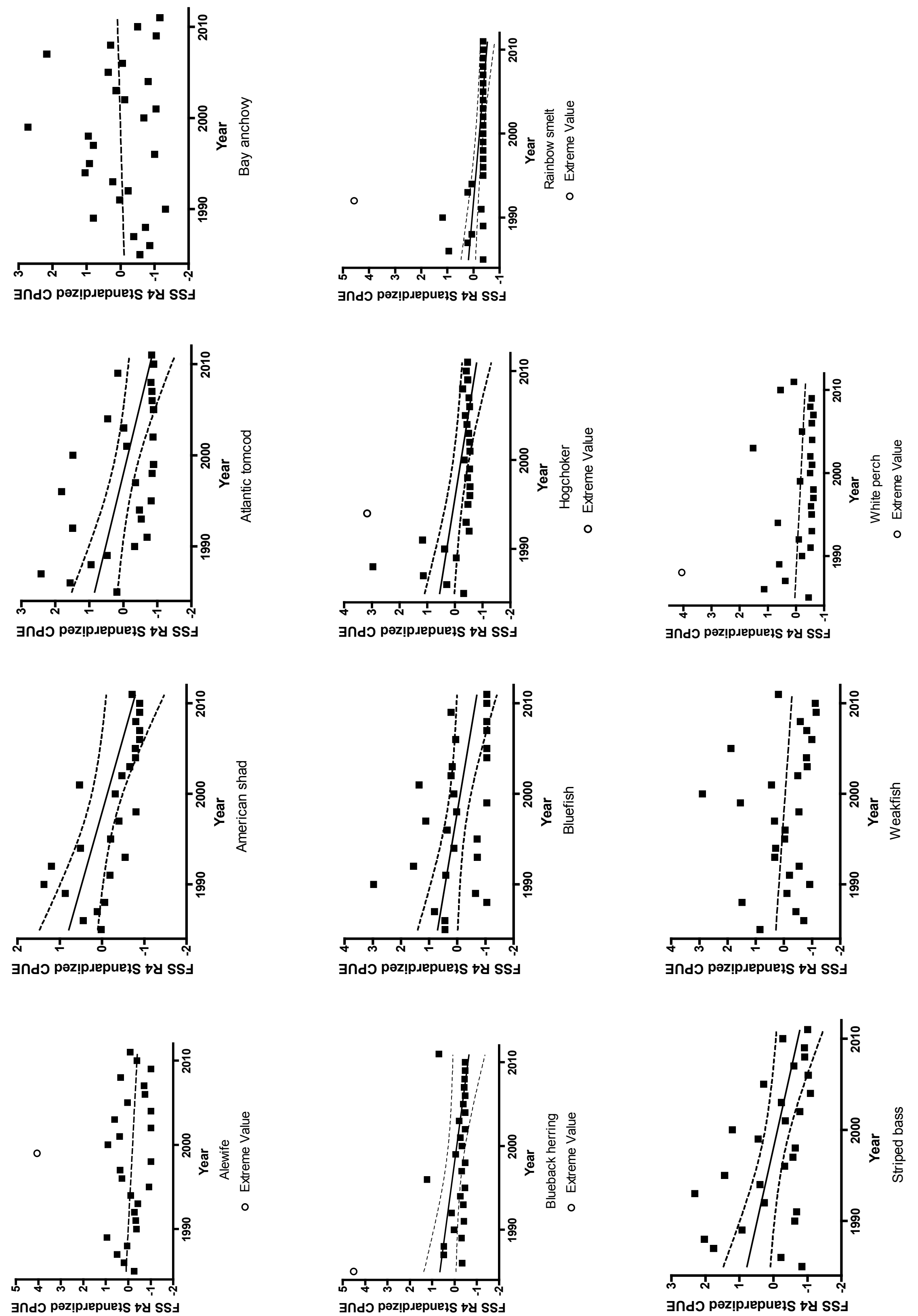


Figure F1. Riverwide LRS YOY CPUE (May–July Sampling Events, 1985–2011)

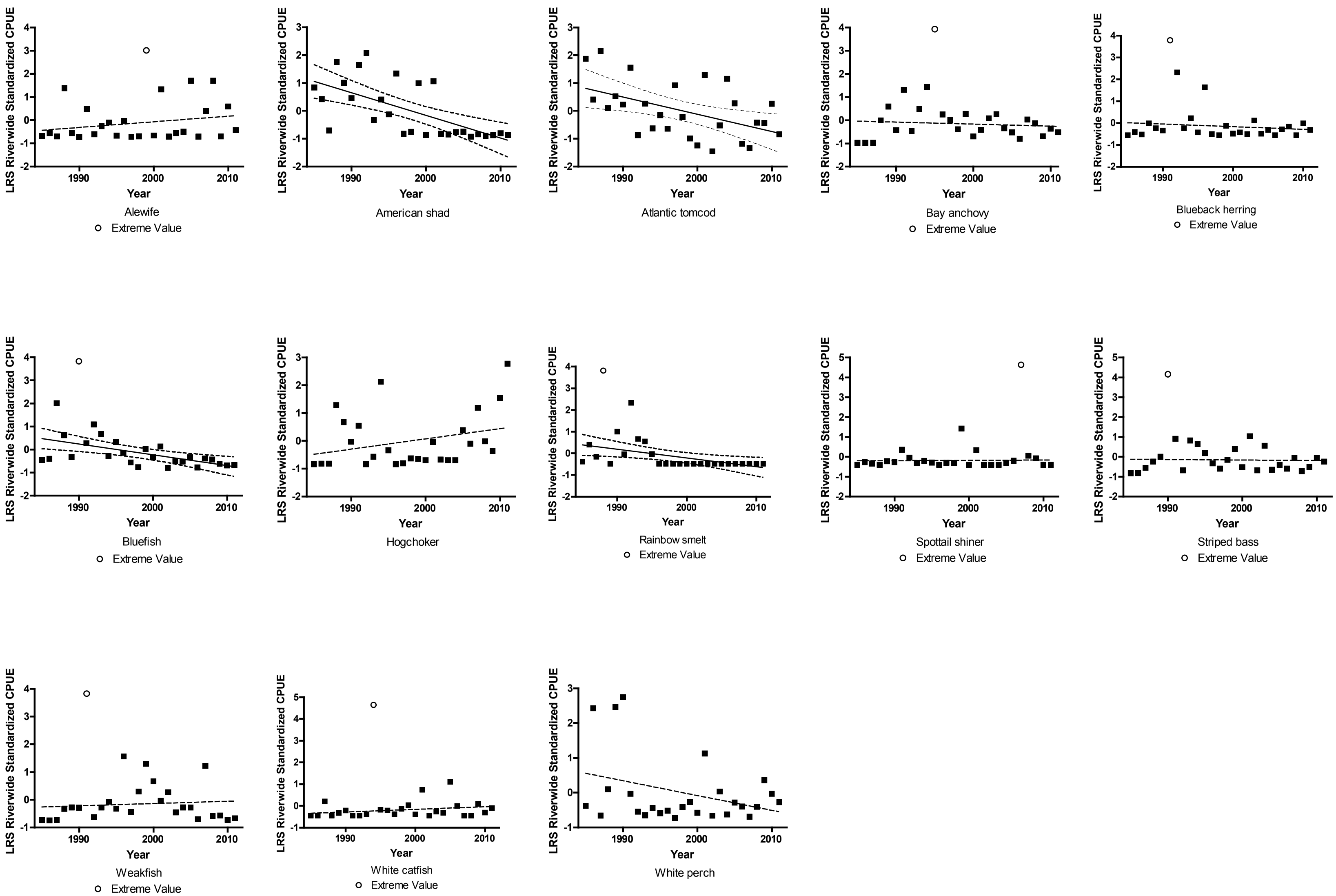


Figure G1. Riverwide FSS YOY CPUE (July–Oct Sampling Events, 1985–2011)

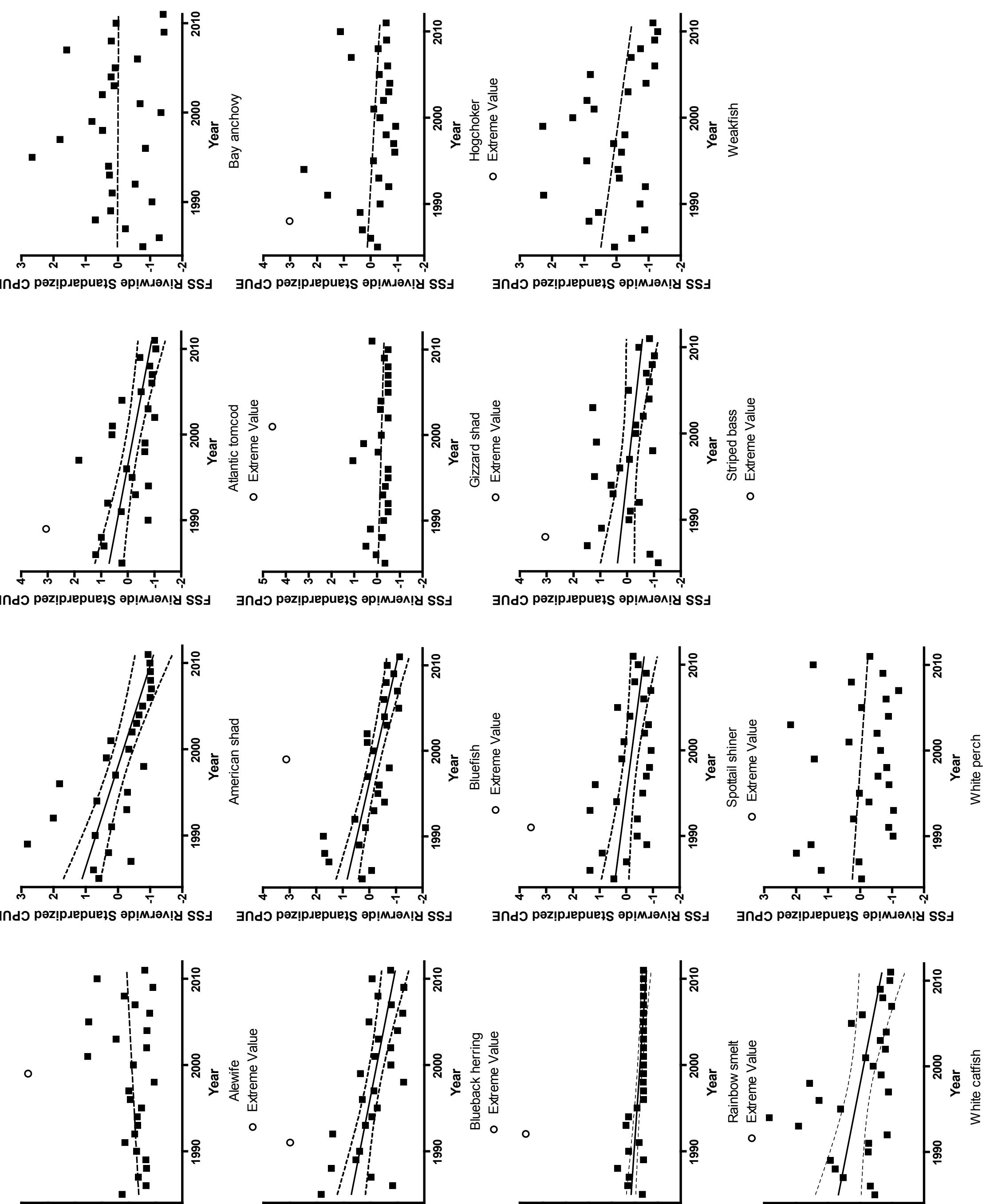


Figure H1. Riverwide BSS YOY CPUE (July–Oct Sampling Events, 1985–2011)

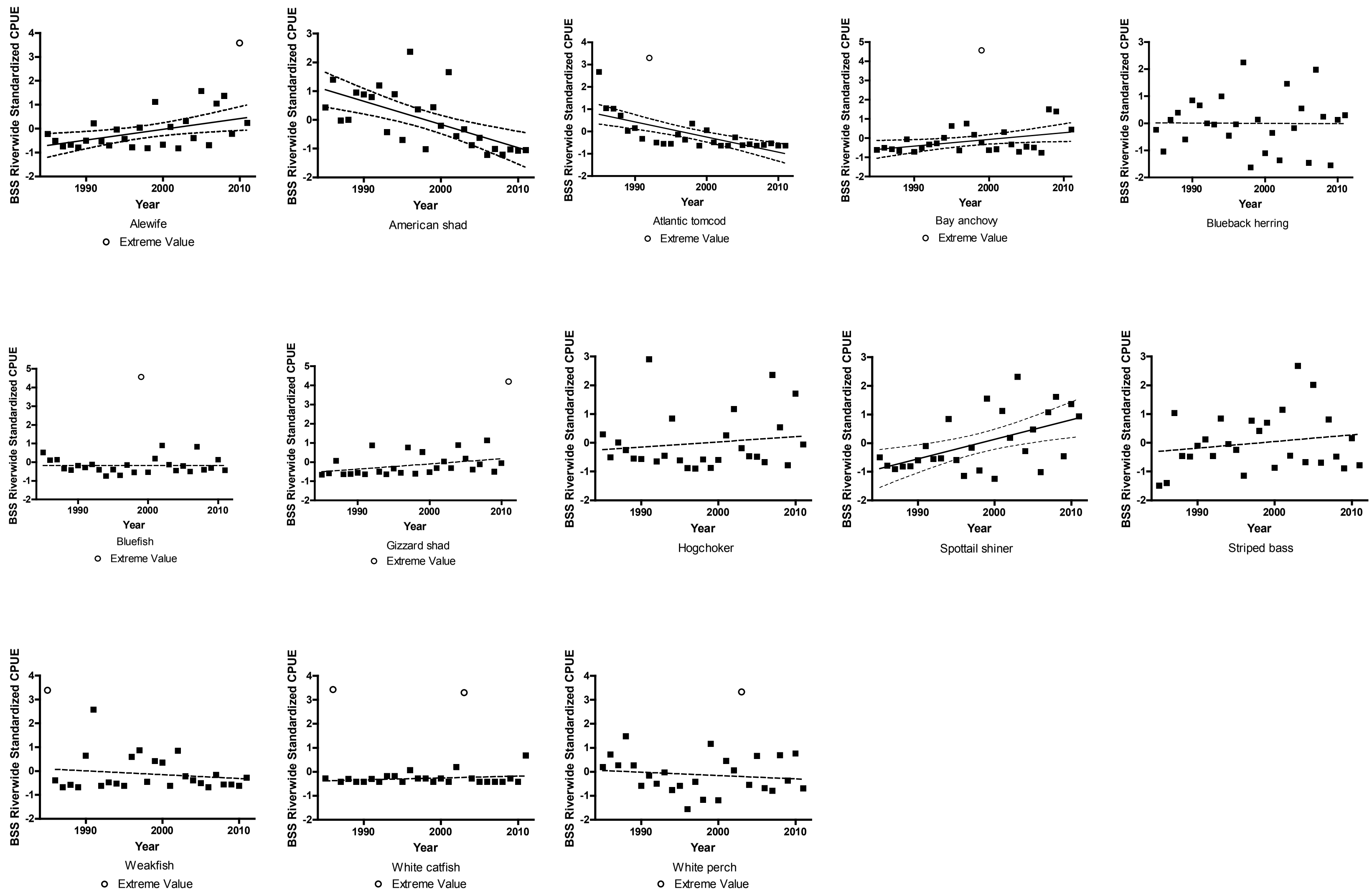


Figure I1. Riverwide LRS YOY Abundance Index (1974–2011)

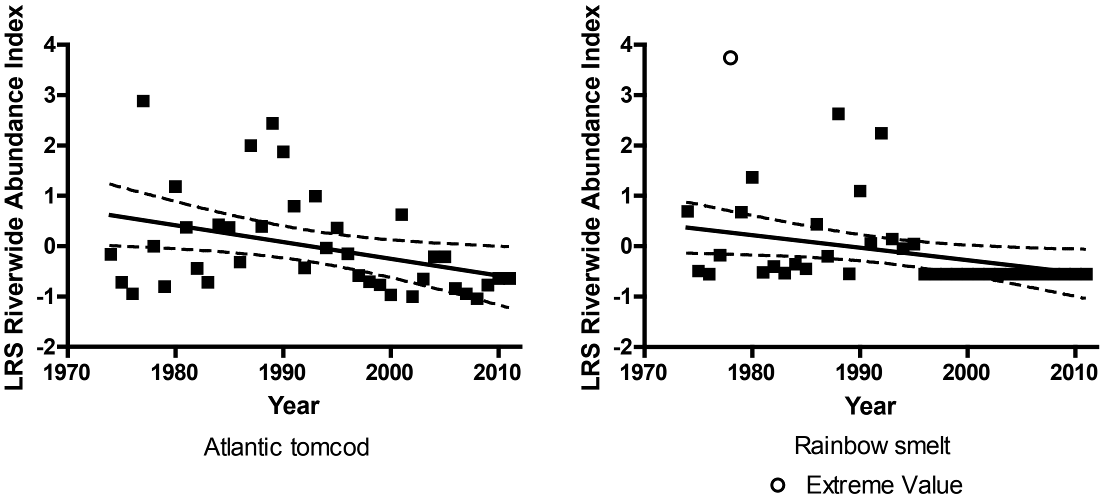


Figure J1. Riverwide FSS YOY Abundance Index (1979–2011)

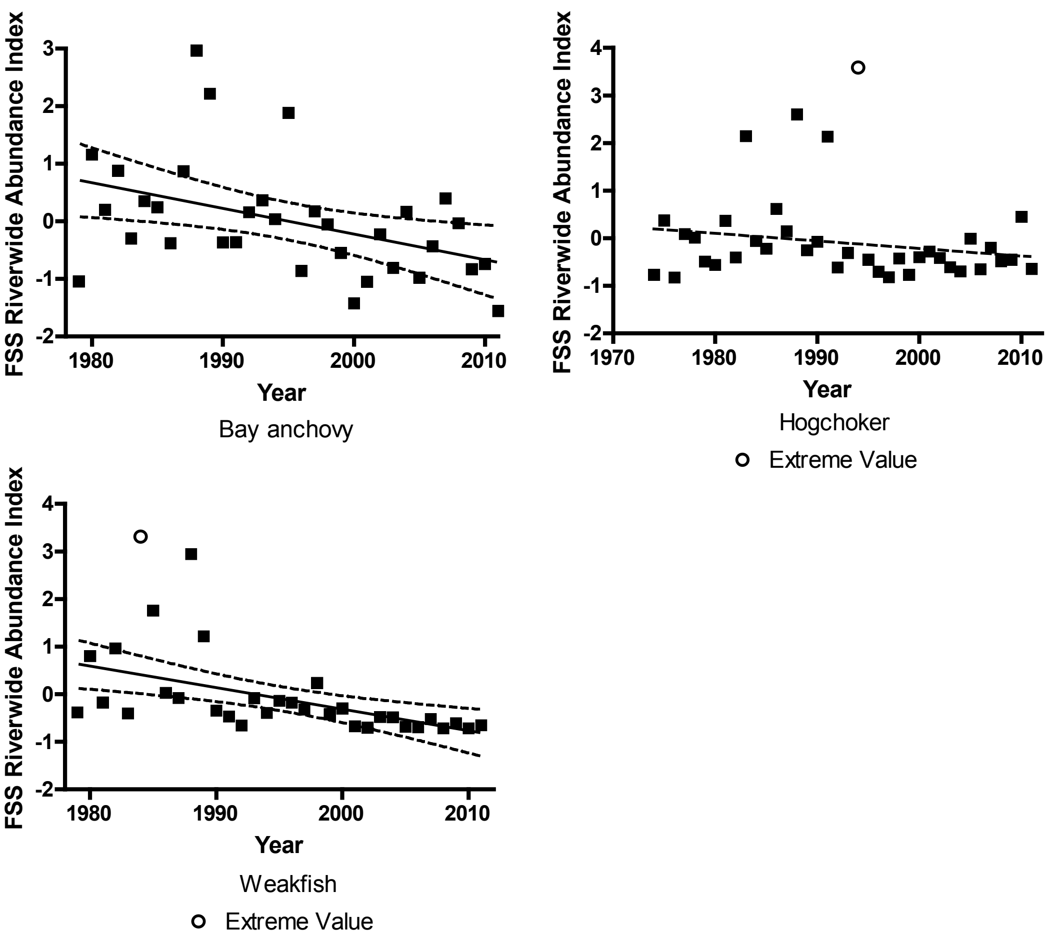
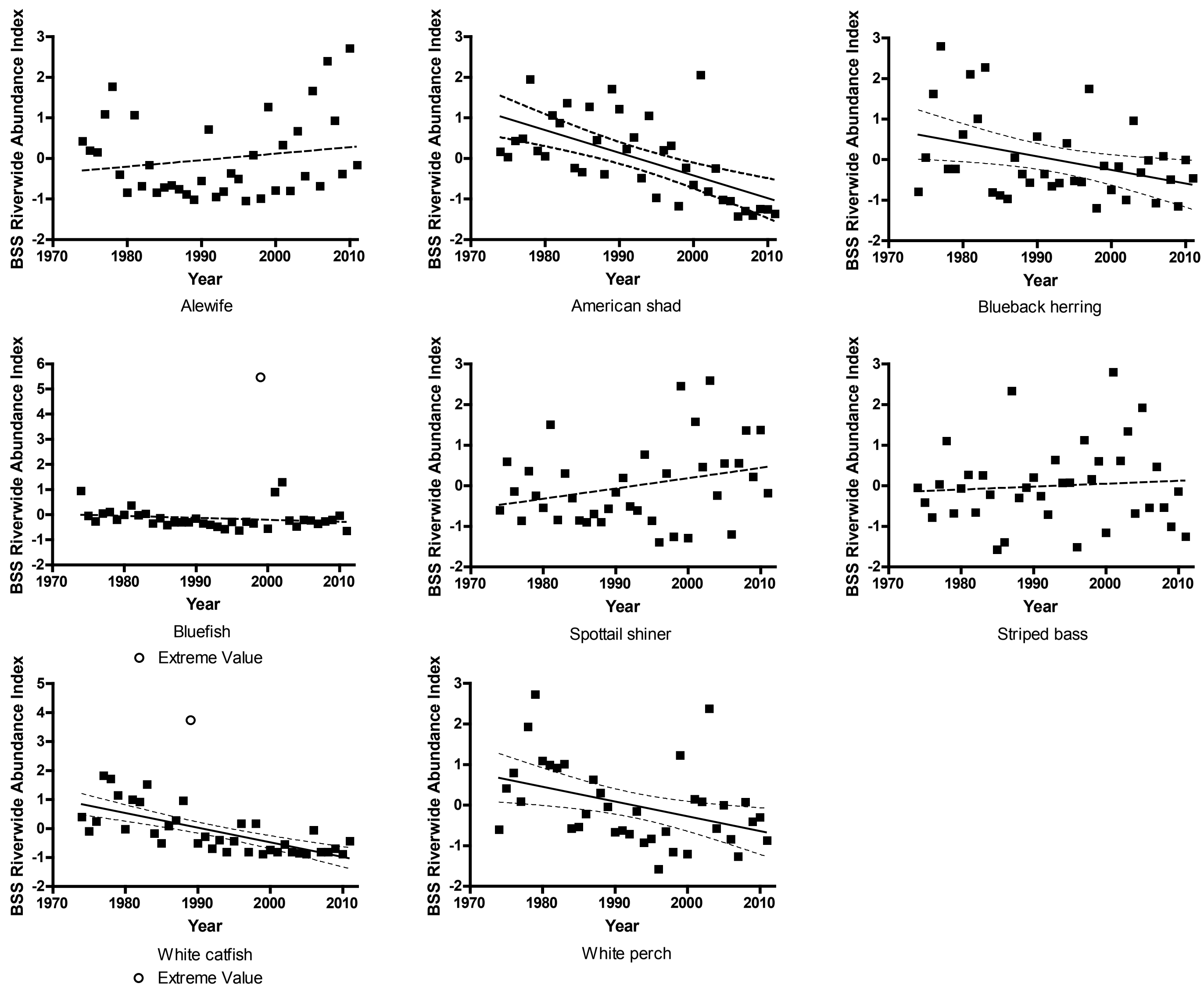


Figure K1. Riverwide BSS YOY Abundance Index (1974–2011)



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 Error of Slope	P value	Slope	Decision
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 Error of Slope	P value	Slope	Decision
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 ± 1 Standard Error of Slope**	**P value**	**Slope**	**Decision**
Alewife	0.123	0.050 ± 0.010	< 0.001	S>0	1
American Shad	0.117	-0.073 ± 0.009	< 0.001	S<0	4
Bay Anchovy	0.317	0.031 ± 0.016	0.063	S=0	1
Blueback Herring	0.232	-0.046 ± 0.013	0.002	S<0	4
Bluefish	0.347	-0.019 ± 0.016	0.264	S=0	1
Hogchoker	0.350	0.021 ± 0.016	0.211	S=0	1
Spottail Shiner	0.349	-0.015 ± 0.016	0.377	S=0	1
Striped Bass	0.229	0.013 ± 0.013	0.339	S=0	1
White Perch	0.387	-0.010 ± 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 ± 1 Standard Error of Slope**	**P value**	**Slope**	**Decision**
American Shad	0.931	-0.041 ± 0.024	0.100	S=0	4
American Shad with 1 value removed	0.411	-0.036 ± 0.016	0.032	S<0	
Atlantic Tomcod	0.930	-0.041 ± 0.024	0.098	S=0	1
Atlantic Tomcod with 1 value removed	0.636	-0.017 ± 0.021	0.429	S=0	
Bay Anchovy	1.036	-0.008 ± 0.025	0.743	S=0	1
Bay Anchovy with 1 value removed	0.529	-0.002 ± 0.018	0.932	S=0	
Bluefish	0.733	-0.068 ± 0.021	0.003	S<0	4
Rainbow Smelt*	0.924	-0.042 ± 0.024	0.089	S=0	4
Rainbow Smelt* with 1 value removed	0.175	-0.026 ± 0.010	0.022	S<0	
Striped Bass	1.040	0.002 ± 0.025	0.950	S=0	1
Weakfish	1.032	-0.011 ± 0.025	0.671	S=0	1
Weakfish with 1 value removed	0.146	0.010 ± 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 ± 1 Standard Error of Slope**	**P value**	**Slope**	**Decision**
Alewife	1.022	-0.017 ± 0.025	0.509	S=0	1
Alewife with 1 value removed	0.346	-0.019 ± 0.015	0.196	S=0	
American Shad	0.798	-0.061 ± 0.022	0.011	S<0	4
Atlantic Tomcod	0.762	-0.065 ± 0.022	0.006	S<0	4
Bay Anchovy	1.036	0.008 ± 0.025	0.765	S=0	1
Blueback Herring	0.876	-0.050 ± 0.023	0.041	S<0	4
Blueback Herring with 1 value removed	0.187	-0.014 ± 0.011	0.220	S=0	
Bluefish	0.852	-0.054 ± 0.023	0.027	S<0	4
Hogchoker	0.810	-0.059 ± 0.022	0.013	S<0	4
Hogchoker with 1 value removed	0.467	-0.052 ± 0.017	0.006	S<0	
Rainbow Smelt*	0.907	-0.045 ± 0.024	0.067	S=0	4
Rainbow Smelt* with 1 value removed	0.125	-0.028 ± 0.009	0.004	S<0	
Striped Bass	0.803	-0.060 ± 0.022	0.012	S<0	4
Weakfish	1.008	-0.022 ± 0.025	0.380	S=0	1
White Perch	0.939	-0.039 ± 0.024	0.114	S=0	1
White Perch with 1 value removed	0.357	-0.014 ± 0.015	0.353	S=0	

* 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 ± 1 Standard Error of Slope**	**P value**	**Slope**	**Decision**
Alewife	0.995	0.026 ± 0.025	0.297	S=0	1
Alewife with 1 value removed	0.650	0.024 ± 0.020	0.233	S=0	
American Shad	0.606	-0.081 ± 0.019	<0.001	S<0	4
Atlantic Tomcod	0.787	-0.062 ± 0.022	0.009	S<0	4
Bay Anchovy	1.024	-0.016 ± 0.025	0.529	S=0	1
Bay Anchovy with 1 value removed	0.409	-0.009 ± 0.016	0.595	S=0	
Blueback Herring	0.987	-0.028 ± 0.025	0.257	S=0	1
Blueback Herring with 1 value removed	0.454	-0.012 ± 0.017	0.484	S=0	
Bluefish	0.768	-0.064 ± 0.022	0.006	S<0	4
Bluefish with 1 value removed	0.306	-0.047 ± 0.014	0.003	S<0	
Hogchoker	0.950	0.037 ± 0.024	0.137	S=0	1
Rainbow Smelt	0.790	-0.062 ± 0.022	0.009	S<0	4
Rainbow Smelt with 1 value removed	0.349	-0.040 ± 0.015	0.014	S<0	
Spottail Shiner	0.989	0.028 ± 0.025	0.267	S=0	1
Spottail Shiner with 1 value removed	0.157	0.002 ± 0.010	0.875	S=0	
Striped Bass	1.004	-0.024 ± 0.025	0.348	S=0	1
Striped Bass with 1 value removed	0.335	-0.003 ± 0.015	0.855	S=0	
Weakfish	1.034	-0.009 ± 0.025	0.718	S=0	1
Weakfish with 1 value removed	0.445	0.008 ± 0.017	0.635	S=0	
White Catfish	1.040	0.000 ± 0.025	0.998	S=0	1
White Catfish with 1 value removed	0.140	0.012 ± 0.009	0.210	S=0	
White Perch	0.921	-0.043 ± 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 ± 1 Standard Error of Slope**	**P value**	**Slope**	**Decision**
Alewife	1.014	0.020 ± 0.025	0.440	S=0	1
Alewife with 1 value removed	0.453	0.017 ± 0.017	0.313	S=0	
American Shad	0.561	-0.086 ± 0.019	< 0.001	S<0	4
Atlantic Tomcod	0.666	-0.076 ± 0.020	0.001	S<0	4
Atlantic Tomcod with 1 value removed	0.434	-0.061 ± 0.017	0.001	S<0	
Bay Anchovy	1.040	-0.002 ± 0.025	0.952	S=0	1
Blueback Herring	0.678	-0.074 ± 0.020	0.001	S<0	4
Blueback Herring with 1 value removed	0.431	-0.063 ± 0.016	0.001	S<0	
Bluefish	0.706	-0.071 ± 0.021	0.002	S<0	4
Bluefish with 1 value removed	0.293	-0.073 ± 0.013	< 0.001	S<0	
Gizzard Shad	1.040	-0.001 ± 0.025	0.960	S=0	1
Gizzard Shad with 1 value removed	0.165	-0.010 ± 0.010	0.327	S=0	
Hogchoker	0.954	-0.036 ± 0.024	0.146	S=0	1
Hogchoker with 1 value removed	0.667	-0.018 ± 0.021	0.391	S=0	
Rainbow Smelt	0.917	-0.043 ± 0.024	0.079	S=0	4
Rainbow Smelt with 1 value removed	0.066	-0.026 ± 0.006	0.001	S<0	
Spottail Shiner	0.832	-0.056 ± 0.023	0.019	S<0	4
Spottail Shiner with 1 value removed	0.415	-0.042 ± 0.016	0.016	S<0	
Striped Bass	0.857	-0.053 ± 0.023	0.030	S<0	4
Striped Bass with 1 value removed	0.599	-0.036 ± 0.020	0.083	S=0	
Weakfish	0.950	-0.037 ± 0.024	0.137	S=0	1
White Catfish	0.859	-0.053 ± 0.023	0.031	S<0	4
White Perch	1.018	-0.019 ± 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	1
Alewife with 1 value removed	0.403	0.045 ± 0.016	0.012	S>0	
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	4
Atlantic Tomcod with 1 value removed	0.307	-0.068 ± 0.014	< 0.0001	S<0	
Bay Anchovy	0.794	0.061 ± 0.022	0.010	S>0	1
Bay Anchovy with 1 value removed	0.347	0.035 ± 0.015	0.033	S>0	
Blueback Herring	1.040	-0.001 ± 0.025	0.962	S=0	1
Bluefish	1.040	0.003 ± 0.025	0.916	S=0	1
Bluefish with 1 value removed	0.184	0.000 ± 0.011	0.985	S=0	
Gizzard Shad	0.814	0.059 ± 0.022	0.014	S>0	1
Gizzard Shad with 1 value removed	0.277	0.027 ± 0.014	0.061	S=0	
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	1
Weakfish with 1 value removed	0.572	-0.016 ± 0.020	0.423	S=0	
White Catfish	1.034	-0.009 ± 0.025	0.710	S=0	1
White Catfish with 2 values removed	0.063	0.008 ± 0.007	0.257	S=0	
White Perch	1.038	-0.003 ± 0.025	0.902	S=0	1
White Perch with 1 value removed	0.590	-0.014 ± 0.019	0.473	S=0	

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	4
Rainbow Smelt with 1 value removed	0.569	-0.025 ± 0.011	0.037	S<0	

Table J. Linear Analysis of FSS Abundance Index

Standardized Data (1979–2011; Hogchoker 1974–2011)

Linear Regression FSS Riverwide Abundance Index					
RIS	**MSE**	**Slope ± 1 Standard Error of Slope**	**P value**	**Slope**	**Decision**
Bay Anchovy	0.839	-0.045 ± 0.017	0.012	S<0	4
Hogchoker	1.000	-0.015 ± 0.015	0.328	S = 0	1
Hogchoker with 1 value removed	0.646	-0.016 ± 0.012	0.190	S = 0	
Weakfish	0.732	-0.056 ± 0.016	0.001	S<0	4
Weakfish with 1 value removed	0.495	-0.045 ± 0.013	0.002	S<0	

Table K. Linear Analysis of BSS Abundance Index

Standardized Data (1974–2011)

Linear Regression BSS Riverwide Abundance Index					
RIS	**MSE**	**Slope ± 1 Standard Error of Slope**	**P value**	**Slope**	**Decision**
Alewife	0.995	0.016 ± 0.015	0.287	S = 0	1
American Shad	0.631	-0.056 ± 0.012	< 0.001	S<0	4
Blueback Herring	0.885	-0.034 ± 0.014	0.021	S<0	4
Bluefish	1.028	0.000 ± 0.015	0.988	S = 0	1
Bluefish with 1 value removed	0.173	-0.008 ± 0.006	0.213	S = 0	
Spottail Shiner	0.946	0.025 ± 0.014	0.086	S = 0	1
Striped Bass	1.022	0.007 ± 0.015	0.634	S = 0	1
White Catfish	0.668	-0.053 ± 0.012	< 0.001	S<0	4
White Catfish with 1 value removed	0.317	-0.050 ± 0.008	< 0.001	S<0	
White Perch	0.859	-0.036 ± 0.014	0.012	S<0	4

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 are presented in alphabetical order.

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

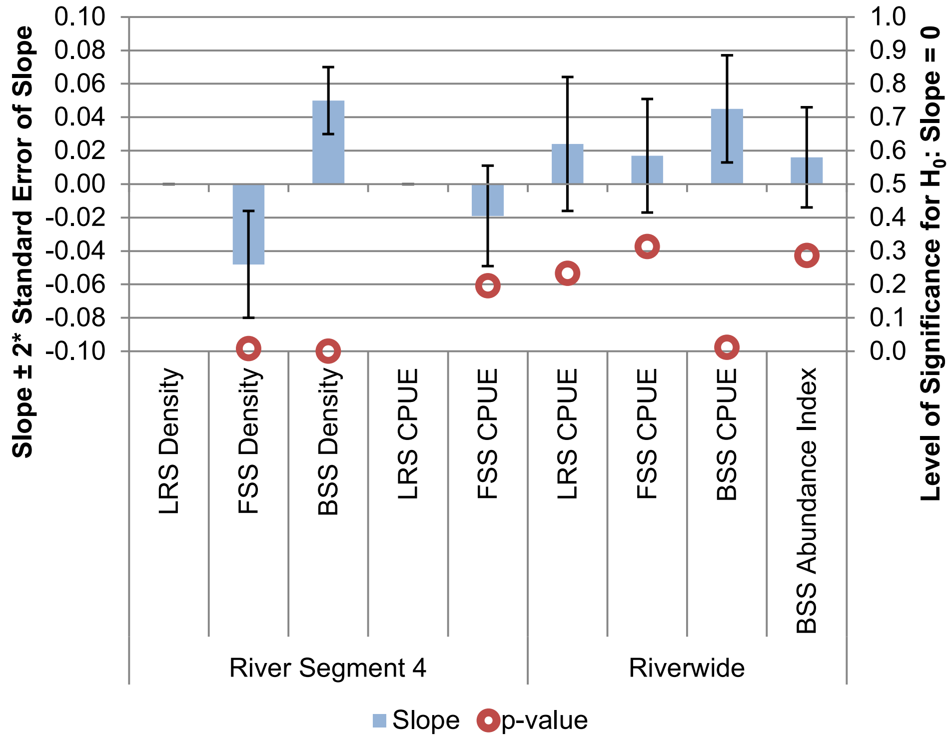


Figure B2. American Shad Estimated Slope (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance

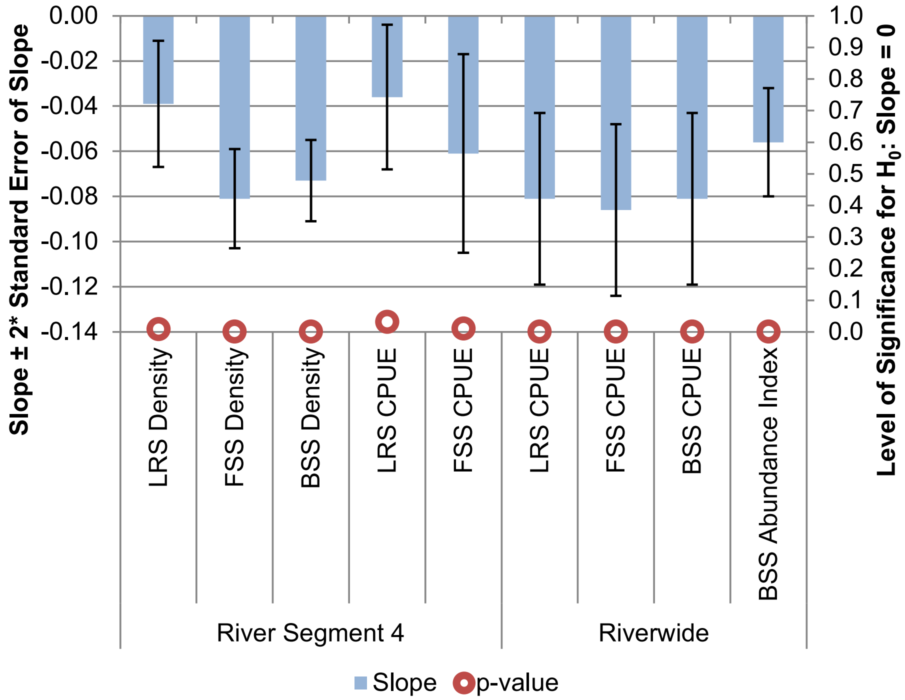


Figure C2. Atlantic Tomcod Estimated Slope (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance

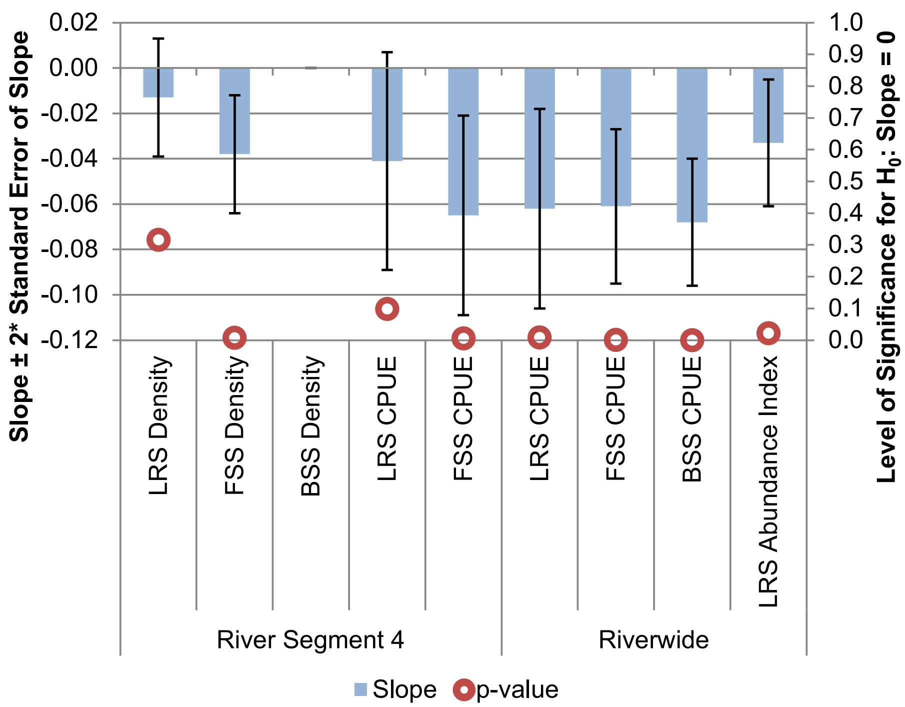


Figure D2. Bay Anchovy Estimated Slope (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance

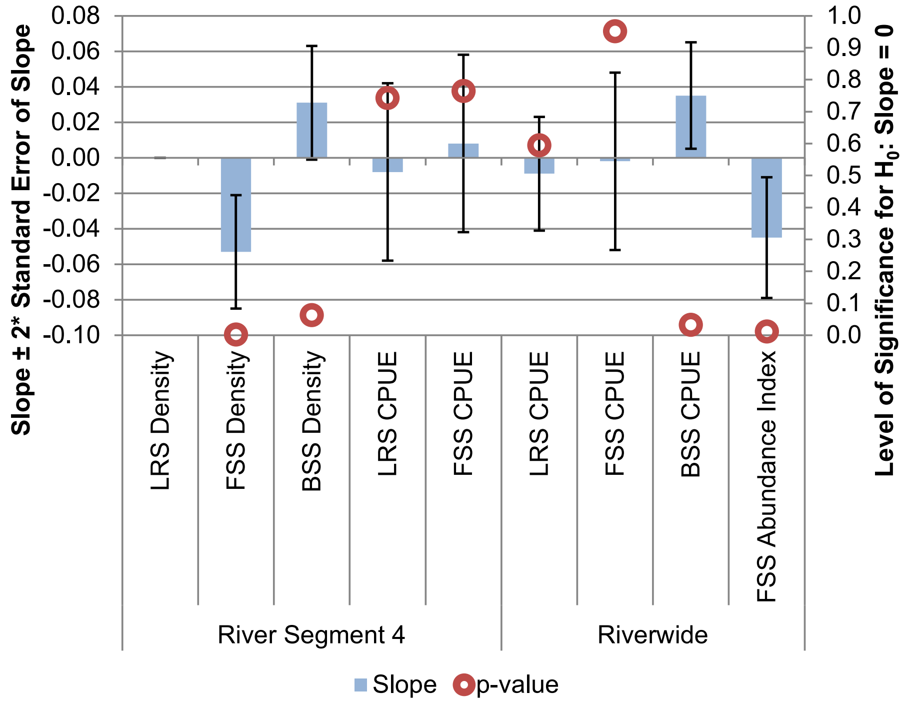


Figure E2. Blueback Herring Estimated Slope (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance

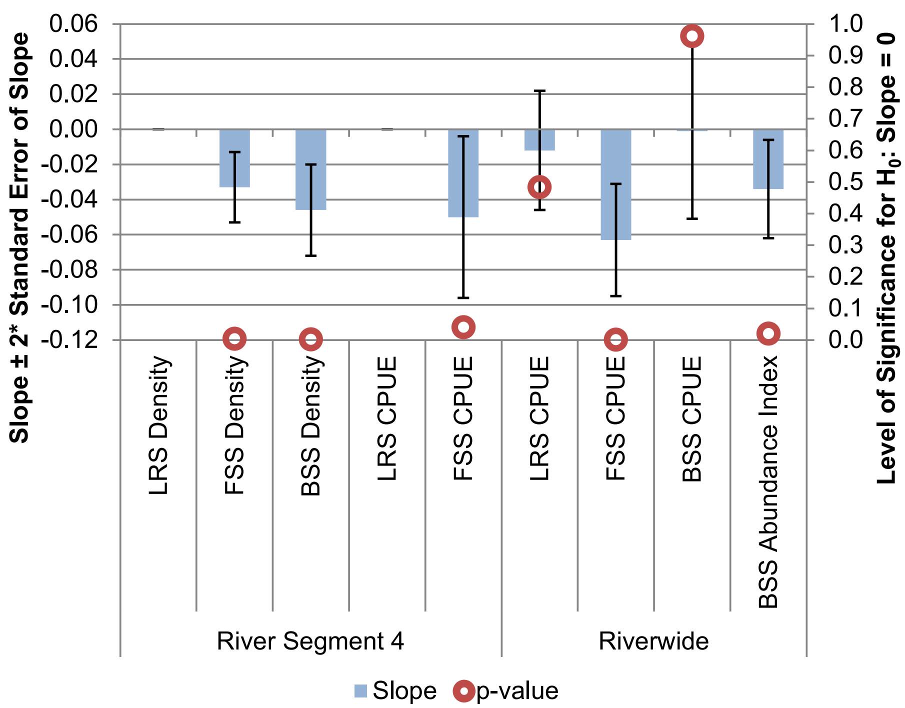


Figure F2. Bluefish Estimated Slope (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance

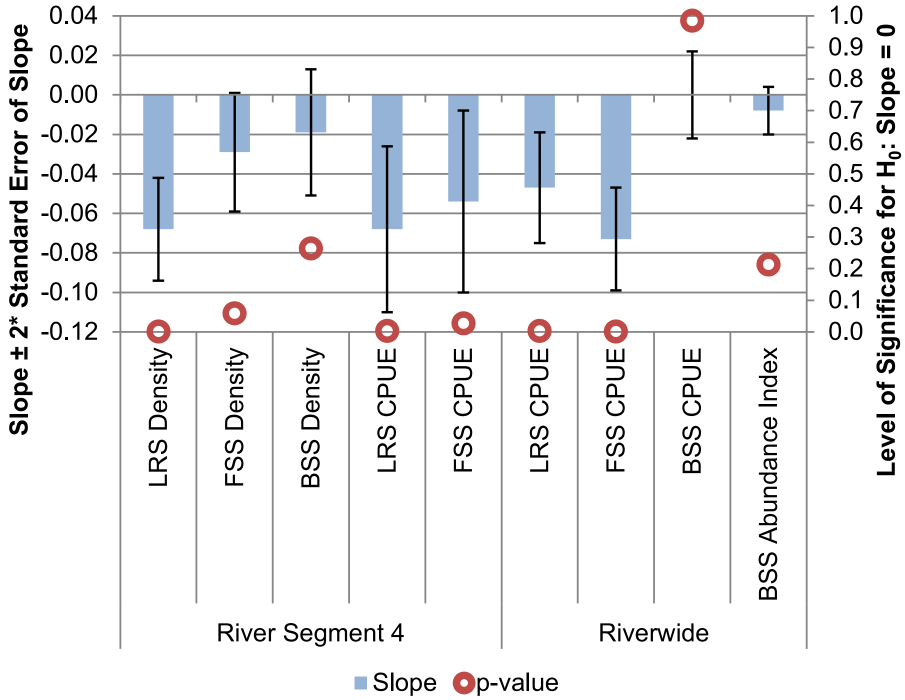
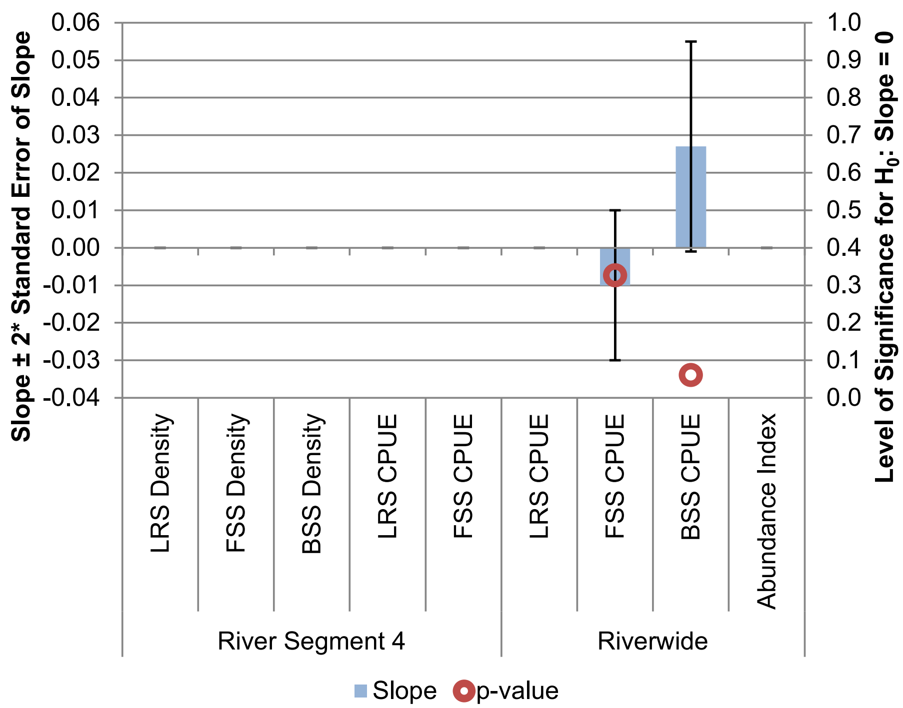
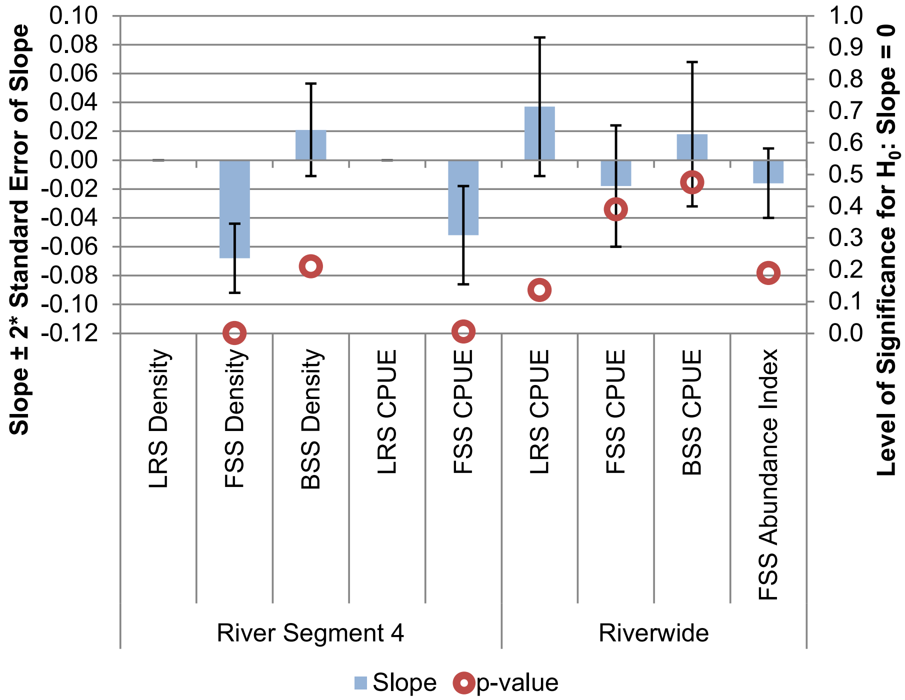


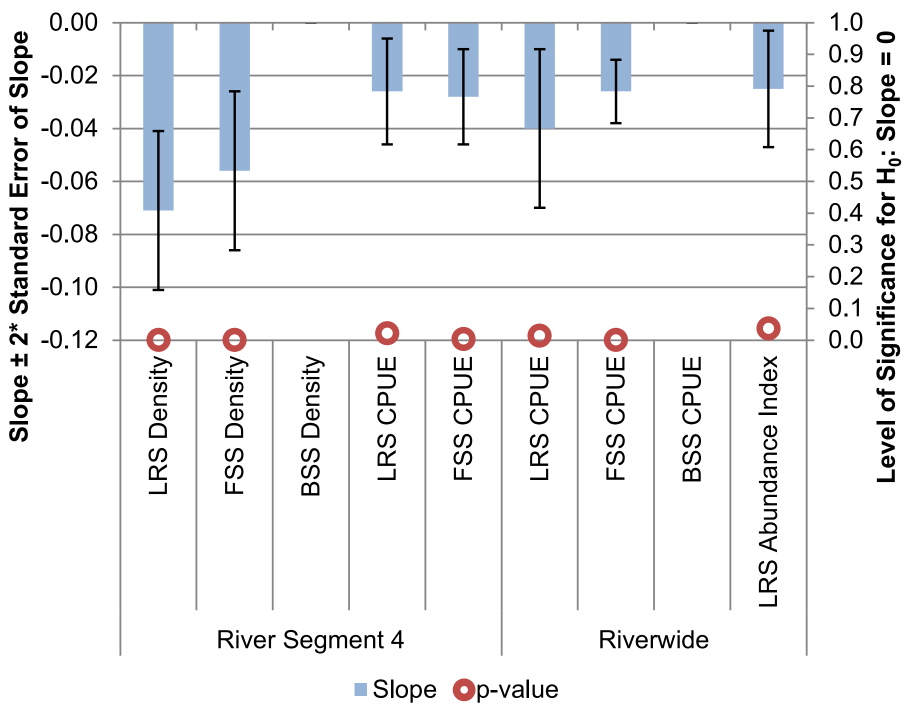
Figure G2. Gizzard Shad Estimated Slope (Blue Bars with Error Bars) and the P-Values for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance



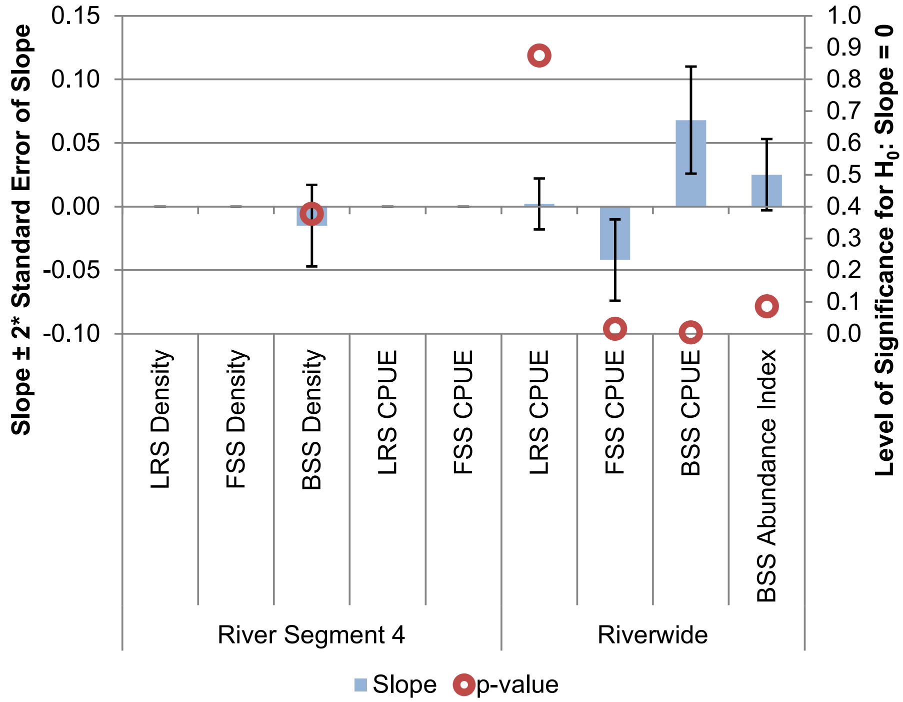
1 **Figure H2. Hogchoker Estimated Slope (Blue Bars with Error Bars) and the P-Values for**
2 **the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance**



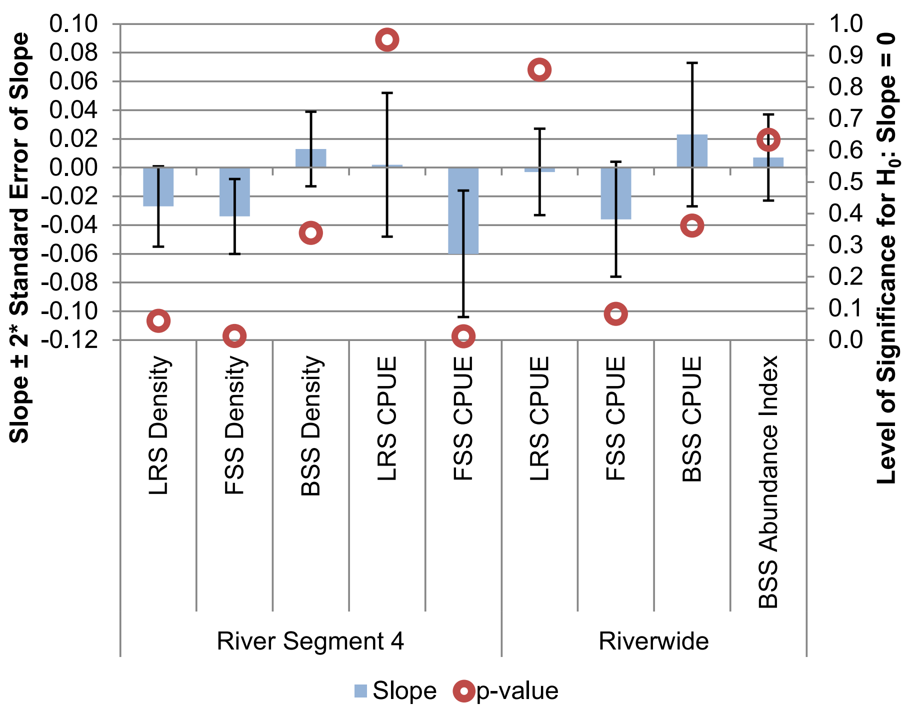
3 **Figure I2. Rainbow Smelt Estimated Slope (Blue Bars with Error Bars) and the P-Values**
4 **for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance**



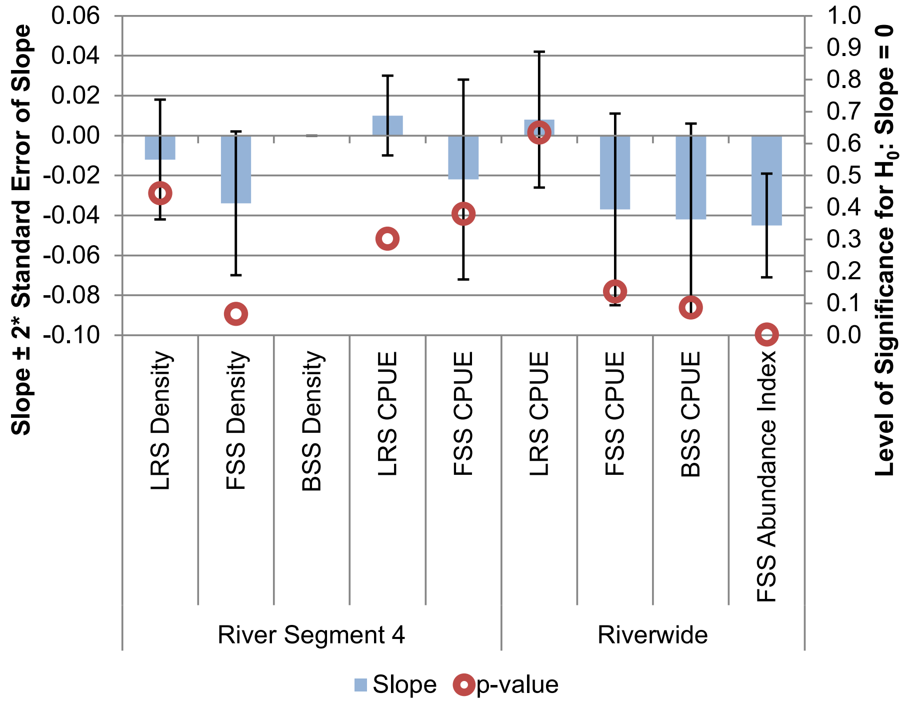
1 **Figure J2. Spottail Shiner Estimated Slope (Blue Bars with Error Bars) and the P-Values**
2 **for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance**



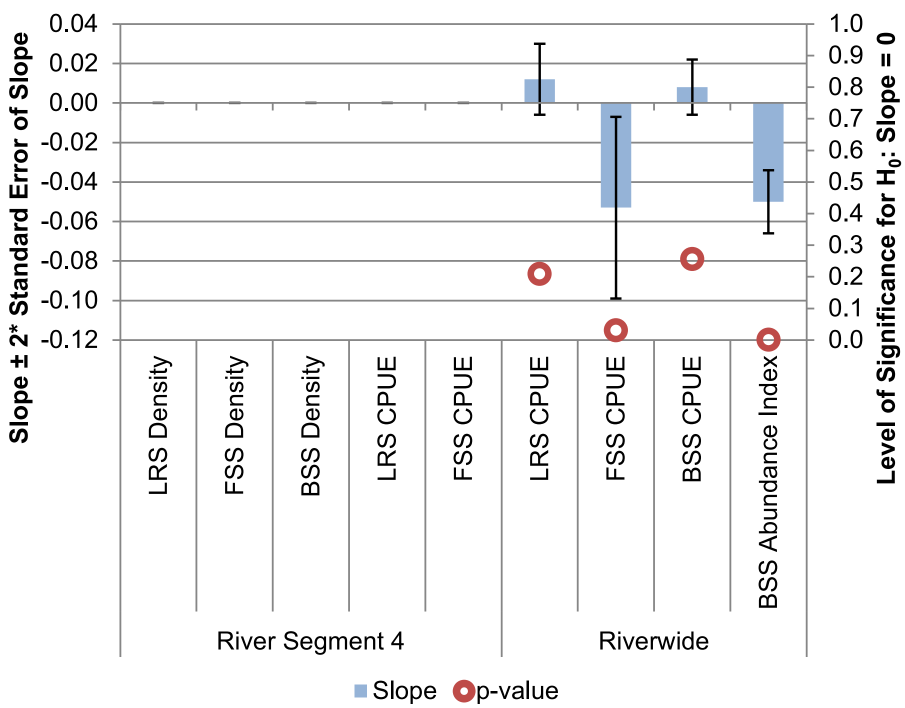
3 **Figure K2. Striped Bass Estimated Slope (Blue Bars with Error Bars) and the P-Values for**
4 **the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance**



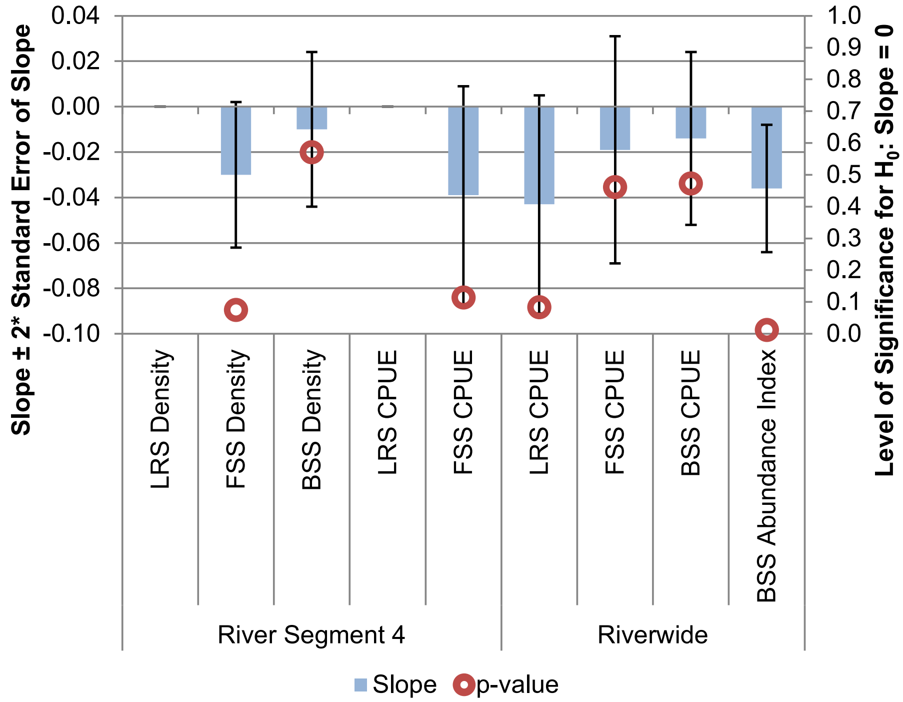
1 **Figure L2. Weakfish Estimated Slope (Blue Bars with Error Bars) and the P-Values for the**
2 **Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance**



3 **Figure M2. White Catfish Estimated Slope (Blue Bars with Error Bars) and the P-Values**
4 **for the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance**



1 **Figure N2. White Perch Estimated Slope (Blue Bars with Error Bars) and the P-Values for**
2 **the Test of Zero Slope (Red Thick Circles) for Each Measure of Abundance**



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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, 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) andin accordance with the requirements in 10 CFR 51.23(b), this supplement incorporates the impact determinations of NUREG–2157, Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel provides an update on the status of the operating licenses for Indian Point Nuclear Generating Unit Nos. 2 and 3.

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