U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

NUREG-1437, Vol. 1
Supplement 38

Generic Environmental Impact Statement for License Renewal of Nuclear Plants

Supplement 38

Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3

Draft Report for Comment Main Report

Office of Nuclear Reactor Regulation

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Main Report

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Any interested party may submit comments on this report for consideration by the NRC staff. Comments may be accompanied by additional relevant information or supporting data. Please specify the report number NUREG-1437, Supplement 38, draft, in your comments, and send them by March 11, 2009, to the following address:

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ABSTRACT

The U.S. Nuclear Regulatory Commission (NRC) considered the environmental impacts of renewing nuclear power plant operating licenses for a 20-year period in NUREG-1437, Volumes 1 and 2, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants" (hereafter referred to as the GEIS),[1] and codified the results in Title 10, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," of the *Code of Federal Regulations* (10 CFR Part 51). In the GEIS (and its Addendum 1), the NRC staff identified 92 environmental issues and reached generic conclusions related to environmental impacts for 69 of these issues that apply to all plants or to plants with specific design or site characteristics. Additional plant-specific review is required for the remaining 23 issues. These plant-specific reviews are to be included in a supplement to the GEIS.

This supplemental environmental impact statement (SEIS) has been prepared in response to an application submitted by Entergy Nuclear Operations, Inc. (Entergy), Entergy Nuclear Indian Point 2, LLC, and Entergy Nuclear Indian Point 3, LLC (all applicants will be jointly referred to as Entergy) to the NRC to renew the operating licenses for Indian Point Nuclear Generating Unit Nos. 2 and 3 (IP2 and IP3) for an additional 20 years under 10 CFR Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants." This draft SEIS includes the NRC staff's analysis which considers and weighs the environmental impacts of the proposed action, the environmental impacts of alternatives to the proposed action, and mitigation measures available for reducing or avoiding adverse impacts. It also includes the NRC staff's preliminary recommendation regarding the proposed action.

Regarding the 69 issues for which the GEIS reached generic conclusions, neither Entergy nor the NRC staff has identified information that is both new and significant for any issues that apply to IP2 and/or IP3. In addition, the NRC staff determined that information provided during the scoping process was not new and significant with respect to the conclusions in the GEIS. Therefore, the NRC staff concludes that the impacts of renewing the operating licenses for IP2 and IP3 will not be greater than the impacts identified for these issues in the GEIS. For each of these issues, the NRC staff's conclusion in the GEIS is that the impact is of SMALL[2] significance (except for the collective offsite radiological impacts from the fuel cycle and high-level waste and spent fuel, which were not assigned a single significance level).

Regarding the remaining 23 issues, those that apply to IP2 and IP3 are addressed in this draft SEIS. The NRC staff determined that several of these issues were not applicable because of the type of facility cooling system or other reasons detailed within this SEIS. For the remaining applicable issues, the NRC staff concludes that the significance of potential environmental impacts related to operating license renewal is SMALL, with four exceptions—entrainment, impingement, heat shock from the facility's heated discharge, and impacts to aquatic endangered species. Overall effects from entrainment and impingement may be SMALL to

(1) The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the "GEIS" include the GEIS and its Addendum 1.

(2) Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.

LARGE, depending on the species affected. Impacts from heat shock likely range from SMALL to MODERATE depending on the conclusions of thermal studies proposed by the New York State Department of Environmental Conservation (NYSDEC). NRC staff did not find data that suggest the effect of heat shock is likely to rise to LARGE. Given the uncertainties in the data NRC staff reviewed, impacts to the endangered shortnose sturgeon could range from SMALL to LARGE.

The NRC staff's preliminary recommendation is that the Commission determine that the adverse environmental impacts of license renewals for IP2 and IP3 are not so great that preserving the option of license renewal for energy planning decisionmakers would be unreasonable. This recommendation is based on (1) the analysis and findings in the GEIS, (2) the environmental report submitted by Entergy, (3) consultation with other Federal, State, and local agencies; (4) the NRC staff's own independent review, and (5) the NRC staff's consideration of public comments received during the scoping process.

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EXECUTIVE SUMMARY

By letter dated April 30, 2007, Entergy Nuclear Operations, Inc. (Entergy) submitted an application to the U.S. Nuclear Regulatory Commission (NRC) to renew the operating licenses for Indian Point Nuclear Generating Unit Nos. 2 and 3 (IP2 and IP3) for an additional 20-year period. If the operating licenses are renewed, State regulatory agencies and Entergy will ultimately decide whether the plant will continue to operate based on factors such as the need for power, issues falling under the purview of the owners, or other 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. If the operating licenses are not renewed, then IP2 and IP3 must be shut down at or before the expiration date of their current operating licenses which expire September 28, 2013, and December 12, 2015, respectively.

The NRC has implemented Section 102 of the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321), in Title 10, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," of the *Code of Federal Regulations* (10 CFR Part 51). In 10 CFR 51.20(b)(2), the Commission requires preparation of an environmental impact statement (EIS) or a supplement to an EIS for renewal of a reactor operating license. In addition, 10 CFR 51.95(c) states that the EIS prepared at the operating license renewal stage will be a supplement to NUREG-1437, Volumes 1 and 2, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants" (hereafter referred to as the GEIS).(1)

Upon acceptance of the IP2 and IP3 application, the NRC began the environmental review process described in 10 CFR Part 51 by publishing a notice of intent to prepare an EIS and conduct scoping. The NRC staff visited the IP2 and IP3 site in September 2007, held two public scoping meetings on September 19, 2007, and conducted two site audits on September 10–14, 2007, and September 24–27, 2007. In the preparation of this draft supplemental environmental impact statement (SEIS) for IP2 and IP3, the NRC staff reviewed the IP2 and IP3 environmental report (ER) and compared it to the GEIS, consulted with other agencies, conducted an independent review of the issues following the guidance in NUREG-1555, "Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal," issued October 1999, and considered the public comments received during the scoping process. The public comments received during the scoping process that were considered to be within the scope of the environmental review are contained in the Scoping Summary Report for Indian Point Nuclear Generating Unit Nos. 2 and 3, issued by NRC staff in December, 2008. In Appendix A of this SEIS, the NRC staff adopt, by reference, the comments and responses in the Scoping Summary Report and provide information on how to electronically access the scoping summary or view a hard copy.

The NRC staff will hold public meetings in Cortlandt Manor, New York, in February 2009 to describe the preliminary results of the NRC environmental review, to answer questions, and to provide members of the public with information to assist them in formulating comments on this

(1) The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the "GEIS" include the GEIS and its Addendum 1.

draft SEIS. When the comment period ends, the NRC staff will consider and address all of the comments received. These comments will be addressed in Appendix A, Part 2, to the final SEIS.

This draft SEIS includes the NRC staff's preliminary analysis that considers and weighs the environmental effects of the proposed action, the environmental impacts of alternatives to the proposed action, and mitigation measures for reducing or avoiding adverse effects. It also includes the NRC staff's preliminary recommendation regarding the proposed action.

The Commission has adopted the following statement of purpose and need for license renewal from the GEIS:

> 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) decisionmakers.

The purpose of the NRC staff's environmental review, as defined in 10 CFR 51.95(c)(4) and the GEIS, is to determine the following:

> …whether or not the adverse environmental impacts of license renewal are so great that preserving the option of license renewal for energy planning decisionmakers would be unreasonable.

Both the statement of purpose and need and the evaluation criterion implicitly acknowledge that there are factors, in addition to license renewal, that will ultimately determine whether an existing nuclear power plant continues to operate beyond the period of the current operating license (or licenses).

NRC regulations (10 CFR 51.95(c)(2)) contain the following statement regarding the content of SEISs prepared at the license renewal stage:

> The supplemental environmental impact statement for license renewal is not required to include discussion of need for power or the economic costs and economic benefits of the proposed action or of alternatives to the proposed action except insofar as such benefits and costs are either essential for a determination regarding the inclusion of an alternative in the range of alternatives considered or relevant to mitigation. In addition, the supplemental environmental impact statement prepared at the license renewal stage need not discuss other issues not related to the environmental effects of the proposed action and the alternatives, or any aspect of the storage of spent fuel for the facility within the scope of the generic determination in 10 CFR 51.23(a) ["Temporary storage of spent fuel after cessation of reactor operation–generic determination of no significant environmental impact"] and in accordance with 10 CFR 51.23(b).

The GEIS contains the results of a systematic evaluation of the consequences of renewing an operating license and operating a nuclear power plant for an additional 20 years. It evaluates 92 environmental issues using the NRC's three-level standard of significance—SMALL, MODERATE, or LARGE—developed using the Council on Environmental Quality guidelines.

The following definitions of the three significance levels are set forth in footnotes to Table B-1 of

Appendix B, “Environmental Effect of Renewing the Operating License of a Nuclear Power Plant,” to 10 CFR Part 51, Subpart A, “National Environmental Policy Act—Regulations Implementing Section 102(2)”:

> 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, important attributes of the resource.
>
> LARGE—Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

For 69 of the 92 issues considered in the GEIS, the analysis in the GEIS reached the following conclusions:

(1) The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristics.

(2) A single significance level (that is, SMALL, MODERATE, or LARGE) has been assigned to the impacts (except for collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal).

(3) Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant-specific mitigation measures are not likely to be sufficiently beneficial to warrant implementation.

These 69 issues were identified in the GEIS as Category 1 issues. In the absence of new and significant information, the staff relied on conclusions in the GEIS for issues designated as Category 1 in Table B-1 of Appendix B to 10 CFR Part 51, Subpart A.

Of the 23 issues that do not meet the criteria set forth above, 21 are classified as Category 2 issues requiring analysis in a plant-specific supplement to the GEIS. The remaining two issues, environmental justice and chronic effects of electromagnetic fields, were not categorized. Environmental justice was not evaluated on a generic basis and must be addressed in a plant-specific supplement to the GEIS. Information on the chronic effects of electromagnetic fields was not conclusive at the time the GEIS was prepared.

This draft SEIS documents the NRC staff’s consideration of all 92 environmental issues identified in the GEIS. The NRC staff considered the environmental impacts associated with alternatives to license renewal and compared the environmental impacts of license renewal and the alternatives. The alternatives to license renewal that were considered include the no-action alternative (not renewing the operating licenses for IP2 and IP3), alternative methods of power generation, and conservation. The NRC staff also considered two alternatives that included continued operation of IP2 and IP3 with either a closed-cycle cooling system, or a combination of intake modifications and habitat restoration projects that may achieve similar effects on aquatic organisms as closed cycle cooling because the New York State Department of Environmental Conservation (NYSDEC) issued a preliminary determination, in its 2003 draft State Pollutant Discharge Elimination System (SPDES) permit that closed cycle cooling is the site-specific best technology available to reduce impacts on fish and shellfish. NYSDEC’s 2003 draft SPDES permit indicated that Entergy could propose another alternative that would have

similar effects on aquatic species. The 2003 SPDES permit is currently subject to adjudication and has not gone into effect.

Entergy and the NRC staff have established independent processes for identifying and evaluating the significance of any new information on the environmental impacts of license renewal. Neither Entergy nor the staff has identified information that is both new and significant related to Category 1 issues that would call into question the conclusions in the GEIS. Similarly, neither the scoping process nor the NRC staff has identified any new issue applicable to IP2 and IP3 that has a significant environmental impact. Therefore, the NRC staff relies on the conclusions of the GEIS for all of the Category 1 issues that are applicable to IP2 and IP3.

Entergy's license renewal application presents an analysis of the 21 Category 2 issues that are applicable to IP2 and IP3, plus environmental justice and chronic effects from electromagnetic fields, for a total of 23 issues. The NRC staff has reviewed the Entergy analysis and has conducted an independent review of each issue. Six of the Category 2 issues are not applicable because they are related to the type of existing cooling system, water use conflicts, and ground water use not found at IP2 and IP3. Entergy has stated that its evaluation of structures and components, as required by 10 CFR 54.21, "Contents of Application—Technical Information," did not identify any major plant refurbishment activities or modifications as necessary to support the continued operation of IP2 and IP3 for the license renewal period. Entergy did, however, indicate that it may replace reactor vessel heads and control rod drive mechanisms at IP2 and IP3, though it has no firm plans to do so at this time. The NRC staff has evaluated the potential impacts of these activities using the framework provided by the GEIS for addressing refurbishment issues.

Seventeen environmental issues related to operational impacts and postulated accidents during the renewal term are discussed in detail in this draft SEIS. These include 15 Category 2 issues and two uncategorized issues, environmental justice and chronic effects of electromagnetic fields. The NRC staff also discusses in detail the potential impacts related to the 10 Category 2 issues that apply to refurbishment activities. The NRC staff concludes that the potential environmental effects for most of these issues are of SMALL significance in the context of the standards set forth in the GEIS with four exceptions—entrainment, impingement, heat shock from the facility's heated discharge, and impacts to aquatic endangered species. The NRC staff jointly assessed the impacts of entrainment and impingement to range from SMALL to LARGE (depending on species affected), based on NRC's analysis of representative important species. Impacts from heat shock likely range from SMALL to MODERATE depending on the conclusions of thermal studies proposed by the New York State Department of Environmental Conservation (NYSDEC). NRC staff did not find data that suggest the effect of heat shock is likely to rise to LARGE. Given the uncertainties in the data NRC staff reviewed, impacts to the endangered shortnose sturgeon could range from SMALL to LARGE. The NRC staff considered mitigation measures for each applicable Category 2 issue.

The NRC staff also determined that appropriate Federal health agencies have not reached a consensus on the existence of chronic adverse effects from electromagnetic fields. Therefore, no further evaluation of this issue is required.

For severe accident mitigation alternatives (SAMAs), the staff concludes that a reasonable, comprehensive effort was made to identify and evaluate SAMAs. Based on its review of the SAMAs for IP2 and IP3 and the plant improvements already made, the NRC staff concludes that

several SAMAs may be cost-beneficial. However, these SAMAs do not relate to adequate management of the effects of aging during the period of extended operation. Therefore, they do not need to be implemented as part of the license renewal pursuant to 10 CFR Part 54, “Requirements for Renewal of Operating Licenses for Nuclear Power Plants.”

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. For purposes of this analysis, the NRC staff determined that the cumulative impacts to terrestrial and aquatic resources in the IP2 and IP3 environs would be LARGE, due primarily to past development and pollution, much of which preceded IP2 and IP3 or occurred as a result of other actions (for example, suburban development and hardening of the Hudson River shoreline).

NRC analysis indicates that the adverse impacts of likely alternatives will differ from those of the proposed action. Most alternatives result in smaller impacts to aquatic life, while creating greater impacts in other resource areas. Often, the most significant environmental impacts of alternatives result from constructing new facilities or infrastructure.

The preliminary recommendation of the NRC staff is that the Commission determine that the adverse environmental impacts of license renewals for IP2 and IP3 are not so great that not preserving the option of license renewal for energy planning decisionmakers would be unreasonable. This recommendation is based on (1) the analysis and findings in the GEIS, (2) the ER submitted by Entergy, (3) consultation with other Federal, State, and local agencies, (4) the staff’s own independent review, and (5) the staff’s consideration of public comments received during the scoping process.

ABBREVIATIONS/ACRONYMS

°	degree(s)
µm	micron(s)
ac	acre(s)
AC	alternating current
ACC	averted cleanup and decontamination
ACEEE	American Council for an Energy Efficient Economy
AEC	Atomic Energy Commission
AFW	auxiliary feed water
AGTC	Algonquin Gas Transmission Company
ALARA	as low as reasonably achievable
ANOVA	analysis of variance
AOC	averted off-site property damage costs
AOE	averted occupational exposure costs
AOSC	averted on-site costs
APE	averted public exposure
ASME	American Society of Mechanical Engineers
ASMFC	Atlantic States Marine Fisheries Commission
ASSS	alternate safe shutdown system
ATWS	anticipated transient without scram
AUTOSAM	Automated Abundance Sampler
BA	biological assessment
Bq/L	bequerel per liter
Bq/kg	bequerel per kilogram
BSS	Beach Seine Survey
BTA	best technology available
BTU	British thermal unit(s)
C	Celsius
CAA	Clean Air Act
CAFTA	computer aided fault-tree analysis code
CAMR	Clean Air Mercury Rule
CCF	common cause failure
CCMP	Comprehensive Conservation and Management Plan
CCW	component cooling water
CDF	core damage frequency
CDM	Clean Development Mechanism
CET	Containment Event Tree
CEQ	Council on Environmental Quality
CFR	*Code of Federal Regulations*
cfs	cubic foot (feet) per second
CHGEC	Central Hudson Gas & Electric Corporation
Ci	curie(s)
cm	centimeter(s)

CMR	conditional mortality rate
CNP	Cook Nuclear Plant
CO	carbon monoxide
CO_2	carbon dioxide
COE	cost of enhancement
COL	Combined License
Con Edison	Consolidated Edison Company of New York
CORMIX	Cornell University Mixing Zone Model
CPUE	catch-per-unit-effort
CST	condensate storage tank
CSET	Containment Safeguards for Event Tree
cu ft	cubic feet
CV	coefficient of variation
CVCS	Chemical and Volume Control System
CWA	Clean Water Act
CWIS	Circulating Water Intake System
CWS	Circulating Water System
CWSH	Circulating Water Screenhouse
cy	cubic yards
CZMA	Coastal Zone Management Act
dB(A)	decibel(s)
DBA	Design-basis accident
DC	direct current
DEIS	Draft Environmental Impact Statement
DNA	deoxyribonucleic acid
DO	dissolved oxygen
DOC	dissolved organic carbon
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DPS	distinct population segment
DSM	demand-side management
DWR	Division of Water Resources
ECL	Environmental Conservation Law
EDG	emergency diesel generator
EIA	Energy Information Administration
EIS	environmental impact statement
ELF-EMF	extremely low frequency-electromagnetic field
Enercon	Enercon Services, Inc.
Entergy	Entergy Nuclear Operations, Inc.
EO	Executive Order
EOP	emergency operating procedure
EPA	U.S. Environmental Protection Agency
EPACT2005	Energy Policy Act of 2005
EPRI	Electric Power Research Institute
ER	Environmental Report

ER-M	effects-range-median
ERS	Environmental Radiation Surveillance
ESA	Endangered Species Act
ESP	Early Site Permit
ESWS	Essential Service Water System
F	Fahrenheit
F&O	Facts and Observations
FAA	Federal Aviation Administration
FDA	Food and Drug Administration
FEIS	Final Environmental Impact Statement
FERC	Federal Energy Regulatory Commission
FES	Final Environmental Statement
FFTM	far field thermal model
FIVE	fire-induced vulnerability evaluation
FJS	Fall Juvenile Survey
F_{MSY}	fishing mortality rate that can produce the maximum sustainable yield
FPC	Federal Power Commission
fps	feet per second
FPS	fire protection system
FR	*Federal Register*
FSAR	Final Safety Analysis Report
FSS	Fall Shoals Survey
ft	foot (feet)
ft^2	square feet
ft^3	cubic feet
ft/mi	feet per mile
FWS	U.S. Fish and Wildlife Service
g	gram(s)
gCeq/kWh	gram(s) of carbon dioxide equivalents per kilowatt-hour
GEIS	*Generic Environmental Impact Statement for License Renewal of Nuclear Plants, NUREG-1437*
GHG	greenhouse gas
GL	Generic Letter
gpm	gallon(s) per minute
GW	gigawatt
HAP	hazardous air pollutant
HCLPF	high confidence of low probability of failure
HEPA	high efficiency particulate air
HLW	high-level waste
hr	hour(s)
HRA	Human Reliability Analysis
HRERF	Hudson River Estuary Restoration Fund
HRF	Hudson River Foundation
HRFI	Hudson River Fisheries Investigation

HRIF	Hudson River Improvement Fund
HRPC	Hudson River Policy Committee
HRSA	Hudson River Settlement Agreement
HVAC	heating, ventilation, and air conditioning
Hz	hertz
in.	inch(es)
INEEL	Idaho National Energy and Environmental Laboratory
IP1	Indian Point Nuclear Generating Unit No. 1
IP2	Indian Point Nuclear Generating Unit No. 2
IP3	Indian Point Nuclear Generating Unit No. 3
IPE	individual plant examination
IPEE	individual plant examination of external events
ISFSI	Independent Fuel Storage Installation
ISLOCA	Interfacing Systems Loss of Coolant Accidents
IWSA	Integrated Waste Services Association
kg	kilogram(s)
kg/yr	kilograms per year
km	kilometer(s)
km^2	square kilometer(s)
kV	kilovolt(s)
kW	kilowatt
kWh	kilowatt hour(s)
lbs	pounds
L	liter(s)
LERF	Large Early Release Frequency
LLMW	low-level mixed waste
LOCA	loss of coolant accident
LOE	Line(s) of Evidence
LOS	level of service
lpm	liters per minute
LPSI	low pressure safety injection
LRS	Long River Survey
LSE	load serving entities
m	meter(s)
mm	millimeter(s)
m^2	square meter(s)
m^3	cubic meter(s)
m^3/sec	cubic meter(s) per second
mA	milliampere(s)
MAAP	Modular Accident Analysis Program
MACCS2	MELCOR Accident Consequence Code System 2
MBq	megabequerel
MCL	maximum contaminant level

MDS	Minimum Desirable Streamflow
mg	milligram(s)
mgd	million gallons per day
mg/L	milligram(s) per liter
mGy	milligray
mi	mile(s)
min	minute(s)
MIT	Massachusetts Institute of Technology
mL	milliliter(s)
MMACR	Modified Maximum Averted Cost-Risk
MMBtu	million British thermal unit(s)
mov	motor-operated valve
mph	miles per hour
mps	meter(s) per second
mrad	millirad(s)
mrem	millirem(s)
MSE	mean squared error
MSL	mean sea level
MSPI	Mitigating Systems Performance Indicator
mSv	millisievert
MT	metric ton(s)
MTU	metric ton of uranium
MUDS	Makeup Discharge Structure
MUSH	Makeup Water Screen House
MW	megawatt
MWd	megawatt-days
MW(e)	megawatt(s) electric
MW(h)	megawatt hour(s)
MW(t)	megawatt(s) thermal
MWSF	Mixed Waste Storage Facility

NAAQS	National Ambient Air Quality Standards
NAS	National Academy of Sciences
NCP	normal charging pump
NEPA	National Environmental Policy Act of 1969, as amended
NESC	National Electric Safety Code
NGVD	National Geodetic Vertical Datum
NHPA	National Historic Preservation Act
NIEHS	National Institute of Environmental Health Sciences
NMFS	National Marine Fisheries Service
NJDEP	New Jersey Department of Environmental Protection
NJPDES	New Jersey Pollutant Discharge Elimination System
NO_2	nitrogen dioxide
NO_x	nitrogen oxide(s)
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission

NRDC	Natural Resource Defense Council
NRHP	National Register of Historic Places
NSPS	New Source Performance Standards
NSSS	nuclear steam supply system
NWJWW	Northern Westchester Joint Water Works
NY/NJ/PHL	New York/New Jersey/Philadelphia
NYCA	New York Control Area
NYCDEP	New York City Department of Environmental Protection
NYCEF	New York City Environmental Fund
NYCRR	New York Code of Rules and Regulations
NYISO	New York Independent System Operator
NYNHP	New York Natural Heritage Program
NYPA	New York Power Authority
NYPSC	New York Public Service Commission
NYRI	New York Regional Interconnect, Inc.
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSERDA	New York State Energy Research and Development Authority
NYSHPO	New York State Historic Preservation Office
O_3	ozone 8-hour standard
OCNGS	Oyster Creek Nuclear Generating Station
ODCM	Offsite Dose Calculation Manual
OL	operating license
PAB	primary auxiliary building
PAH	polycyclic aromatic hydrocarbon
PAYS	Pay as You Save
PCB	polychlorinated biphenyls
pCi/L	picoCuries per liter
pCi/kg	picoCuries per kilogram
PDS	plant damage state
PILOT	payment-in-lieu-of-taxes
$PM_{2.5}$	particulate matter, 2.5 microns or less in diameter
PM_{10}	particulate matter, 10 microns or less in diameter
POC	particulate organic carbon
PORV	power operated relief valve
POTW	publicly owned treatment works
ppm	parts per million
ppt	parts per thousand
PRA	probabilistic risk assessment
PSA	probabilistic safety assessment
PSD	Prevention of Significant Deterioration
PV	photovoltaic
PWR	pressurized water reactor
PWW	Poughkeepsie Water Works
PYSL	post yolk-sac larvae

REMP	Radiological Environmental Monitoring Program
R-EMP	regional environmental monitoring and assessment program
radwaste	radioactive waste
RAI	request for additional information
RCP	reactor coolant pump
RCRA	Resource Conservation and Recovery Act
RCS	reactor cooling system
REMP	radiological environmental monitoring program
RHR	residual heat removal
Riverkeeper	Hudson River Fishermen's Association
RIS	Representative Important Species
RKM	river kilometer(s)
RLE	review level earthquake
RM	river mile(s)
RMP	Risk Management Plan
ROD	Record of Decision
ROI	region of influence
ROW	right-of-way
RPC	long-term replacement power costs
rpm	revolutions per minute
RRW	risk reduction worth
RWST	refueling water storage tank

s	second(s)
SAFSTOR	safe storage condition
SAMA	severe accident mitigation alternative
SAR	Safety Analysis Report
SAV	submerged aquatic vegetation
SBO	station blackout
Scenic Hudson	Scenic Hudson Preservation Conference
SCR	selective catalytic reduction
SECPOP	sector population, land fraction and economic estimation program
SEIS	Supplemental Environmental Impact Statement
SER	Safety Evaluation Report
SFP	Spent Fuel Pool
SGBD	steam generator blowdown
SGTR	Steam Generator Tube Ruptures
SO_2	sulfur dioxide
SO_x	sulfur oxide(s)
SOP	standard operating procedure(s)
SPDES	State Pollutant Discharge Elimination System
SPU	stretch power update
sq mi	square mile(s)
SRP	Standard Review Plan
SSBR	spawning stock biomass per-recruit
SSE	safe shutdown earthquake

Sv	person-sievert
SWS	service water system
T	temperature
TD	turbine driven
TDS	total dissolved solids
TI-SGTR	thermally-induced Steam Generator Tube Ruptures
TL	total length
TLD	Thermoluminescent dosimeter
TMDL	Total Maximum Daily Load
TOC	total organic carbon
TRC	TRC Environmental Corporation
UHS	ultimate heat sink
U.S.	United States
USACE	U.S. Army Corps of Engineers
USCB	U.S. Census Bureau
USD	Unified School District
USGS	U.S. Geological Survey
UWNY	United Water New York
V	volt(s)
VALNF	value of non-farm wealth
VOC	volatile organic compound
WET	whole effluent toxicity
WJWW	Westchester Joint Water Works
WOE	weight of evidence
WOG	Westinghouse Owner's Group
YSL	yolk-sac larvae
YOY	young of year
yr	year(s)

1.0 INTRODUCTION

Under the U.S. Nuclear Regulatory Commission's (NRC's) environmental protection regulations in Title 10, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," of the *Code of Federal Regulations* (10 CFR Part 51), which implement the National Environmental Policy Act of 1969, as amended (NEPA), renewal of a nuclear power plant operating license requires the preparation of an environmental impact statement (EIS). In preparing the EIS, the NRC staff is required first to issue the statement in draft form for public comment and then to issue a final statement after considering public comments on the draft. To support the preparation of the EIS, the NRC staff prepared NUREG-1437, Volumes 1 and 2, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants" (hereafter referred to as the GEIS) (NRC 1996, 1999).[1] The GEIS is intended to (1) provide an understanding of the types and severity of environmental impacts that may occur as a result of license renewal of nuclear power plants under 10 CFR Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants," (2) identify and assess the impacts that are expected to be generic to license renewal, and (3) support 10 CFR Part 51 by defining the number and scope of issues that need to be addressed by the applicants in plant-by-plant renewal proceedings. Use of the GEIS guides the preparation of complete plant-specific information in support of the operating license renewal process.

Entergy Nuclear Indian Point 2, LLC, and Entergy Nuclear Indian Point 3, LLC, operate the Indian Point Nuclear Generating Unit Nos. 2 and 3 (IP2 and IP3) nuclear power reactors, respectively, as indirect wholly owned subsidiaries of Entergy Corporation and indirect wholly owned subsidiaries of Entergy Nuclear Operations, Inc. (Entergy). IP2 and IP3 are located in Buchanan, New York.

IP2 has operated under operating license DPR-26, which was issued by the NRC, since August 1974. The IP2 operating license will expire on September 28, 2013. IP3 has operated under operating license DPR-64, which was issued by the NRC, since August 1976. The IP3 operating license will expire on December 12, 2015. Unit No. 1 (IP1) was shut down in 1974.

Entergy, Entergy Nuclear Indian Point 2, LLC, and Entergy Nuclear Indian Point 3, LLC, are joint applicants for the renewal of the operating licenses (the joint applicants will be referred to as Entergy). Entergy submitted an application to the NRC to renew the IP2 and IP3 operating licenses for an additional 20 years each under 10 CFR Part 54 on April 30, 2007 (Entergy 2007a). Pursuant to 10 CFR 54.23, "Contents of Application—Environmental Information," and 10 CFR 51.53(c), Entergy submitted an environmental report (ER) (Entergy 2007b) as part of the license renewal application in which Entergy analyzed the environmental impacts associated with the proposed license renewal action, considered alternatives to the proposed action, and evaluated mitigation measures for reducing adverse environmental effects. Entergy submitted supplemental information clarifying operating licenses and applicant names in a letter on May 3, 2007 (Entergy 2007c).

This report is the draft facility-specific supplement to the GEIS (the supplemental EIS (SEIS)) for the Entergy license renewal application. This draft SEIS is a supplement to the GEIS because it

(1) The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the "GEIS" include the GEIS and its Addendum 1.

relies, in part, on the findings of the GEIS. The NRC staff will also prepare a separate safety evaluation report in accordance with 10 CFR Part 54.

1.1 Report Contents

The following sections of this introduction (1) describe the background for the preparation of this draft SEIS, including the development of the GEIS and the process used by the NRC staff to assess the environmental impacts associated with license renewal, (2) describe the proposed Federal action to renew the IP2 and IP3 operating licenses, (3) discuss the purpose and need for the proposed action, and (4) present the status of IP2 and IP3 compliance with environmental quality standards and requirements that have been imposed by Federal, State, regional, and local agencies that are responsible for environmental protection.

The ensuing chapters of this draft SEIS closely parallel the contents and organization of the GEIS. Chapter 2 describes the site, power plant, and interactions of the plant with the environment. Chapters 3 and 4, respectively, discuss the potential environmental impacts of plant refurbishment and plant operation during the renewal term. Chapter 5 contains an evaluation of potential environmental impacts of plant accidents and includes consideration of severe accident mitigation alternatives. Chapter 6 discusses the uranium fuel cycle and solid waste management. Chapter 7 discusses decommissioning, and Chapter 8 discusses alternatives to license renewal. Finally, Chapter 9 summarizes the findings of the preceding chapters and draws conclusions about the adverse impacts that cannot be avoided, the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and the irreversible or irretrievable commitment of resources. Chapter 9 also presents the NRC staff's preliminary recommendation with respect to the proposed license renewal action.

Additional information is included in appendices. Appendix A contains public comments related to the environmental review for license renewal and staff responses to those comments. Appendices B through G include the following:

- the preparers of the supplement (Appendix B)
- the chronology of the NRC staff's environmental review correspondence related to this draft SEIS (Appendix C)
- the organizations contacted during the development of this draft SEIS (Appendix D)
- the IP2 and IP3 compliance status in Table E-1 and copies of consultation correspondence prepared and sent during the evaluation process) (Appendix E)
- GEIS environmental issues that are not applicable to IP2 and IP3 (Appendix F)
- NRC staff evaluation of severe accident mitigation alternatives (Appendix G)

1.2 Background

Use of the GEIS, which examines the possible environmental impacts that could occur as a result of renewing individual nuclear power plant operating licenses under 10 CFR Part 54, and

the established license renewal evaluation process support the thorough evaluation of the impacts of operating license renewal.

1.2.1 Generic Environmental Impact Statement

The NRC initiated a generic assessment of the environmental impacts associated with the license renewal term to improve the efficiency of the license renewal process by documenting the assessment results and codifying the results in the Commission's regulations. This assessment is provided in the GEIS, which serves as the principal reference for all nuclear power plant license renewal EISs.

The GEIS documents the results of the systematic approach that the NRC staff used to evaluate the environmental consequences of renewing the licenses of individual nuclear power plants and operating them for an additional 20 years. For each potential environmental issue, the GEIS (1) describes the activity that affects the environment, (2) identifies the population or resource that is affected, (3) assesses the nature and magnitude of the impact on the affected population or resource, (4) characterizes the significance of both beneficial and adverse effects, (5) determines whether the results of the analysis apply to all plants, and (6) considers whether additional mitigation measures would be warranted for impacts that would have the same significance level for all plants.

The NRC's standard of significance for impacts was established using the Council on Environmental Quality (CEQ) term "significantly" (40 CFR 1508.27, which requires consideration of both "context" and "intensity"). Using the CEQ terminology, the NRC established three significance levels—SMALL, MODERATE, or LARGE. The definitions of the three significance levels are set forth in the footnotes to Table B-1 of 10 CFR Part 51, Subpart A, "National Environmental Policy Act—Regulations Implementing Section 102(2)," Appendix B, "Environmental Effect of Renewing the Operating License of a Nuclear Power Plant," as follows:

> 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, important attributes of the resource.
>
> LARGE—Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

The GEIS assigns a significance level to each environmental issue, assuming that ongoing mitigation measures would continue.

The GEIS includes a determination of whether the analysis of the environmental issue could be applied to all plants and whether additional mitigation measures would be warranted. Issues are assigned a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1 issues are those that meet all of the following criteria:

(1) The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristics.

(2) A single significance level (i.e., SMALL, MODERATE, or LARGE) has

been assigned to the impacts (except for collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal).

(3) Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

For issues that meet the three Category 1 criteria, no additional plant-specific analysis is required in this draft SEIS unless new and significant information is identified.

Category 2 issues are those that do not meet one or more of the criteria of Category 1; therefore, additional plant-specific review for these issues is required.

In the GEIS, the staff assessed 92 environmental issues and determined that 69 qualified as Category 1 issues, 21 qualified as Category 2 issues, and 2 issues were not categorized. The two issues not categorized are environmental justice and chronic effects of electromagnetic fields. Environmental justice was not evaluated on a generic basis and must be addressed in a plant-specific supplement to the GEIS. Information on the chronic effects of electromagnetic fields was not conclusive at the time the GEIS was prepared.

Of the 92 issues, 11 are related only to refurbishment, 6 are related only to decommissioning, 67 apply only to operation during the renewal term, and 8 apply to both refurbishment and operation during the renewal term. A summary of the findings for all 92 issues in the GEIS is codified in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B.

1.2.2 License Renewal Evaluation Process

An applicant seeking to renew its operating license is required to submit an ER as part of its application. The license renewal evaluation process involves careful review of the applicant's ER and assurance that all new and potentially significant information not already addressed in or available during the GEIS evaluation is identified, reviewed, and assessed to verify the environmental impacts of the proposed license renewal.

In accordance with 10 CFR 51.53(c)(2) and (3), the ER submitted by the applicant must do the following:

- provide an analysis of the Category 2 issues in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, in accordance with 10 CFR 51.53(c)(3)(ii)
- discuss actions to mitigate any adverse impacts associated with the proposed action and environmental impacts of alternatives to the proposed action

In accordance with 10 CFR 51.53(c)(2), the ER does not need to do the following:

- consider the economic benefits and costs of the proposed action and alternatives to the proposed action except insofar as such benefits and costs are either (1) essential for making a determination regarding the inclusion of an alternative in the range of alternatives considered or (2) relevant to mitigation

- consider the need for power and other issues not related to the environmental effects of the proposed action and the alternatives
- 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)
- pursuant to 10 CFR 51.23(c)(3)(iii) and (iv), contain an analysis of any Category 1 issue unless there is significant new information on a specific issue

New and significant information is (1) information that identifies a significant environmental issue not covered in the GEIS and codified in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, or (2) information that was not considered in the analyses summarized in the GEIS and that leads to an impact finding that is different from the finding presented in the GEIS and codified in 10 CFR Part 51.

In preparing to submit its application to renew the IP2 and IP3 operating licenses, Entergy developed a process to ensure that (1) information not addressed in or available during the GEIS evaluation regarding the environmental impacts of license renewal for IP2 and IP3 would be properly reviewed before submitting the ER and (2) such new and potentially significant information related to renewal of the licenses for IP2 and IP3 would be identified, reviewed, and assessed during the period of NRC review. Entergy reviewed the Category 1 issues that appear in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, to verify that the conclusions of the GEIS remain valid with respect to IP2 and IP3. This review was performed by personnel from Entergy who were familiar with NEPA issues and the scientific disciplines involved in the preparation of a license renewal ER.

The NRC staff also has a process for identifying new and significant information. That process is described in detail in NUREG-1555, "Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal," issued March 2000 (NRC 2000). The search for new information includes (1) review of an applicant's ER and the process for discovering and evaluating the significance of new information, (2) review of records of public comments, (3) review of environmental quality standards and regulations, (4) coordination with Federal, State, and local environmental protection and resource agencies, and (5) review of the technical literature. New information discovered by the NRC staff is evaluated for significance using the criteria set forth in the GEIS. For Category 1 issues where new and significant information is identified, reconsideration of the conclusions for those issues is limited in scope to the assessment of the relevant new and significant information; the scope of the assessment does not include other facets of the issue that are not affected by the new information.

Chapters 3 through 7 discuss the environmental issues considered in the GEIS that are applicable to IP2 and IP3. At the beginning of the discussion of each set of issues, there is a table that identifies the issues to be addressed and lists the sections in the GEIS where the issue is discussed. Category 1 and Category 2 issues are listed in separate tables. For Category 1 issues for which there is no new and significant information, the table is followed by a set of short paragraphs that state the GEIS conclusion codified in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, followed by the staff's analysis and conclusion. For Category 2 issues, in addition to the list of GEIS sections where the issue is discussed, the tables list the subparagraph of 10 CFR 51.53(c)(3)(ii) that describes the analysis required and

the draft SEIS sections where the analysis is presented. The draft SEIS sections that discuss the Category 2 issues are presented immediately following the table.

The NRC prepares an independent analysis of the environmental impacts of license renewal and compares these impacts with the environmental impacts of alternatives. The evaluation of the Entergy license renewal application began with the publication of a notice of acceptance for docketing, notice of opportunity for a hearing, and notice of intent to prepare an EIS and conduct scoping in the *Federal Register,* May 11, 2007 (72 FR 26850; NRC 2007). A public scoping meeting was held on June 27, 2007, in Cortlandt Manor, New York. Comments received during the scoping period have been summarized by the NRC in a summary report issued in December of 2008 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML083360115). The NRC staff adopts by reference the scoping summary report in Part 1 of Appendix A to this draft SEIS.

The NRC staff followed the review guidance contained in NUREG-1555, Supplement 1 (NRC 2000). The NRC staff, and the contractor retained to assist the NRC staff, visited the IP2 and IP3 site on September 11 and 12, 2007, and again on September 24 and 25, 2007, to gather information and to become familiar with the site and its environs. The NRC staff also reviewed the comments received during scoping and consulted with Federal, State, regional, and local agencies. A list of the organizations consulted is provided in Appendix D. Other documents related to IP2 and IP3 were reviewed and are referenced within this draft SEIS.

This draft SEIS presents the NRC staff's preliminary analysis that considers and weighs the environmental effects of the proposed renewal of the operating licenses for IP2 and IP3, the environmental impacts of alternatives to license renewal, and mitigation measures available for avoiding adverse environmental effects. Chapter 9, "Summary and Conclusions," provides the NRC staff's preliminary recommendation to the Commission on whether the adverse environmental impacts of license renewal are so great that preserving the option of license renewal for energy-planning decisionmakers would be unreasonable.

A 75-day comment period will begin on the date of publication of the U.S. Environmental Protection Agency Notice of Filing of the draft SEIS to allow members of the public to comment on the preliminary results of the NRC staff's review. During this comment period, a public meeting will be held in Cortlandt Manor, New York, in February 2009. During this meeting, the NRC staff will describe the preliminary results of the NRC environmental review and answer questions related to it to provide members of the public with information to assist them in formulating their comments.

1.3 The Proposed Federal Action

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.

1.4 The Purpose and Need for the Proposed Action

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 an operating license is to maintain the availability of the nuclear plant to meet system energy requirements beyond the current term of the unit's license.

1.5 Compliance and Consultations

Entergy is required to hold certain Federal, State, and local environmental permits, as well as meet relevant Federal and State statutory requirements. In its ER, Entergy provided a list of the authorizations from Federal, State, and local authorities for current operations as well as environmental approvals and consultations associated with the IP2 and IP3 license renewals. Authorizations and consultations relevant to the proposed operating license renewal actions are included in Appendix E.

The NRC staff has reviewed the list and consulted with the appropriate Federal, State, and local agencies to identify any compliance or permit issues or significant environmental issues of concern to the reviewing agencies. These agencies did not identify any new and significant

environmental issues. The ER states that Entergy is in compliance with applicable environmental standards and requirements for IP2 and IP3. The NRC staff has not identified any environmental issues that are both new and significant.

1.6 References

10 CFR Part 51. *Code of Federal Regulations*, Title 10, *Energy,* Part 51, “Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions.”

10 CFR Part 54. *Code of Federal Regulations*, Title 10, *Energy,* Part 54, “Requirements for Renewal of Operating Licenses for Nuclear Power Plants.”

40 CFR Part 1508. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 1508, “Terminology and Index.”

Atomic Energy Act of 1954. 42 *United States Code* 2011, *et seq*.

Entergy Nuclear Operations, Inc. (Entergy). 2007a. “Indian Point, Units 2 & 3, License Renewal Application.” April 23, 2007. ADAMS Accession No. ML071210512.

Entergy Nuclear Operations, Inc. (Entergy). 2007b. “Applicant’s Environment Report, Operating License Renewal Stage.” (Appendix E to “Indian Point, Units 2 & 3, License Renewal Application”.) April 23, 2007. ADAMS Accession No. ML071210530.

Entergy Nuclear Operations, Inc. (Entergy). 2007c. Letter from Fred Dacimo, Indian Point Energy Center Site Vice President, to the U.S. NRC regarding Indian Point Nuclear Generating Units Nos. 2 and 3. Docket Nos. 50-247, 50-286. May 3, 2007. ADAMS Accession No. ML071280700.

National Environmental Policy Act of 1969 (NEPA). 42 *United States Code* 4321, *et seq*.

U.S. Nuclear Regulatory Commission (NRC). 1996. “Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants.” NUREG-1437, Volumes 1 and 2, Washington, DC.

U.S. Nuclear Regulatory Commission (NRC). 1999. “Generic Environmental Impact Statement for License Renewal of Nuclear Plants Main Report,” Section 6.3, “Transportation,” Table 9.1, “Summary of Findings on NEPA Issues for License Renewal of Nuclear Power Plants.” NUREG-1437, Volume 1, Addendum 1, Washington, DC.

U.S. Nuclear Regulatory Commission (NRC). 2000. “Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal.” NUREG-1555, Supplement 1, Washington, DC.

U.S. Nuclear Regulatory Commission (NRC). 2007. “Entergy Nuclear Operations, Inc.; Notice of Receipt and Availability of Application for Renewal of Indian Point Nuclear Generating Unit Nos. 2 and 3; Facility Operating License Nos. DPR-26 and DPR-64 for an Additional 20-Year Period.” *Federal Register*, Volume 72, Number 91, p. 26850. May 11, 2007.

2.0 DESCRIPTION OF NUCLEAR POWER PLANT AND SITE AND PLANT INTERACTION WITH THE ENVIRONMENT

Indian Point Nuclear Generating Unit Nos. 2 and 3 (IP2 and IP3) are located on approximately 239 acres (97 hectares (ha)) of land in the Village of Buchanan in upper Westchester County, New York. The facility is on the eastern bank of the Hudson River at river mile (RM) 43 (river kilometer (RKM) 69) about 2.5 miles (mi) (4.0 kilometers (km)) southwest of Peekskill, the closest city, and about 24 mi (39 km) north of New York City.

Both IP2 and IP3 use Westinghouse pressurized-water reactors and nuclear steam supply systems (NSSSs). Primary and secondary plant cooling is provided by a once-through cooling water intake system that supplies cooling water from the Hudson River. The plant and its surroundings are described in Section 2.1, and the plant's interaction with the environment is presented in Section 2.2.

Indian Point Nuclear Generating Station Unit No. 1 (IP1, now permanently shut down) shares the site with IP2 and IP3. IP1 is located between IP2 and IP3. IP1 was shut down on October 31, 1974, and has been placed in a safe storage condition (SAFSTOR) awaiting final decommissioning.

2.1 Plant and Site Description and Proposed Plant Operation During the Renewal Term

The entirety of the Indian Point site is surrounded by a perimeter fence, establishing an area known as the "owner controlled area." Security personnel patrol all roads within the site. Within the fence lies an area of greater security known as the "protected area." The protected area is more heavily guarded and controlled by a second fence and an intrusion detection system. The protected area is accessible only through manned security buildings and gates requiring electronic identification. In addition, spaces within the protected area designated as "vital areas" have additional access controls (Entergy 2006a).

The area within a 6-mi (10-km) radius of the IP2 and IP3 site includes the Village of Buchanan, located about 0.5 mi (0.8 km) southeast of the site, and the City of Peekskill, located 2.5 mi (4.0 km) northeast. In the 2000 U.S. census, populations of these towns were 2,189 and 22,441, respectively. The largest town within a 6-mi (10-km) radius of the site is Haverstraw, New York, with a 2000 population of approximately 33,811 (USCB 2000). Haverstraw is located to the southwest on the western bank of the Hudson River. Several other small villages, including Verplanck and Montrose, lie within a 6-mi (10-km) radius of the IP2 and IP3 site. The area within a 6-mi (10-km) radius of the site also includes several thousand acres of the Bear Mountain State Park located across the Hudson River, the nearly 2000-acre (809-ha) Camp Smith (a New York State military reservation) located 2.3 mi (3.7 km) north of the site, and a portion—about 2000 acres (809 ha)—of the U.S. Military Academy at West Point.

The area within a 50-mi (80-km) radius of the site includes parts of New York, New Jersey, and Connecticut. New York City, located approximately 24 mi (39 km) south of the plant, is the largest city within 50 mi (80 km) with a 2006 population of approximately 8,214,426 (USCB 2006). Other population centers include Danbury and Stamford, Connecticut; Newark, New

Jersey; and Poughkeepsie, New York. The area within a 50-mi (80-km) radius also includes all of the U.S. Military Academy at West Point, located 7.5 mi (12 km) northwest of the site, and the Picatinny Arsenal, located 35.5 mi (57.1 km) southwest of the site in New Jersey (Entergy 2007a).

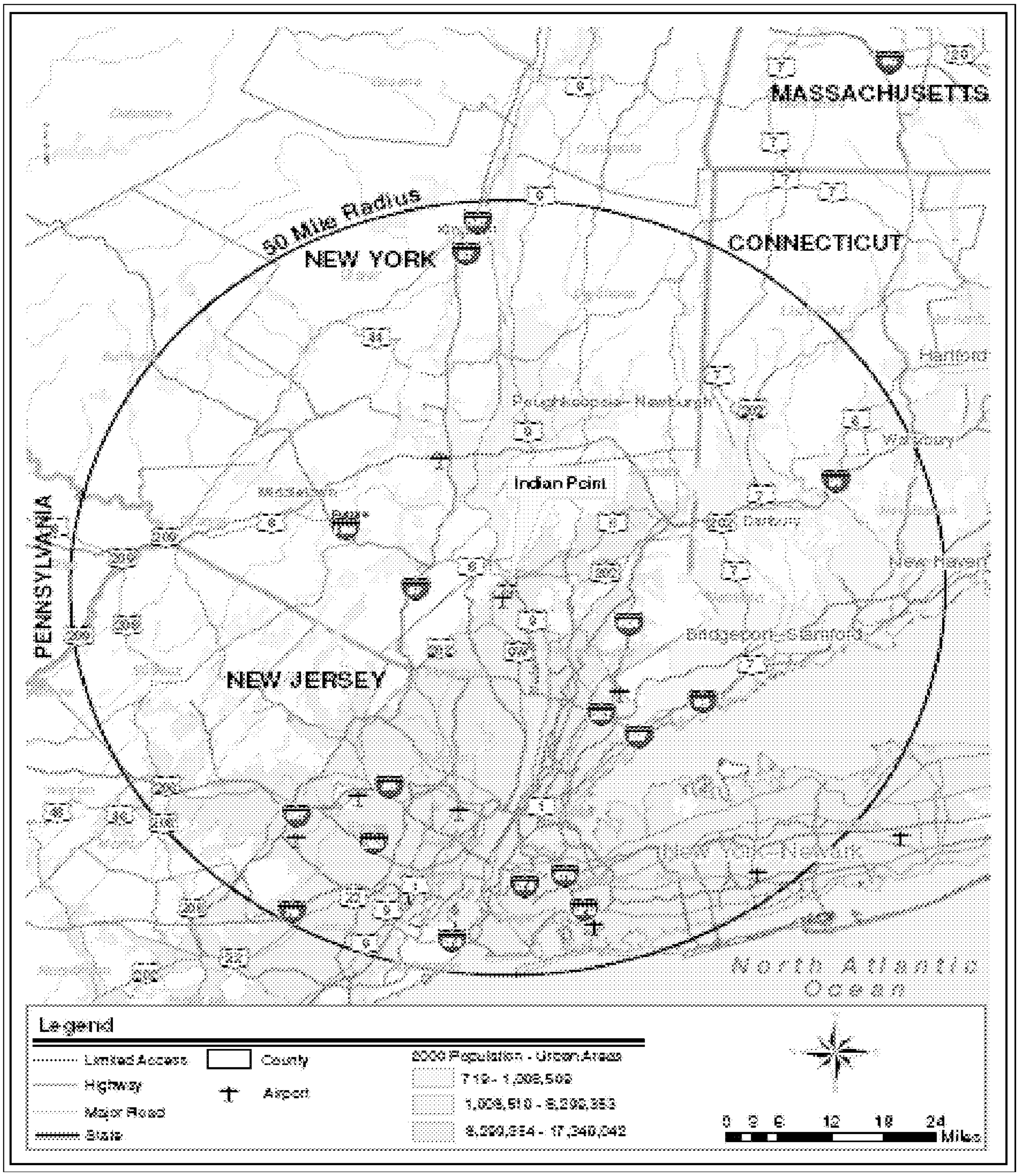
The region surrounding the Indian Point site has undulating terrain with many peaks and valleys. Dunderberg Mountain lies on the western side of the Hudson River 1 mi (1.6 km) northwest of the site. North of Dunderberg Mountain, high grounds reach an elevation of 800 feet (ft) (244 meters (m)) above the western bank of the Hudson River. To the east of the site lie the Spitzenberg and Blue Mountains. These peaks are about 600 ft (183 m) in height. There is also a weak, poorly defined series of ridges that run in a north-northeast direction east of IP2 and IP3. The Timp Mountains are west of the facility. These mountains rise to a maximum elevation of 846 ft (258 m). Elevations south of the site are 100 ft (30.5 m) or less and gradually slope toward the Village of Verplanck (Entergy 2007a).

The site location and features within 50-mi (80-km) and 6-mi (10-km) radii are illustrated in Figures 2-1 and 2-2, respectively.

2.1.1 External Appearance and Setting

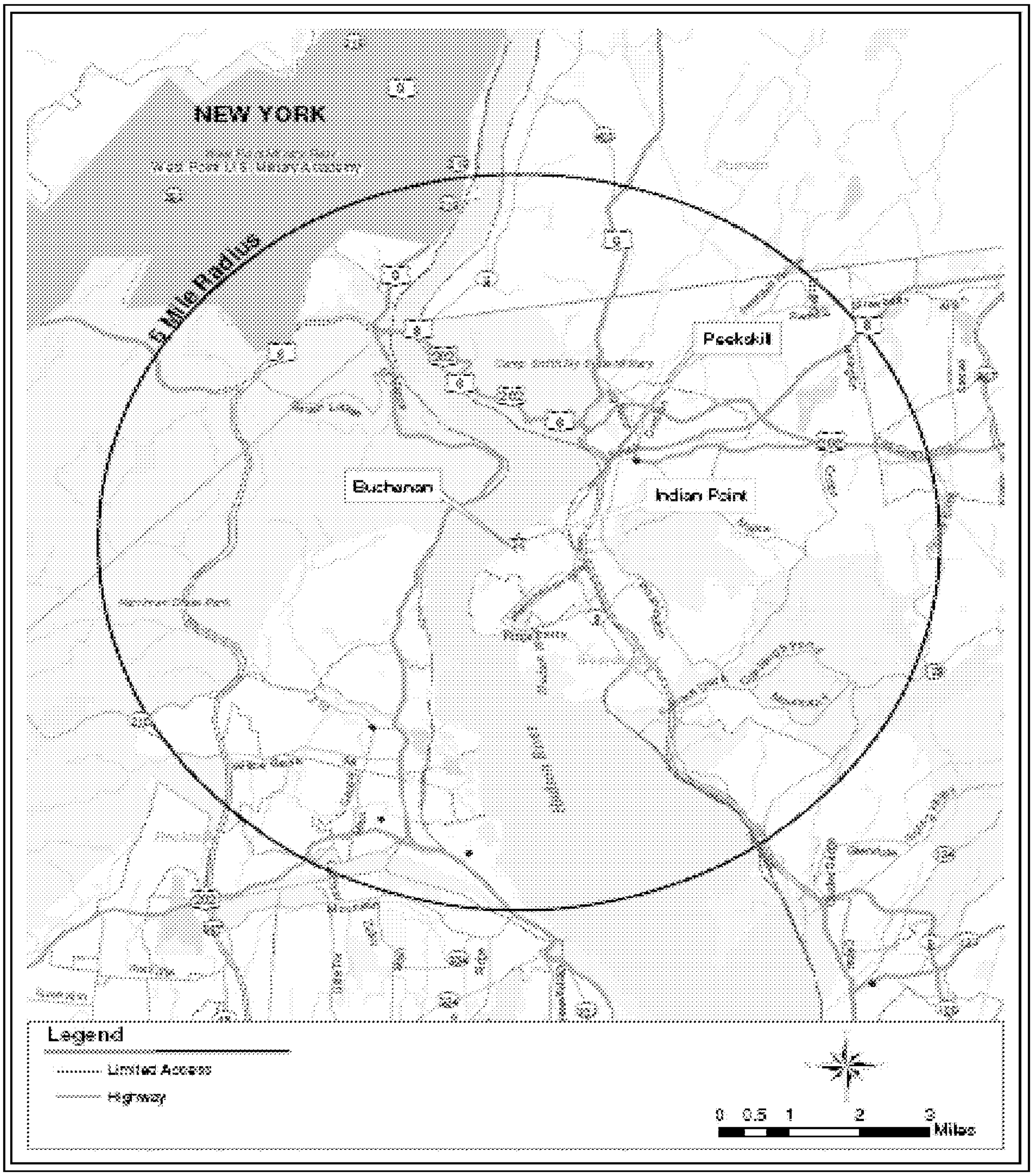
As discussed in Section 2.1, the immediate area around the Indian Point site is completely enclosed by a security fence. Access to the site is controlled at a security gate on Broadway (main entrance). Controlled access to the site is also available using the existing wharf on the Hudson River. The wharf is used to receive heavy equipment shipped to the site by barge. There are no rail lines that service the site. The nearest residence is less than 0.5 mi (0.8 km) from IP2 and IP3 and about 100 meters (m) (328 ft) beyond the site boundary to the east-southeast (ENN 2007a).

The facility can be seen easily from the river. Surrounding high ground and vegetation make it difficult to see the facility from beyond the security fence on land, except from Broadway. The 334-ft (102-m) tall superheater stack for IP1, the 134-ft (40.8-m) tall IP2 and IP3 turbine buildings, and the 250-ft (76.2-m) tall reactor containment structures are the tallest structures on the site (Entergy 2007a).



Source: Entergy 2007a

Figure 2-1. Location of IP2 and IP3, 50-mi (80-km) radius



Source: Entergy 2007a

Figure 2-2. Location of IP2 and IP3, 6-mi (10-km) radius

Other visible IP2 and IP3 site features include auxiliary buildings, intake structures, the discharge structure, electrical switchyard, and associated transmission lines (Entergy 2007a). The site boundary and general facility layout are depicted in Figures 2-3 and 2-4, respectively.

The facility contains several stationary bulk petroleum and chemical storage tanks. Bulk chemical storage tanks are registered with the New York State Department of Environmental Conservation (NYSDEC) via Hazardous Substance Bulk Storage Registration Certificates. The tanks and their contents are managed in accordance with the NYSDEC Chemical Bulk Storage Regulations. The IP2 bulk petroleum storage tanks are registered with NYSDEC via a Major Oil Storage Facility License, while the IP3 tanks are registered with the Westchester County Department of Health via a Petroleum Bulk Storage Registration Certificate.

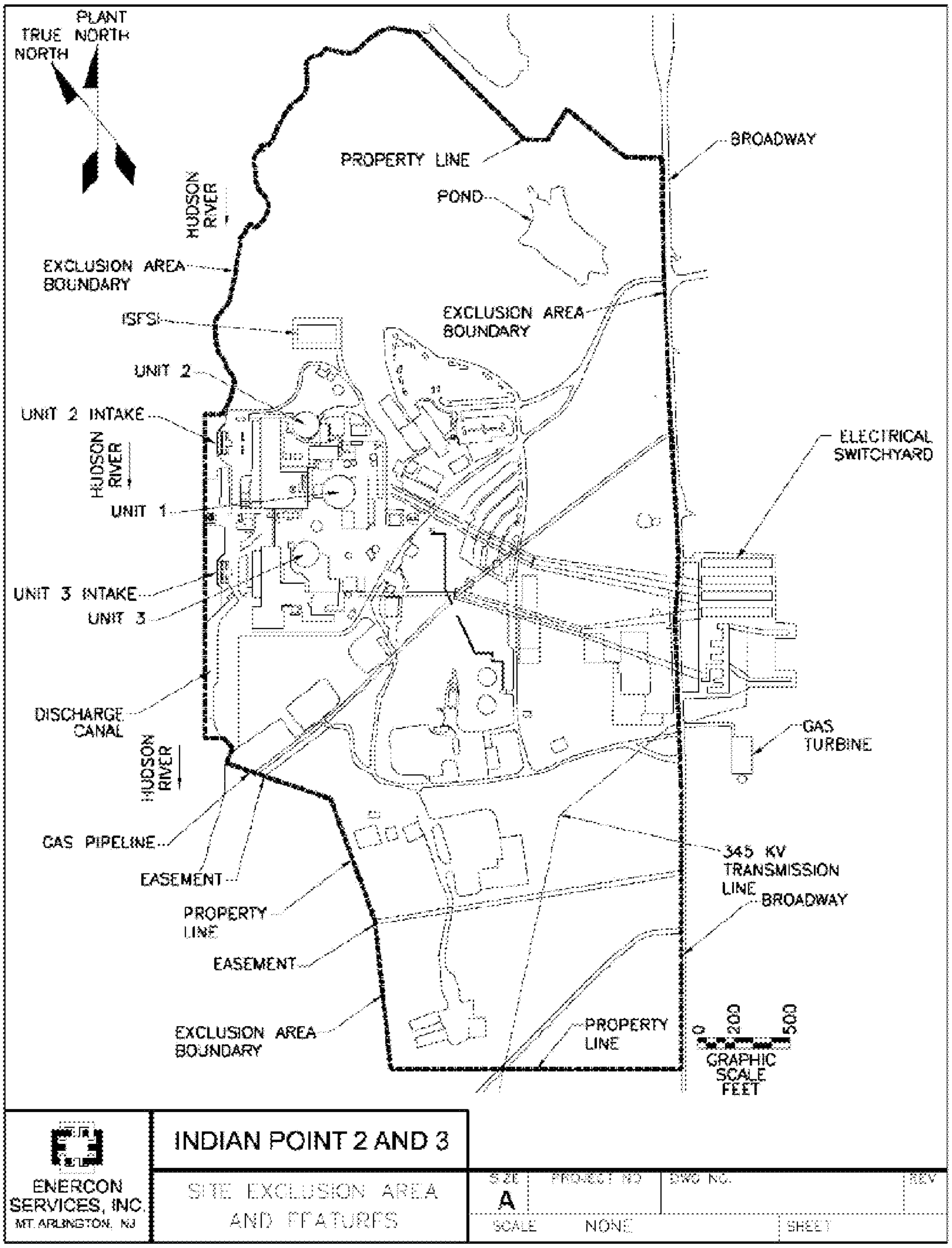
IP2 and IP3 each use two main transformers to increase voltage from their respective turbine generators. The transformers increase generator output from 22 kilovolts (kV) to 345 kV. Power is then delivered to the Consolidated Edison Company (Con Edison) transmission grid by way of two double-circuit 345-kV lines. These lines connect the main onsite transformers to the offsite Buchanan substation which is located across Broadway near the main entrance to the site. The lines that connect the transformers to the substation are about 2000 ft (610 m) in length and, except for the terminal 100 ft where they cross over Broadway (a public road) and enter the substation, lines are located within the site boundary (Entergy 2007a). The 345-kV transmission lines that distribute power from the substation are shown in Figure 2-3.

2.1.2 Reactor Systems

As noted in Section 2.0, both IP2 and IP3 employ Westinghouse pressurized-water reactors and four-loop NSSSs. Each NSSS loop contains a reactor coolant pump and a steam generator. The reactor coolant system transfers the heat generated in the reactor core to the steam generators, which produce steam to drive the electrical turbine generators (Entergy 2007b).

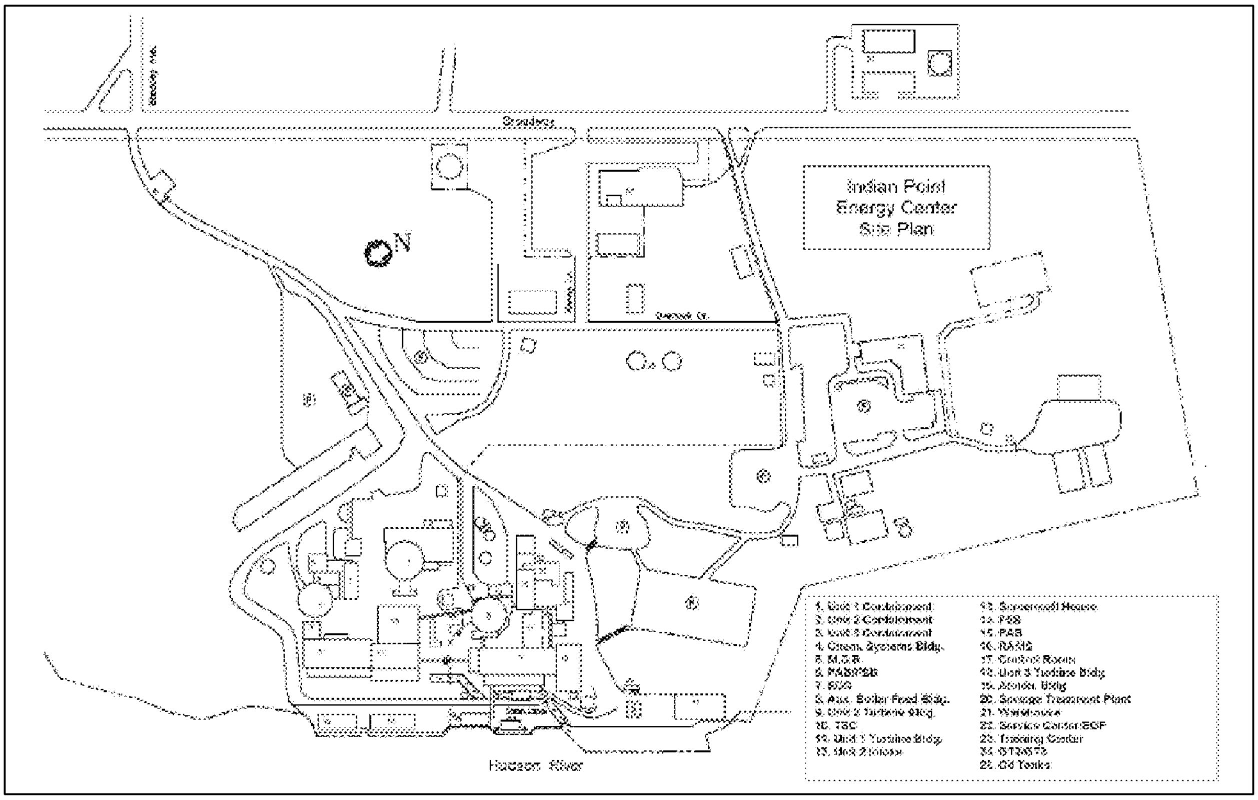
IP2 is currently licensed to operate at a core power of 3216 megawatt thermal (MW(t)), which results in a turbine generator output of approximately 1078 megawatt electric (MW(e)). IP3 is currently licensed to operate at 3216 MW(t), which results in a turbine generator output of approximately 1080 MW(e). IP2 and IP3 have similar designs with independent functional and safety systems. The units share the following systems (Entergy 2007b):

- discharge canal, outfall structure, and associated instrumentation and sampling systems
- electrical supplies and interties
- station air interties
- demineralized water, condensate makeup, and hydrogen interties
- city water and fire protection interties
- dedicated No. 2 fuel oil systems for diesel generators
- sewage treatment facility
- auxiliary steam system intertie



1 Source: Entergy 2007a

2 **Figure 2-3. IP2 and IP3 property boundaries and environs**



Source: Entergy 2007a

Figure 2-4. IP2 and IP3 site layout

- service boiler fuel oil supply system
- liquid steam generator blowdown, radioactive waste processing, and discharge (to IP1) facilities

The nuclear fuel for IP2 and IP3 is made of low-enrichment (less than 5 percent by weight uranium-235) uranium dioxide pellets stacked in pre-pressurized tubes made from zircaloy or ZIRLO. The fuel tube rods have welded end plugs. Based on core design values, IP2 and IP3 operate at an individual rod average fuel burnup of no more than 62,000 megawatt-days per metric ton of heavy metal. This ensures that peak burnups remain within the acceptable limits specified in Table B-1 of Appendix B, “Environmental Effect of Renewing the Operating License of a Nuclear Power Plant,” to Subpart A, “National Environmental Policy Act—Regulations Implementing Section 102(2),” of Title 10, Part 51, “Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions,” of the *Code of Federal Regulations* (10 CFR Part 51) (Entergy 2006a). Reactor fuel that has exhausted a certain percentage of its fissile uranium content so that it is no longer an efficient fissile fuel source is referred to as spent fuel. The spent fuel is removed from the reactor core and replaced by fresh fuel during routine refueling outages. Refueling outages at IP2 and IP3 typically occur every 24 months. The spent fuel assemblies are then stored in the spent fuel pool (SFP) in the fuel storage building.

Located north of IP2 inside the protected area fence, the spent fuel will be transferred to dry storage (Entergy 2007a) at an onsite independent spent fuel storage installation (ISFSI). The first fuel was moved from IP2 to the ISFSI pad, which is approximately 100 ft (30.5 m) wide by 200 ft (61.0 m) long, during the first week of January 2008 (Entergy 2008a).

IP2 and IP3 containment buildings completely enclose each unit's reactor and the reactor coolant system. The containment buildings are designed to minimize leakage of radioactive materials to the environment if a design-basis loss-of-coolant accident were to occur. The containment structures have an outer shell of reinforced concrete and an inner steel liner (Entergy 2007b).

The IP2 containment building contains a containment purge supply and exhaust system and a containment pressure relief system. The purge supply and exhaust system provides fresh air to the containment and filters air released from containment. The containment pressure relief system regulates normal pressure in the containment during reactor power operation (Entergy 2007b).

The IP3 containment building contains a vapor containment heating and ventilation purge system and a vapor containment pressure relief system. The heating and ventilation system regulates fresh air flow into the containment and filters air before its dispersion to the environment. The vapor containment pressure relief system regulates pressure changes in containment during reactor power operation (Entergy 2007b).

2.1.3 Cooling and Auxiliary Water Systems

IP2 and IP3 have once-through condenser cooling systems that withdraw water from and discharge it to the Hudson River. The systems are described in detail in the IP2 and IP3 environmental report (ER) (Entergy 2007a). This section provides a general description based on the information provided by Entergy in the ER.

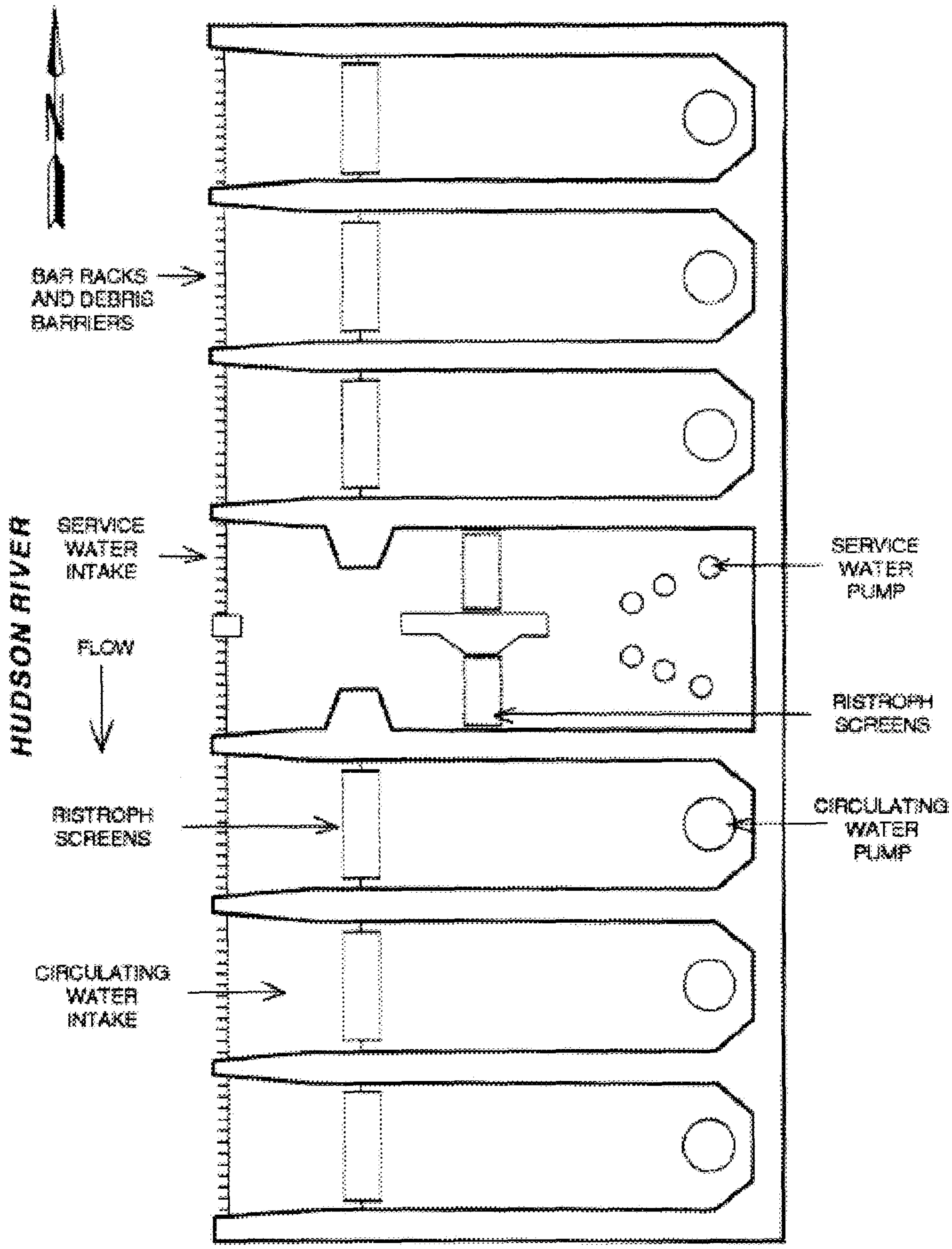
The maximum design flow rate for each cooling system is approximately 1870 cubic feet per second (cfs), 840,000 gallons per minute (gpm), or 53.0 cubic meters per second (m^3/s).

Two shoreline intake structures—one for each unit—are located along the Hudson River on the northwestern edge of the site and provide cooling water to the site. Each structure consists of seven bays, six for circulating water and one for service water. The IP2 intake structure has seven independent bays, while the IP3 intake structure has seven bays that are served by a common plenum. In each structure, six of the seven bays contain cooling water pumps, and the seventh bay contains service/auxiliary water pumps. Before it is pumped to the condensers, river water passes through traveling screens in the intake structure bays to remove debris and fish.

The six IP2 circulating water intake pumps are dual-speed pumps. When operated at high speed (254 revolutions per minute (rpm)), each pump provides 312 cfs (140,000 gpm; 8.83 m^3/s) and a dynamic head of 21 ft (6.4 m). At low speed (187 rpm), each pump provides 187 cfs (84,000 gpm; 5.30 m^3/s) and a dynamic head of 15 ft (4.6 m). The six IP3 circulating water intake pumps are variable-speed pumps. When operated at high speed (360 rpm), each pump provides 312 cfs (140,000 gpm; 8.83 m^3/s); at low speed, it provides a dynamic head of 29 ft (8.8 m) and 143 cfs (64,000 gpm; 4.05 m^3/s). In accordance with the October 1997 Consent Order (issued pursuant to the Hudson River Settlement Agreement; see

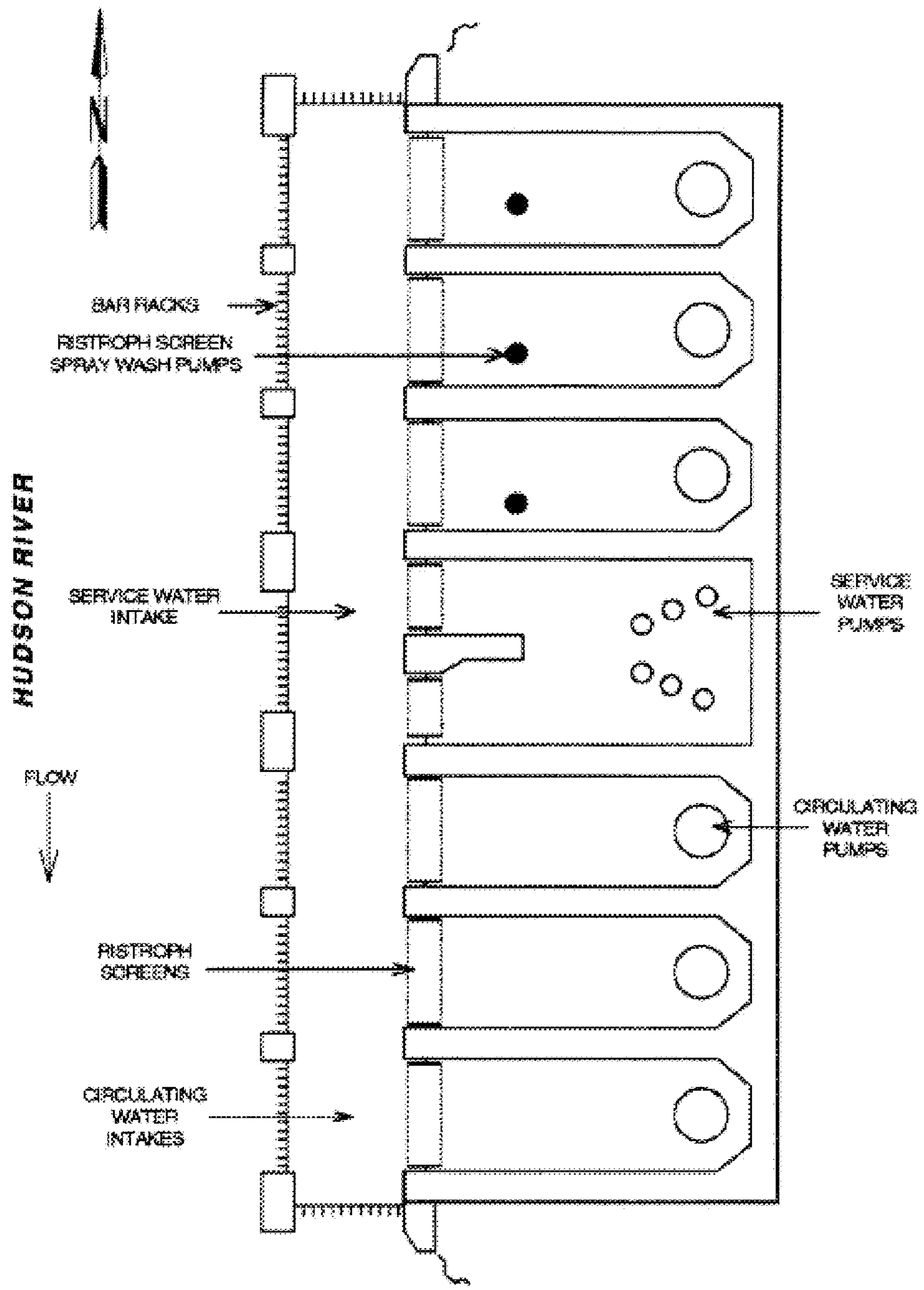
Section 2.2.5.3 for more information), the applicant adjusts the speed of the intake pumps to mitigate impacts to the Hudson River.

Each coolant pump bay is about 15 ft (4.6 m) wide at the entrance, and the bottom is located 27 ft (8.2 m) below mean sea level. Before entering the intake structure bays, water flows under a floating debris skimmer wall, or ice curtain, into the screen wells. This initial screen keeps floating debris and ice from entering the bay. At the entrance to each bay, water also passes through a subsurface bar screen to prevent additional large debris from becoming entrained in the cooling system. Next, smaller debris and fish are screened out using modified Ristroph traveling screens. Figures 2-5 through 2-8 illustrate the IP2 and IP3 intake structures and bays.



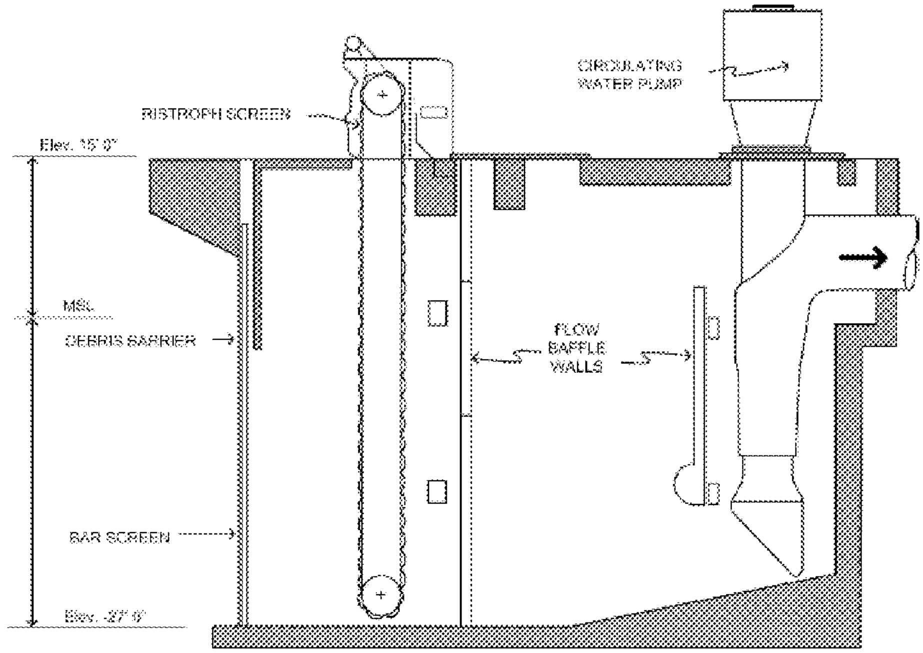
1 Source: Entergy 2007a

2 **Figure 2-5. IP2 intake structure**



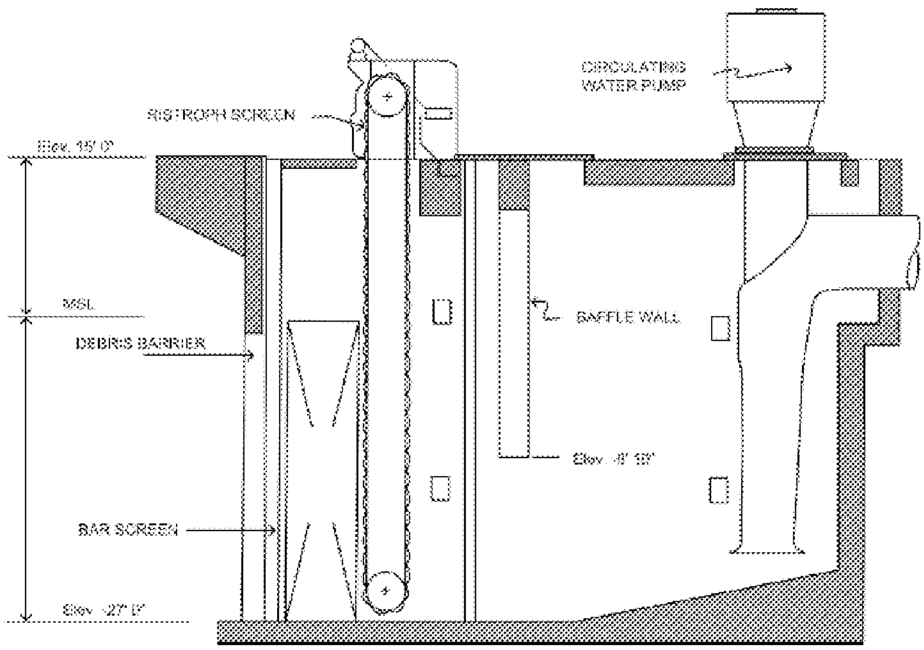
1 Source: Entergy 2007a

2 **Figure 2-6. FIP3 intake structure**



Source: Entergy 2007a

Figure 2-7. IP2 intake system



Source: Entergy 2007a

Figure 2-8. IP3 intake system

The modified Ristroph traveling screens consist of a series of panels that rotate continuously. As each screen panel rotates out of the intake bay, impinged fish are retained in water-filled baskets at the bottom of each panel and are carried over the headshaft, where they are washed out onto a mesh using low-pressure sprays from the rear side of the machine. The 0.25-by-0.5-inch (in.) (0.635-by-1.27 centimeters (cm)) mesh is smooth to minimize fish abrasion by the mesh. Two high-pressure sprays remove debris from the front side of the machine after fish removal.

From the mesh, fish return to the river via a 12-in. (30-cm) diameter pipe. The pipe extends 200 ft (61.0 m) into the river north of the IP2 intake structure and discharges at a depth of 35 ft (11 m).

After moving through the condensers, cooling water is discharged to the discharge canal via a total of six 96-in. (240-cm) diameter pipes. The cooling water enters below the surface of the 40-ft (12-m) wide canal. The canal discharges to the Hudson River through an outfall structure located south of IP3 at about 4.5 feet per second (fps) (1.4 meters per second (mps)) at full flow. As the discharged water enters the river, it passes through 12 discharge ports (4-ft by 12-ft each (1-m by 3.7-m)) across a length of 252 ft (76.8 m) about 12 ft (3.7 m) below the surface of the river. The increased discharge velocity, about 10 fps (3.0 mps), enhances mixing to minimize thermal impact.

The discharged water is at an elevated temperature, and therefore, some water is lost because of evaporation. Based on conservative estimates, the staff of the U.S. Nuclear Regulatory Commission (NRC) estimates that this induced evaporation resulting from the elevated discharge temperature would be less than 60 cfs (27,000 gpm or 1.7 m^3/s). This loss is about .5 percent of the annual average downstream flow of the Hudson River, which is more than 9000 cfs (4 million gpm or 255 m^3/s). The average cooling water transient time ranges from 5.6 minutes for the IP3 cooling water system to 9.7 minutes for the IP2 system.

Auxiliary water systems for service water are also provided from the Hudson River via the dedicated bays in the IP2 and IP3 intake structures. The primary role of service water is to cool components (e.g., pumps) that generate heat during operation. Secondary functions of the service water include the following:

- protect equipment from potential contamination from river water by providing cooling to intermediate freshwater systems
- provide water for washing the modified Ristroph traveling screens
- provide seal water for the main circulating water pumps

The IP2 service water bay has six identical centrifugal sump-type pumps, each having a capacity of at least 11 cfs (5000 gpm; 0.31 m^3/s) at 220-ft (67-m) total design head. The IP3 service water bay also has six similar pumps, each rated at 13 cfs (6000 gpm; 170 m^3/s) and 195-ft (59.4-m) total design head. The average approach velocity at the entrance to each service water bay when all pumps are operating is about 0.2 fps (0.06 mps). Each service water bay also contains two Ristroph screens to reduce fish entrainment.

Additional service water is provided to the nonessential service water header for IP2 through the IP1 (which is decommissioned) river water intake structure. The IP1 intake includes four intake bays each with a coarse bar screen and a single 0.125-in. (0.318-cm) mesh screen. The intake

structure contains two 36-cfs (16,000-gpm; 1.0-m^3/s) spray wash pumps. The screens are washed automatically and materials are sluiced to the Hudson River.

2.1.4 Radioactive Waste Management Systems and Effluent Control Systems

IP2 and IP3 radioactive waste systems are designed to collect, treat, and dispose of radioactive and potentially radioactive wastes that are byproducts of plant operations. These byproducts include activation products resulting from the irradiation of reactor water and impurities therein (principally metallic corrosion products) and fission products resulting from their migration through the fuel cladding or uranium contamination within the reactor coolant system. Operating procedures for radioactive waste systems are designed to ensure that radioactive wastes are safely processed and discharged from the plant within the limits set forth in 10 CFR Part 20, "Standards for Protection against Radiation"; Appendix I, " Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low as Is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities"; the plant's technical specifications; and the IP2 and IP3 Offsite Dose Calculation Manual (ODCM) (Entergy 2007a).

Radioactive wastes resulting from plant operations are classified as liquid, gaseous, or solid. Liquid radioactive wastes are generated from liquids received directly from portions of the reactor coolant system or were contaminated by contact with liquids from the reactor coolant system. Gaseous radioactive wastes are generated from gases or airborne particulates vented from reactor and turbine equipment containing radioactive material. Solid radioactive wastes are solids from the reactor coolant system, solids that came into contact with reactor coolant system liquids or gases, or solids used in the reactor coolant system or steam and power conversion system operation or maintenance.

As indicated in Section 2.1.2, reactor fuel that has exhausted a certain percentage of its fissile uranium content is referred to as spent fuel. Spent fuel assemblies are removed from the reactor core and replaced with fresh fuel assemblies during routine refueling outages, typically every 24 months. Spent fuel assemblies are then stored for a period of time in the SFP in the fuel storage building and may later be transferred to dry storage at a recently constructed onsite ISFSI. Entergy has constructed an ISFSI in the north end of the IP2 and IP3 site in an area that was previously undeveloped. The facility is planned to hold up to 78 Holtec International HI-STORM 100S(B) casks (Entergy 2007a) .

The IP2 and IP3 ODCM contains the methodology and parameters used to calculate offsite doses resulting from radioactive gaseous and liquid effluents and the gaseous and liquid effluent monitoring alarm and trip setpoints used to verify that radioactive discharges meet regulatory limits. The ODCM also contains the radioactive effluent controls and radiological environmental monitoring activities and descriptions of the information that should be included in the annual Radiological Environmental Operating Report and annual Radioactive Effluent Release Report (Entergy 2007a) .

2.1.4.1 Liquid Waste Processing Systems and Effluent Controls

The liquid waste processing system collects, holds, treats, processes, and monitors all liquid radioactive wastes for reuse or disposal.

IP2

In IP2, the liquid waste holdup system collects low-level radioactive waste from throughout the facility and holds the waste until it can be processed. During normal plant operations the system receives input from numerous sources, such as equipment drains and leak lines, chemical laboratory drains, decontamination drains, demineralizer regeneration, reactor coolant loops and reactor coolant pump secondary seals, valve and reactor vessel flange leak lines, and floor drains. Liquid waste is divided into two general classifications—high-quality liquid waste from the reactor coolant drain tank and routine liquid waste from the waste holdup tank which contains reactor coolant. The IP2 liquid wastes are transferred from the waste holdup tank to the IP1 waste collection system (described later in this section). The liquid waste can also be transferred from the waste holdup tank to the waste condensate tank, where its radioactivity can be analyzed to determine whether the waste is acceptable for discharge into the condenser circulating water and into the Hudson River.

In the event of primary reactor coolant water (radioactive) leakage into the secondary-side water (nonradioactive) system, potentially contaminated water that collects in the secondary-side drains may be collected and sent to a collection point in the auxiliary boiler feedwater building for eventual processing.

IP3

In IP3, the liquid waste holdup system collects low-level radioactive waste from throughout the facility and holds the waste until it can be processed. During normal plant operations, the system receives input from numerous sources, such as equipment drains and leak lines, radioactive chemical laboratory drains, decontamination drains, demineralizer regeneration, reactor coolant loops and reactor coolant pump secondary seals, valve and reactor vessel flange leak-offs, and floor drains. The system consists of three tanks—a 24,500–gallon (gal) (92,700-liter (L)) waste holdup tank located in the waste holdup pit, and the two 62,000-gal (235,000-L) waste holdup tanks located in the liquid radioactive waste storage facility.

The liquid radioactive waste storage facility, which houses the 62,000-gal (235,000-L) waste tanks, is an underground concrete structure. The 62,000-gal (235,000-L) tanks are supported on concrete piers. The building is supported on hard rock. The foundation consists of a rigid 2-in. (5.0-cm) thick slab that is waterproofed. The reinforced concrete walls of the building are also waterproofed. The roof is made of 3-in. (7.6-cm) reinforced concrete poured on a steel deck and beam system.

When the waste has been sampled and analyzed and found to be acceptable for discharge, it is pumped from the waste holdup tank to the monitor tanks. When one monitor tank is filled, it is isolated, and the waste liquid is recirculated and sampled for radioactive and chemical analysis while the second tank is in service accumulating waste. If the waste material in the filled monitor tank meets release standards, the waste liquid is pumped to the service water discharge for release into the Hudson River. If it does not meet release standards, it is returned to the waste holdup tanks for additional processing. Entergy performs radioactive and chemical analyses to determine the amount of radioactivity released. There is also a radiation monitor which provides surveillance over the operation to ensure that the discharge is within radiation standards. If the radioactivity in the liquid waste being discharged exceeds the radiation standard, the discharge is terminated.

IP1

Radioactive waste storage and processing facilities located in IP1 provide additional waste processing services for the two operating units. IP1 contains four tanks with a capacity of 75,000 gal (284,000 L) each. From these tanks, the liquid can be processed by use of sluicable demineralizer vessels. There is also a portable demineralization system located in the IP1 Chemical System Building to process liquid waste. This system uses a number of inline ion exchanger resin beds and filters to remove radionuclides and chemicals from the waste stream. Once the contents of the waste tanks meet release criteria, the liquid waste is discharged into the river.

Liquid Releases

Liquid releases to the Hudson River are limited to the extent possible to satisfy the dose design objectives of Appendix I to 10 CFR Part 50. IP2 and IP3 have controls, described in their ODCMs, for limiting the release of radioactive liquid effluents. The controls are based on the concentrations of radioactive materials in liquid effluents and the calculated projected dose to a hypothetical member of the public. Concentrations of radioactive material that may be released in liquid effluents are limited to the concentrations specified by 10 CFR Part 20. For the calendar year, the ODCM limits the dose to a member of the public from liquid effluents to 3 millirems (mrem) (0.03 millisievert (mSv)) to the total body and 10 mrem (0.10 mSV) to any organ (Entergy 2007a).

Entergy maintains radioactive liquid effluent discharges in accordance with the procedures and methodology described in the ODCM. The liquid radioactive waste processing system is effectively used to reduce radioactive materials in liquid effluents before discharge to meet the as-low-as-reasonably-achievable (ALARA) dose objectives in Appendix I to 10 CFR Part 50.

The NRC staff reviewed the IP2 and IP3 radioactive effluent release reports for 2002 through 2006 for liquid effluents (Entergy 2003a, 2003b, 2004, 2005a, 2006b, 2007c) to determine whether releases were reasonable. In 2006, 5.99×10^{7} gal (2.27×10^{8} L) of radiological liquid effluents diluted with 1.47×10^{12} gal (5.58×10^{12} L) of water were discharged from the IP2 and IP3 site. The amount of radioactivity discharged in the form of fission and activation products from the IP2 and IP3 site in 2006 totaled 5.92×10^{-2} curies (Ci) (2.19×10^{3} megabecquerels (MBq)). A total of 1.56×10^{3} Ci (5.77×10^{7} MBq) of tritium was released from the IP2 and IP3 site in 2006. A total of 3.82×10^{-1} Ci (1.41×10^{4} MBq) of dissolved and entrained gases was released in liquid discharges from the IP2 and IP3 site in 2006 (Entergy 2007c). The liquid discharges for 2006 are consistent with the radioactive liquid effluents discharged from 2002 through 2005. The NRC staff expects variations in the amount of radioactive effluents released from year to year by Entergy based on the overall performance of the plant and the number and scope of maintenance and refueling outages. The liquid radioactive wastes reported by Entergy are reasonable, and the NRC staff noted no unusual trends.

Though Entergy has indicated that it may replace IP2 and IP3 reactor vessel heads and control rod drive mechanisms during the period of extended operation, such replacement actions are not likely to result in a significant increase of liquid radioactive effluents being discharged compared to the amount discharged during normal plant operations. This is based on consideration that liquids generated, processed, and released during the outage will likely be offset by the amount of liquid waste that would not be generated, processed, and released during normal plant operations during the outage period. Based on the NRC staff's evaluation

of recent historical releases in the previous paragraph and based on the NRC staff's expectation that no significant increase in liquid effluents from the potential replacement of the reactor heads and control rod drive mechanisms is likely to occur, the NRC staff expects similar quantities of radioactive liquid effluents to be generated during normal operation and outages from IP2 and IP3 during the period of extended operation.

Releases to Ground Water

In addition to the planned radioactive liquid discharges made through the liquid waste processing system, Entergy identified a new release pathway as a result of the discovery of tritium contamination in the ground outside the IP2 SFP. This release was listed as an abnormal release in the 2006 radioactive effluent release report. The applicant included a detailed radiological assessment of all the liquid effluent releases and the projected doses in its 2006 annual radioactive effluent release report (Entergy 2007c). The following information is from that report.

The applicant estimated that approximately 0.19 Ci ($7.03x10^{3}$ MBq) of tritium migrated directly to the Hudson River by the ground water flow path in 2006, resulting in an approximate total body dose of $2.10x10^{-6}$ mrem ($2.10x10^{-8}$ mSv). The amount of tritium released through this pathway is approximately 0.015 percent of the tritium released to the river from routine releases. Tritium releases in total (ground water as well as routine liquid effluent) represent less than 0.001 percent of the Federal dose limits for radioactive effluents from the site. Strontium-90, nickel-63, and cesium-137 collectively contributed approximately $5.70x10^{-4}$ Ci (21.1 MBq) from the ground water pathway, which resulted in a calculated annual dose of approximately $1.78x10^{-3}$ mrem ($1.78x10^{-5}$ mSv) to the total body, and $7.21x10^{-3}$ mrem ($7.21x10^{-5}$ mSv) to the critical organ, which was the adult bone (primarily because of strontium-90). Storm drain releases to the discharge canal were conservatively calculated to be approximately $9.40x10^{-2}$ Ci ($3.48x10^{3}$ MBq) of tritium, resulting in an approximate total body dose of $2.00x10^{-8}$ mrem ($2.00x10^{-10}$ mSv). Entergy asserts that the annual dose to a member of the public from the combined ground water and storm water pathways at IP2 and IP3 remains well below NRC and U.S. Environmental Protection Agency (EPA) radiation protection standards (Entergy 2007c). The NRC staff further discusses releases to groundwater, including recent inspection results, in Section 2.2.7 of this SEIS.

2.1.4.2 Gaseous Waste Processing Systems and Effluent Controls

IP2

The gaseous radioactive waste processing system and the plant ventilation system control, collect, process, store, and dispose of gaseous radioactive wastes generated as a result of normal operations. During plant operations, gaseous waste is generated by degassing the reactor coolant and purging the volume control tank, displacing cover gases as liquid accumulates in various tanks, equipment purging, and sampling operations and automatic gas analysis for hydrogen and oxygen in cover gases. The majority of the gas received by the waste disposal system during normal plant operations is cover gas displaced from the chemical and volume control system holdup tanks as they fill with liquid.

Vented gases flow to a waste gas compressor suction header. One of two compressors is in continuous operation with the second unit designed to operate as a backup for peak load conditions. From the compressors, gas flows to one of four large gas decay tanks. The control arrangement on the gas decay tank inlet header allows plant personnel to place one large tank

in service and to select a second large tank for backup. When the tank in service becomes pressurized to a preset level, a pressure transmitter automatically opens the inlet valve to the backup tank, closes the inlet valve to the filled tank, and triggers an alarm to alert personnel to select a new backup tank. Gas held in the decay tanks can either be returned to the chemical and volume control system holdup tanks or be discharged to the environment, provided that the gas meets radiation limits.

Six additional small gas decay tanks are available for use during degassing of the reactor coolant system before the reactor is brought to a cold shutdown. The reactor coolant fission gas activity is distributed among the six tanks through a common inlet header. A radiation monitor in the sample line to the gas analyzer checks the gas decay tank radioactivity inventory each time a sample is taken for hydrogen-oxygen analysis. An alarm notifies plant personnel when the inventory limit is approached so that another tank can be placed into service.

Before a tank's contents can be discharged into the environment, they must be sampled and analyzed to verify that sufficient decay of the radioactive material has occurred and to document the amount of radioactivity that will be released. If appropriate radioactivity criteria are met, the gas is discharged to a plant vent at a controlled rate and checked by a radiation monitor in the vent. In addition to the radiation monitor, gas samples are manually taken and analyzed to ensure that radiation protection limits are maintained. During a release, a trip valve in the discharge line closes automatically when there is an indication of a high-radioactivity level in the plant vent (Entergy 2007a).

IP3

The gaseous radioactive waste processing system and the plant ventilation system control, collect, process, store, and dispose of gaseous radioactive wastes generated as a result of normal operations. During plant operations, gaseous waste is generated by degassing the reactor coolant and purging the volume control tank, displacement of cover gases as liquid accumulates in various tanks, equipment purging, sampling operations and automatic gas analysis for hydrogen and oxygen in cover gases, and venting of actuating nitrogen for pressure control valves.

The majority of the gas received by the waste disposal system during normal operations is cover gas displaced from the chemical and volume control system holdup tanks as they fill with liquid. Since this gas must be replaced when the tanks are emptied during processing, facilities are provided to return gas from the decay tanks to the holdup tanks. A backup supply from the nitrogen header is provided for makeup if the return flow from the gas decay tanks is not available.

Gases vented to the vent header flow to the waste gas compressor header. One of the two compressors is in continuous operation with the second unit as a backup for peak load conditions. From the compressors, gas flows to one of four large gas decay tanks. The control arrangement on the gas decay tanks inlet header allows for the operation of one tank with a second tank as backup. When the tank in service is filled, a pressure transmitter automatically opens the inlet valve to the backup tank and closes the valve of the filled tank and sounds an alarm. Plant personnel then select a new tank to be the backup and repeat the process.

Gases are held in the decay tanks to reduce the amount of radioactivity released into the environment. These gases can either be returned to the chemical and volume control system holdup tanks or discharged to the environment if the radioactivity meets radiation standards.

There are six additional small gas decay tanks for use during degassing of the reactor coolant before the reactor is brought to a cold shutdown. The reactor coolant fission gas activity inventory is distributed equally among the six tanks through the use of a common header. The total radioactivity in any one gas decay tank is controlled in order to limit the potential radiological consequences if any tank ruptures.

Before a tank's contents can be released into the environment, they must be sampled and analyzed to verify that there was sufficient decay and to provide a record of the type and quantity of radioactivity to be released. Once these steps are completed, the gas may be released to the plant vent at a controlled rate and monitored by a radiation monitor. The radiation monitor, upon detecting high radioactivity levels, can automatically close the discharge line to the plant vent. Samples are also taken manually to document releases (Entergy 2007a).

Gaseous Releases

Entergy maintains radioactive gaseous effluents in accordance with the procedures and methodology described in the ODCM. The gaseous radioactive waste processing system is effectively used to reduce radioactive materials in gaseous effluents before discharge to meet the ALARA dose objectives in Appendix I to 10 CFR Part 50.

The NRC staff reviewed the IP2 and IP3 annual radioactive effluent release reports from 2002 through 2006 for gaseous effluents (Entergy 2003a, 2003b, 2004a, 2005a, 2006b, 2007c) to determine whether the releases were reasonable. There were no abnormal gaseous releases from IP2 and IP3 in 2006. The amount of radioactivity discharged in the form of fission and activation gases from the operating reactors at the IP2 and IP3 site in 2006 totaled 2.20×10^{2} Ci (8.14×10^{6} MBq). A total of 20.8 Ci (7.69×10^{5} MBq) of tritium was released from the IP2 and IP3 site in 2006. A total of 7.87×10^{-4} Ci (29.1 MBq) of radioiodines and 4.76×10^{-5} Ci (1.76 MBq) of particulates was released from the IP2 and IP3 site in 2006 (Entergy 2007c). The gaseous discharges for 2006 are consistent with the radioactive gaseous effluents discharged from 2002 through 2005. The NRC staff expects variations in the amount of radioactive effluents released from year to year based on the overall performance of the plant and the number and scope of maintenance and refueling outages. The gaseous radioactive wastes reported by Entergy are reasonable, and the NRC staff noted no unusual trends.

Though Entergy has indicated that it may replace IP2 and IP3 reactor vessel heads and control rod drive mechanisms during the period of extended operation, such replacement actions are not likely to result in a significant increase in discharges of gaseous radioactive effluents above the amount discharged during normal plant operations. This is based on consideration that any gaseous effluents released during the outage will be offset by the amount of gaseous effluents that would not be generated, processed, and released during normal plant operations. Based on the NRC staff's evaluation of recent historical releases in the previous paragraph and based on the NRC staff's expectation that no significant increase in gaseous effluents from the potential replacement of the reactor heads and control rod drive mechanisms will occur, the NRC staff expects that similar quantities of radioactive gaseous effluents will be generated during normal operations and outages at IP2 and IP3 during the period of extended operation.

2.1.4.3 Solid Waste Processing

IP2 and IP3 solid radioactive wastes include solidified waste derived from processed liquid and sludge products; spent resins, filters, and paper; and glassware used in the radiation-controlled areas of the plant. Waste resin is stored in the spent resin storage tank to allow radioactive

decay. When a sufficient volume of resin is accumulated, it is moved from storage and placed into a high-integrity container. The wet waste is then dewatered and prepared for transportation in accordance with the plant's process control program. The process control program contains the criteria and requirements that the waste must meet to comply with NRC and U.S. Department of Transportation (DOT) requirements for transportation of radioactive waste on the public roads. The other solid radioactive wastes, such as paper, rags, and glassware, are also processed for shipping in accordance with the process control program. Entergy, when possible, sends the solid radioactive waste to a material recovery center or to a facility licensed to incinerate and perform other techniques to reduce the waste volume before disposal. Additional interim radioactive waste storage space is located in the IP1 containment.

<u>IP2</u>

At IP2, the original four steam generators are stored in the Original Steam Generator Storage Facility. The facility is made of reinforced concrete and is designed to contain contaminated materials and allow for decontamination of materials if necessary. The structure is built to prevent both the intrusion of water into the facility and the leakage of contaminated water from the facility. The floor of the facility is sloped to direct any liquids to a sump. The floor slab and lower portion of the walls have a protective coating to facilitate decontamination, if required. A passive high-efficiency filter is used to prevent airborne contamination from being vented outside the facility. This facility is located within the owner-controlled area outside of the protected area.

<u>IP3</u>

At IP3, solid radioactive waste (dry activated waste or solidified resins) may be stored in the IP3 Interim Radioactive Waste Storage Facility before being shipped off site. The facility is a concrete structure designed to minimize the impact of stored materials on the public and the environment. It is shielded to limit the offsite annual radiation dose to less than 5 mrem (0.05 mSv). As at IP2, a reinforced concrete structure is used to store the original four steam generators, which were removed in 1989. This structure, called the Replaced Steam Generator Storage Facility, is shielded to reduce radiation exposure, and all openings are sealed with no provision for ventilation. There is a locked and locally alarmed labyrinth entrance that allows for periodic surveillance of the steam generators. There are no gaseous or liquid releases from this facility.

<u>Solid Waste Shipment</u>

IP2 and IP3 radioactive waste shipments are packaged in accordance with NRC and DOT requirements. The type and quantities of solid radioactive waste generated at and shipped from the site vary from year to year, depending on plant activities (i.e., refueling outage, maintenance work, and fuel integrity). Entergy ships radioactive waste to the Studsvic facility in Irwin, Tennessee, the Race facility in Memphis, Tennessee, or the Duratek facility in Oak Ridge, Tennessee, where the wastes undergo additional processing before being sent to a facility for disposal. In the recent past, Entergy had shipped waste to the Barnwell facility in Barnwell County, South Carolina, or the Envirocare facility in Clive, Utah, for disposal (Entergy 2007a). In July 2008, however, the State of South Carolina closed access to radioactive waste generators in States that are not part of the Atlantic Low-Level Waste Compact. (Envirocare, however, remains open for Class A wastes.)

In the near term, Entergy is working to address the loss of the low-level solid radioactive waste disposal repository in Barnwell, South Carolina. During the NRC environmental site audit, IP2 and IP3 staff indicated that they would be able to safely store their low-level waste on site in existing onsite buildings. Entergy indicates that it is currently developing a comprehensive plan to address the potential need for long-term storage. The radiation dose from the storage of low-level radioactive waste would be required to continue to result in doses to members of the public that are below the limits in 10 CFR Part 20 and 40 CFR Part 190, "Environmental Radiation Protection Requirements for Normal Operations of Activities in the Uranium Fuel Cycle," which apply to all operations and facilities at the site.

In 2006, Entergy made a total of 49 shipments of Class A, B, and C solid radioactive waste to offsite processing vendors. The solid waste volumes were 5.31×10^4 cubic feet (1.50×10^3 m^3) of resins, filters, evaporator bottoms, and dry active waste, with an activity of 9.49×10^2 Ci (3.51×10^7 MBq). Entergy shipped no irradiated components or control rods in 2006 (Entergy 2007c). The solid waste volumes and radioactivity amounts generated in 2006 are typical of annual waste shipments made by Entergy. The NRC staff expects variations in the amount of solid radioactive waste generated and shipped from year to year based on the overall performance of the plant and the number and scope of maintenance work and refueling outages. The NRC staff finds the volume and activity of solid radioactive waste reported by Entergy are reasonable, and no unusual trends were noted.

Entergy has indicated that it may replace IP2 and IP3 reactor vessel heads and control rod drive mechanisms during the period of extended operation (Entergy 2008b), and such replacement actions are likely to result in a small increase in the amount of solid radioactive waste generated. This is partly because the number of personnel working at the plant will increase, leading to increased use of protective clothing and safety equipment and an increased use of filters. Also, work activities will create a general increase in debris that will have to be disposed of as radioactive waste. However, the increased volume is expected to be within the range of solid waste that can be safely handled by IP2 and IP3 during the period of extended operation. In the GEIS (NRC 1996), NRC indicated that doses from onsite storage of assemblies removed during refurbishment would be "very small and insignificant." Retired vessel heads will likely be stored on site in a concrete building (Entergy 2008b), subject to regular monitoring and dose limits under 10 CFR Part 20 and 40 CFR Part 190.

2.1.5 Nonradioactive Waste Systems

IP2 and IP3 generate solid, hazardous, universal, and mixed waste from routine facility operations and maintenance activities.

2.1.5.1 Nonradioactive Waste Streams

Nonradioactive waste is produced during plant maintenance, cleaning, and operational processes. Most of the wastes consist of nonhazardous waste oil and oily debris and result from operation and maintenance of oil-filled equipment.

The facility generates solid waste, as defined by the Resource Conservation and Recovery Act (RCRA), as part of routine plant maintenance, cleaning activities, and plant operations. These solid waste streams include nonradioactive resins and sludges, putrescible wastes, and recyclable wastes.

Universal wastes constitute a majority of the remaining waste volumes generated at the facility. Universal waste is hazardous waste that has been specified as universal waste by EPA. Universal wastes, including mercury-containing equipment, batteries, fluorescent bulbs, and pesticides, have specific regulations (40 CFR Part 273, “Standards for Universal Waste Management”) to ensure proper collection and recycling or treatment.

Hazardous wastes routinely make up a small percentage of the total wastes generated at the IP2 and IP3 facility and include spent and expired chemicals, laboratory chemical wastes, and other chemical wastes (Entergy 2007a). Hazardous waste is nonradioactive waste that is listed by EPA as hazardous waste or that exhibits characteristics of ignitability, corrosivity, reactivity, or toxicity (40 CFR Part 261, “Identification and Listing of Hazardous Waste”). RCRA, as well as the NYSDEC regulatory requirements set forth in Title 6 of the New York Codes, Rules, and Regulations (NYCRR) Parts 371-376, that regulate storage and handling of hazardous waste and requires a hazardous waste permit for facilities that store large quantities of hazardous waste for more than 90 days.

The IP2 and IP3 facility has hazardous and mixed waste storage facilities covered by permits issued by NYSDEC under NYCRR Part 373. The permits, NYD991304411 and NYD085503746, are for the accumulation and temporary onsite storage of hazardous and mixed waste for more than 90 days at IP2 and IP3 respectively. The permits have been administratively continued based on a conditional mixed waste exemption (Entergy 2007a).

Some amounts of chemical and biocide wastes are produced at the facility from processes used to control the pH in the coolant, to control scale, to control corrosion, to regenerate resins, and to clean and defoul the condensers. These waste liquids are typically discharged in accordance with the site’s State Pollutant Discharge Elimination System (SPDES) Permit, NY-0004472, along with cooling water discharges (Entergy 2007a).

Hazardous and universal wastes are collected in central collection areas. The materials are received in various forms and are packaged to meet all regulatory requirements before final disposition at an appropriate offsite facility. Entergy tracks wastes like waste oil, oily debris, glycol, lighting ballasts containing polychlorinated biphenyls (PCBs), fluorescent lamps, batteries, and hazardous wastes (i.e., paints, lead abatement waste, broken lamps, off-specification and expired chemicals)—by volume at the facility. The total amount of tracked hazardous and universal wastes for 2006 was 17,987 pounds (lb) (8158 kilograms (kg)) with waste oil making up 70 percent of the total weight (Entergy 2007a).

Most sanitary wastewater from the IP2 and IP3 facility operations is transferred to the Village of Buchanan publicly owned treatment works system. A few isolated areas at the facility have their own septic tanks. Although the sanitary wastewaters are nonradioactive, a radiation monitoring system continuously monitors the effluent from the protected area (Entergy 2007a).

The testing of the emergency generators and boiler operations generates nonradioactive gaseous effluents. Emissions are managed in accordance with IP2 and IP3 air quality permits, 3-5522-00011/00026 and 3-5522-00105/00009, respectively (Entergy 2007a).

Low-level mixed waste (LLMW) is waste that exhibits hazardous characteristics and contains low levels of radioactivity. LLMW at IP2 and IP3 is regulated under RCRA and NYSDEC regulatory requirements as set forth in 6 NYCRR Parts 373 and 374.

2.1.5.2 Pollution Prevention and Waste Minimization

Entergy's Waste Minimization Plan describes programs that have been implemented at the facility. This plan is used in conjunction with other waste minimization procedures, waste management procedures, chemical control procedures, and other site-specific procedures to reduce waste generation (Entergy 2007a).

2.1.6 Facility Operation and Maintenance

Maintenance activities conducted at IP2 and IP3 include inspection, testing, and surveillance to maintain licensing requirements and to ensure compliance with environmental and safety requirements. Various programs and activities currently exist at the facility to maintain, inspect, test, and monitor the performance of facility equipment. These maintenance activities include inspection requirements for reactor vessel materials, in-service inspection and testing of boilers and pressure vessels, the maintenance structures monitoring program, and water chemistry maintenance.

Additional programs include those implemented to meet technical specification surveillance requirements, those implemented in response to the NRC generic communications, and various periodic maintenance, testing, and inspection procedures. Certain program activities are performed during the operation of the unit, while others are performed during scheduled refueling outages. As mentioned in Section 2.1.2, Entergy typically refuels IP2 and IP3 on 24-month cycles.

2.1.7 Power Transmission System

The applicant has identified two 345-kV transmission lines that connect IP2 and IP3 to the Con Edison electrical transmission grid. Feeder W95 and feeder W96 deliver power from IP2 and IP3, respectively, to the Buchanan substation located across Broadway near the entrance to the IP2 and IP3 site. Other than these two transmission lines, no other lines or facilities were constructed specifically to connect the two generating units to the existing transmission grid. Because the Buchanan substation and the regional transmission system to which it connects were designed and constructed before IP2 and IP3 (Entergy 2007a; NRC 1975; USAEC 1972), they are beyond the scope of this evaluation.

Each of the W95 and W96 lines is approximately 2000 ft (610 m) long. The lines are within the site except for the terminal 100-ft (30.5-m) segments that cross Broadway and enter the substation. In addition to transmitting the output power from IP2 and IP3 off site, the transmission system also provides IP2 and IP3 with the auxiliary power necessary for startup and normal shutdown. Offsite (standby) power is supplied to IP2 and IP3 by 138-kV input lines that use the same transmission towers as the W95 and W96 output lines (Entergy 2005b; NRC 1975). The W95 and W96 lines are each within a separate right-of-way (ROW), so the ROWs total approximately 4000 ft (1220 m) in length. About 500 ft (150 m) of this ROW length is vegetated; the remainder crosses roads, parking lots, buildings, and other facilities. In the vegetated segments, the NRC staff observed that the ROW is approximately 150 ft (46 m) wide, the growth of trees is prevented, and a cover of mainly grasses and forbs is maintained.

2.2 Plant Interaction with the Environment

2.2.1 Land Use

Within the 239-acre (97-ha) Indian Point site, IP2 and IP3 (see Figure 2-3) are located north and south, respectively, of IP1, which is in SAFSTOR until it is eventually decommissioned. The developed portion of the IP2 and IP3 site is approximately 124.3 acres (50.3 ha), or over half the site (see Figure 2-3). The remaining portions of the site are unused, undeveloped, and include fields and forest uplands (approximately 112.4 acres (45.5 ha) and wetlands, streams, and a pond (2.4 acres (0.97 ha)). Much of the site (approximately 159 acres (64.3 ha)) has been disturbed at some time during the construction and operation of the three units (ENN 2007b).

The immediate area around the station is completely enclosed by a fence with access to the station controlled at a security gate. The plant site can be accessed by road or from the Hudson River. Land access to the plant site is from Broadway (main entrance). The existing wharf is used to receive heavy equipment as needed, although access to the site from the river is controlled by site access procedures. The plant site is not served by railroad. The exclusion area, as defined by 10 CFR 100.3, "Definitions," surrounds the site as shown in Figure 2-3 (Entergy 2007a).

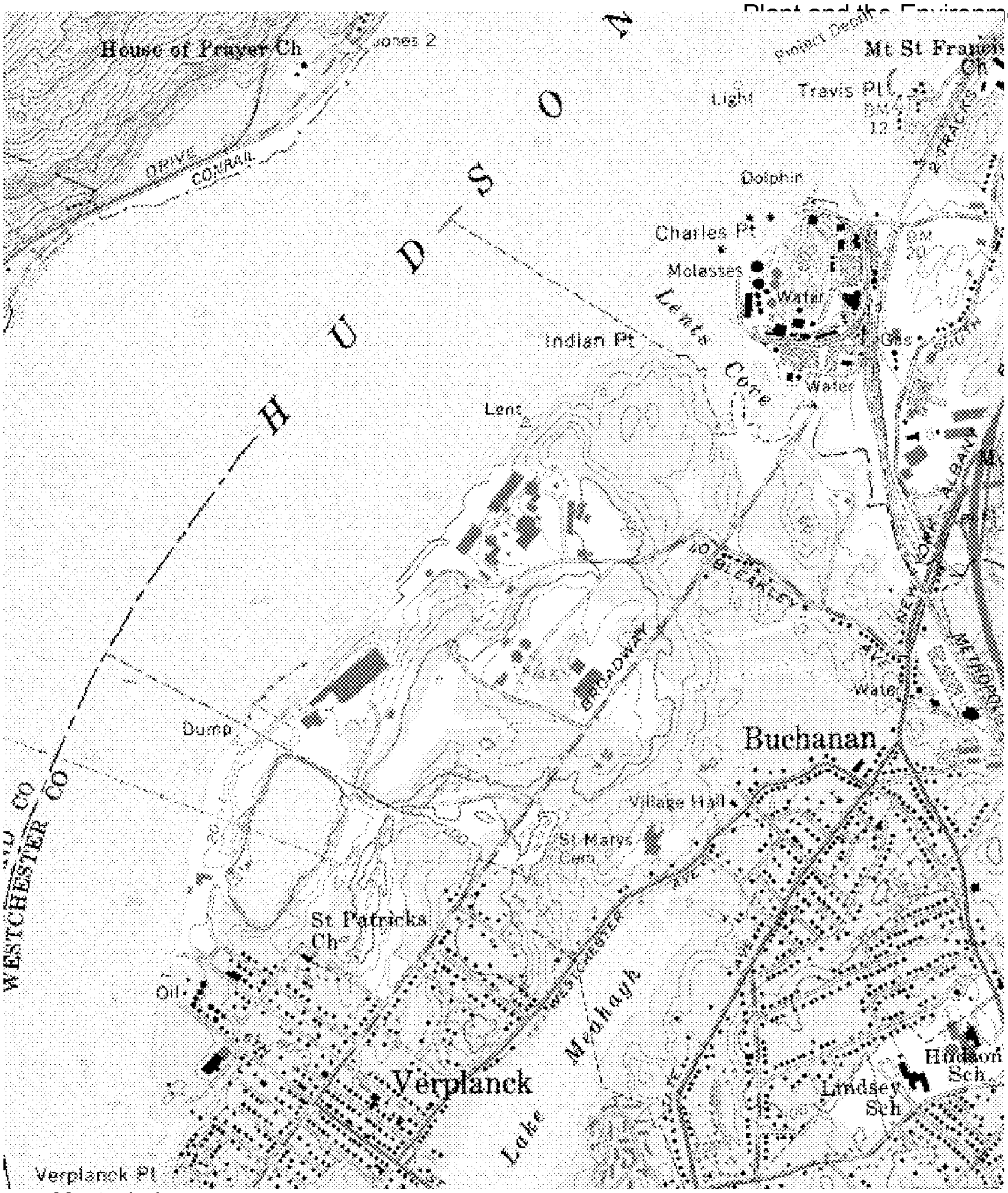
2.2.2 Water Use

The Hudson River is an important regional resource of significant aesthetic value in addition to providing transportation, recreation, and water supply. The Hudson River at IP2 and IP3 is tidally influenced and becomes increasingly so as it proceeds south. IP2 and IP3 have a once-through condenser cooling system that withdraws water from the Hudson River. The same amount of water that is withdrawn for condenser cooling is discharged. However, the discharged water is at an elevated temperature and, therefore, can induce some additional evaporation. The NRC staff conservatively estimates that this induced evaporation from elevated discharge temperature is less than 60 cfs (1.7 m^3/s). The remaining consumptive water uses are insignificant relative to induced evaporation.

2.2.3 Water Quality

Being tidally influenced, the salinity of the Hudson River varies as upstream flows and tides fluctuate. The salinity decreases when stream flows increase and tides drop. The salinity increases during periods of low flow and high tides. The periodic higher salinity levels limit some of the uses that a lower salinity river might support (e.g., drinking water supply).

Discharges to the Hudson River are regulated by the Clean Water Act (CWA). The CWA is administered by EPA. EPA has delegated responsibility for administration of the National Pollutant Discharge Elimination System to NYSDEC. The IP2 and IP3 ownership submitted timely and sufficient applications to renew its SPDES permits before the expiration of those permits in 1992. Pursuant to the New York State Administrative Procedure Act, these permits do not expire until NYSDEC makes its final determination. To date, this final determination has not been made. In 1991, NYSDEC, the facility owners, and several stakeholder groups entered into a consent order (issued pursuant to the Hudson River Settlement Agreement; see Section 2.2.5.3 for more information) to mitigate impacts of the thermal plume entering the Hudson River from the plant's discharge.



Source: Maptech, Inc.

Figure 2-9. Topographic features surrounding IP2 and IP3

IP2 and IP3 do not intentionally discharge contaminants in a manner that would contaminate the ground water beneath the site. However, in 2005, tritium was located beneath the IP2 and IP3 site. During a subsequent subsurface monitoring program at the site, radioactive forms of cesium, cobalt, nickel, and strontium also were found. The radiological impact of these leaks on ground water is discussed in Section 2.2.7 of this draft SEIS (the leaks are also mentioned in Section 2.1.4.1 of this draft SEIS).

2.2.4 Meteorology and Air Quality

2.2.4.1 Climate

IP2 and IP3 are located in the Village of Buchanan, New York, in Westchester County on the eastern bank of the Hudson River at approximately RM 43 (RKM 69). The river bisects the area within a 6-mi (9.7-km) radius of the site and geographically separates Westchester County from Rockland County to the west. The Hudson River flows northeast to southwest at the site but turns sharply northwest approximately 2 mi northeast of the plant. The western bank of the Hudson River is flanked by the steep, heavily wooded slopes of the Dunderberg and West Mountains to the northwest (elevations 1086 and 1257 ft (331 and 383 m) above mean sea level (MSL), respectively) and Buckberg Mountain to the west-southwest (elevation 793 ft (242 m) above MSL). These peaks extend to the west and gradually rise to slightly higher peaks (Entergy 2007a).

The climate is continental, characterized by rapid changes in temperature, resulting in hot summers and cold winters. The area, being adjacent to the St. Lawrence River Valley storm track, is subject to cold air masses approaching from the west and north. It has a variable climate, characterized by frequent and swift changes. The climate is also subject to some modification by the Atlantic Ocean. The moderating effect on temperatures is more pronounced during the warmer months than in winter when bursts of cold air sweep down from Canada. In the warmer seasons, temperatures rise rapidly in the daytime. However, temperatures also fall rapidly after sunset so that the nights are relatively cool. Occasionally, there are extended periods of oppressive heat up to a week or more in duration. Winters are usually cold and sometimes fairly severe. Furthermore, the area is also close to the path of most storm and frontal systems that move across the North American continent. Weather conditions often approach from a westerly direction, and the frequent passage of weather systems often helps reduce the length of both warm and cold spells. This is also a major factor in keeping periods of prolonged air stagnation to a minimum (NOAA 2004).

The State of New York has a climate that varies greatly. For example, the average January temperature ranges from 14 degrees Fahrenheit (F) (-10 degrees Celsius (C)) in the central Adirondacks to 30 degrees F (-1.1 degrees C) on Long Island. The average July temperature in the central Adirondacks is 66 degrees F (19 degrees C), and 74 degrees F (23 degrees C) on Long Island. The highest temperature ever recorded in the State was 108 degrees F (42 degrees C) at Troy on July 22, 1926. The lowest recorded temperature, -52 degrees F (-47 degrees C), occurred at Old Forge, in the Fulton Chain of Lakes area, on February 18, 1979 (World Book Encyclopedia 2006). In Westchester County, where IP2 and IP3 are located, temperatures are mild in the summer and cold in the winter. Buchanan, New York, has a mean daily maximum temperature range from 28 degrees F (-2.2 degrees C) in winter to 87 degrees F (31 degrees C) in summer. The mean daily minimum temperatures range from about

20 degrees F (-6.7 degrees C) in winter to about 72 degrees F (22 degrees C) in summer (Indian Point Energy Center 2004).

Precipitation varies considerably in New York. The areas of Tug Hill, the southwestern slopes of the Adirondacks, the central Catskills, and the southeast areas usually receive 44 in. (110 cm) of rain a year, while other portions of the State get only 36 in. (91 cm). The Great Lakes, with their broad expanse of open water, supply moisture for abundant winter snowfall. Syracuse, Rochester, and Buffalo routinely receive annual snowfalls that are the highest for any major city in the United States (World Book Encyclopedia 2006). Most of the precipitation in this area is derived from moisture-laden air transported from the Gulf of Mexico and cyclonic systems moving northward along the Atlantic coast. The annual rainfall is rather evenly distributed over the year. Also, being adjacent to the track of storms that move through the Saint Lawrence River Valley, and under the influence of winds that sweep across Lakes Erie and Ontario to the interior of the State, the area is subject to cloudiness and winter snow flurries. Furthermore, the combination of a valley location and surrounding hills produces numerous advection fogs which also reduce the amount of sunshine received (NOAA 2004).

In the IP2 and IP3 Buchanan area, precipitation averages 37 in. (94 cm) per year and is distributed rather evenly throughout the 12-month period. The lowest amount is in February, and the highest is in May (Indian Point Energy Center 2004). Although the Village of Buchanan area is subject to a wide range of snowfall amounting to as little as 20 in. (51 cm) or as much as 70 in. (180 cm), Westchester County snowfall amounts typically average between approximately 25 to 55 in. (64 to 140 cm) per year (NRCC 2006).

Wind velocities are moderate. The north-south Hudson River Valley has a marked effect on the lighter winds, and in the warm months, average wind direction is usually southerly. For the most part, the winds at Buchanan have northerly and westerly components. Destructive winds rarely occur. Tornadoes, although rare, have struck the area, causing major damage (NOAA 2004).

On average, seven tornadoes strike New York every year (USDOC 2008a). Westchester County has had a total of eight tornadoes since 1950, seven of which have been F1 or less (“weak” tornadoes). The eighth tornado, which struck portions of Westchester County on July 12, 2006, was rated as an F2 at its maximum intensity (briefly a “strong” tornado) but was an F1 for most of its existence. Based on climatic data compared to other regions of the United States, the probability of a tornado striking the IP2 and IP3 site is small, and tornado intensities in Westchester County are relatively low (USDOC 2008b).

2.2.4.2 Meteorological System

Entergy’s meteorological system consists of three instrumented towers, redundant power and ventilation systems, redundant communication systems, and a computer processor/recorder.

Entergy describes the primary system as a 122-m (400-ft) instrumented tower located on the site that provides the following:

- wind direction and speed measurement at a minimum of two levels, one of which is representative of the 10-m (33-ft) level
- standard deviations of wind direction fluctuations as calculated at all measured levels
- vertical temperature difference for two layers (122–10 m (400–33 ft) and 60–10 m (197–33 ft))

- ambient temperature measurements at the 10-m (33-ft) level
- precipitation measurements near ground level
- Pasquill stability classes as calculated from temperature difference (Indian Point Energy Center 2005)

The meteorological measurement system is located in a controlled environmental housing and connected to a power supply system with a redundant power source. A diesel generator provides immediate power to the meteorological tower system within 15 seconds after an outage trips the automatic transfer switch. Support systems include an uninterruptible power supply, dedicated ventilation systems, halon fire protection, and dedicated communications (Indian Point Energy Center 2005).

Entergy indicates that the meteorological system transmits 15-minute average data simultaneously to two loggers at the primary tower site. One data logger transmits to a computer that determines joint frequency distributions, and the second transmits to a computer in the Buchanan Service Center that allows remote access to the data. Meteorological data can be transmitted simultaneously to emergency responders and the NRC in a format designated by NUREG-0654/FEMA-REP-1. Fifteen-minute averages of meteorological parameters for the preceding 12 hours are available from the system (Indian Point Energy Center 2005).

The backup meteorological system is independent of the primary system and consists of a backup tower located approximately 2700 ft (833 m) north of the primary tower and a data acquisition system located in the Emergency Operations Facility. The backup system provides measurements at the 10-m (33-ft) level of wind direction and speed and an estimate of atmospheric stability (Pasquill category using sigma theta, which is a standard deviation of wind fluctuation). The backup system provides information in real-time mode. Changeover from the primary system to the backup system occurs automatically. In the event of a failure of the backup meteorological measurement system, a standby backup system exists at the 10-m (33-ft) level of the Buchanan Service Center building roof. It also provides measurements of the 10-m (33-ft) level of wind direction and speed and an estimate of atmospheric stability (Pasquill category using sigma theta, which is a standard deviation of wind fluctuations). The changeover from the backup system to the standby system also occurs automatically. As in the case of the primary system, the backup meteorological measurement system and associated controlled environmental housing system are connected to a power system which is supplied from redundant power sources. In addition to the backup meteorological measurement system, a backup communications line to the meteorological system is operational. During an interim period, the backup communications are provided via telephone lines routed through a telephone company central office separate from the primary circuits (Indian Point Energy Center 2005).

2.2.4.3 Air Quality

Under the Clean Air Act, EPA established National Ambient Air Quality Standards (NAAQS) for specific concentrations of certain pollutants, called criteria pollutants. Areas in the United States having air quality as good as or better than these standards (i.e., pollutant levels lower than the NAAQS) were designated as attainment areas for the various pollutants. Areas with monitored pollutant levels greater than these standards are designated as nonattainment areas. Areas in the United States whose pollutant levels were greater than the NAAQS and are now lower than the NAAQS are designated as maintenance areas.

Four States are located within a 50-mi (80-km) radius of the site. These include Pennsylvania's eastern tip, Connecticut, New York, and New Jersey. The 50-mi (80-km) radius includes nonattainment areas for the ozone (O_3) 8-hour standard, particulate matter less than 10 microns in diameter (PM_{10}), and particulate matter less than 2.5 microns in diameter ($PM_{2.5}$). The portion of Pennsylvania (Pike County) located within the 50-mi (80-km) radius is in attainment for all criteria pollutants.

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, King, Nassau, Orange, Queens, Richmond, Rockland, Suffolk, and Westchester*—O_3 and $PM_{2.5}$

- Dutchess—O_3
- New York*—O_3, PM_{10}, and $PM_{2.5}$
- Putnam—O_3

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

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 25 tons (t) (23 metric tons (MT)) per year per station by restricting engine run time and fuel consumption. IP2 and IP3 are not subject to the Risk Management Plan (RMP) requirements described in 40 CFR Part 68, as no RMP-regulated chemicals stored on site exceed the threshold values listed in 40 CFR Part 68 (Entergy 2007a).

There are no Mandatory Class I Federal areas designated by the National Park Service, U.S. Fish and Wildlife Service (FWS), or the U.S. Forest Service within 50 mi (80 km) of the site. Class I areas are locations in which visibility is an important attribute. As defined in the Clean Air Act, they include several types of areas that were in existence as of August 7, 1977—national parks over 6000 acres (2430 ha), national wilderness areas, and national memorial parks over 5000 acres (2020 ha), and international parks (NPS 2006a). The closest Class I Area is Lye Brook Wilderness Area, Vermont, approximately 150 mi (240 km) east-northeast of IP2 and IP3 (NPS 2006b).

2.2.5 Aquatic Resources

In this section, the NRC staff describes the physical, chemical, and biological characteristics of the Hudson River estuary. In addition, the NRC staff describes the major anthropogenic events that have influenced the estuary and the history of regulatory action over the past 50 years.

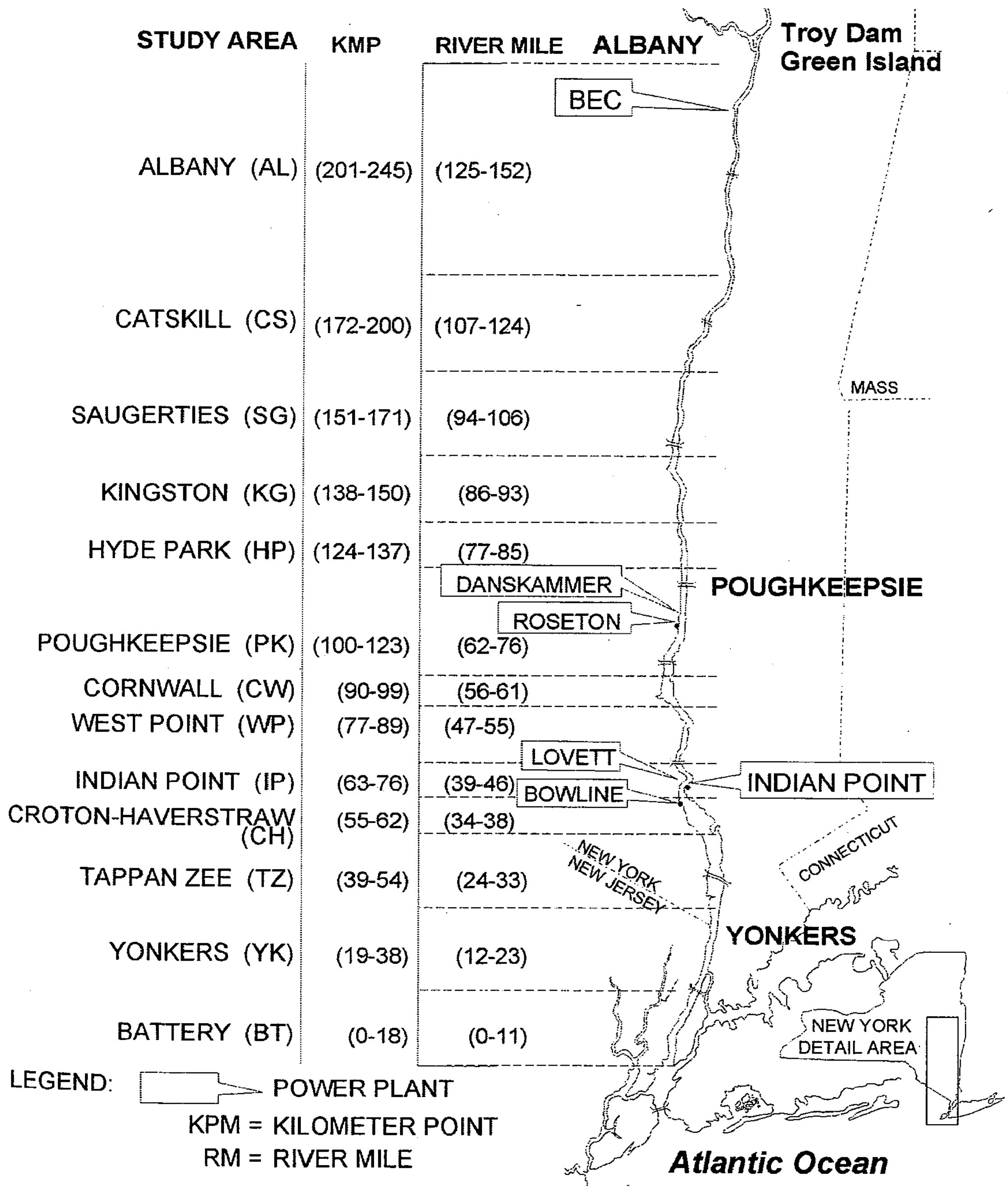
2.2.5.1 The Hudson River Estuary

Watershed Description

The Hudson River originates at Tear-of-the-Clouds in the Adirondack Mountains of northern New York State. From its source, the river flows south 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 (sq mi) (34,540 sq km), 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 (Abood et al. 2006). The basin is bounded by the St. Lawrence and Lake Champlain drainage basins to the north; the Connecticut and Housatonic River basins to the east; the Delaware, Susquehanna, Oswego, and Black River basins to the west; and the basins of small tributaries and New York Harbor on the south. From the Troy Dam to the Battery, the lower Hudson River basin is about 154 mi (248 km) long and drains an area of about 5277 sq mi (13,670 sq km). The average slope of the lower Hudson River, defined in terms of the half-tide level, is about 0.6 m (2 ft) over 150 mi (240 km) (Abood et al. 2006). During the development of the multiutility studies in the 1970s, the lower portion of the Hudson River from the Troy Dam to the Battery was divided into 13 study areas (river segments), depicted in Figure 2-10. The study area and river segment designations identified in the figure will be used to discuss monitoring results and data collection locations throughout this document.

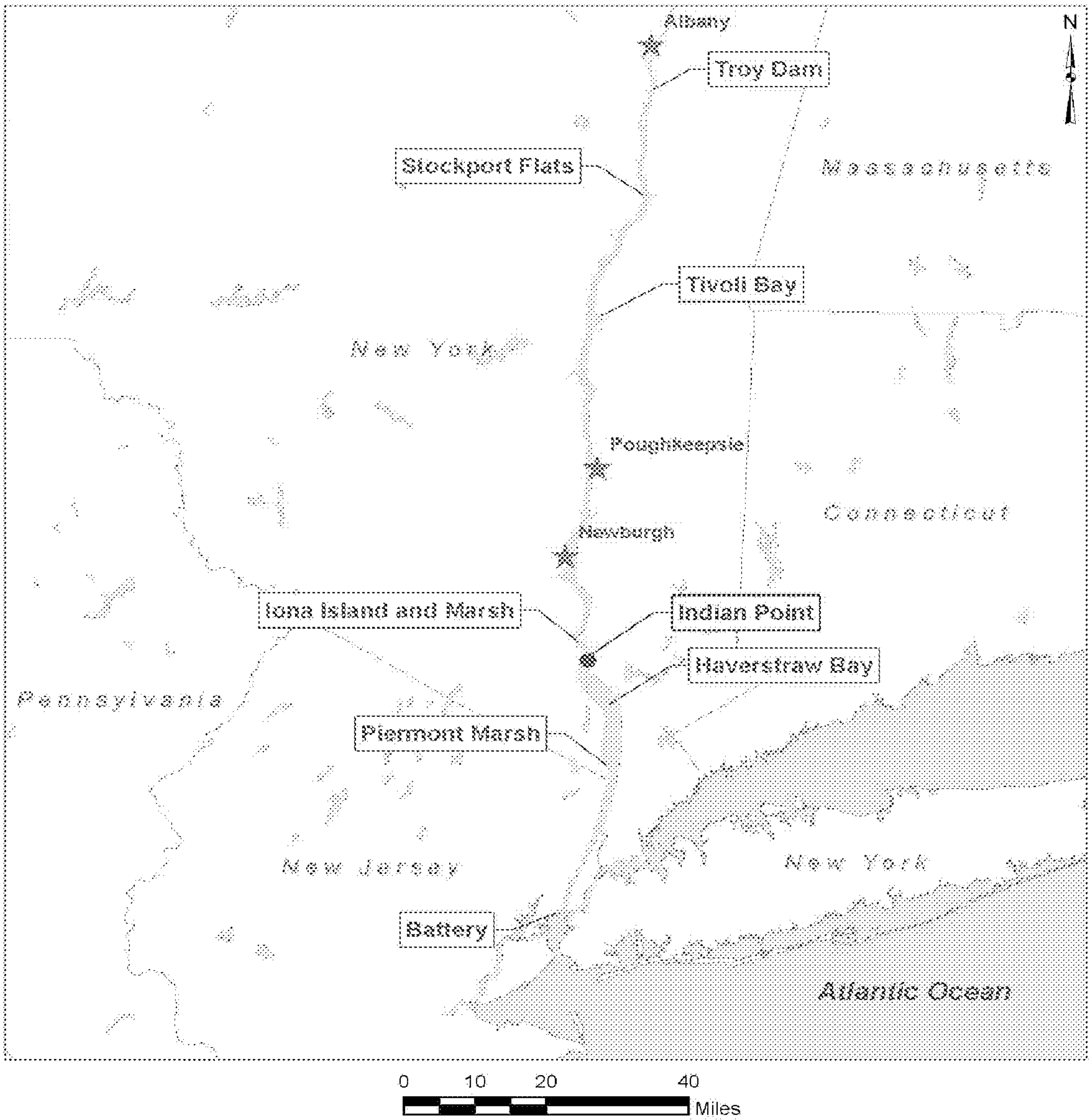
Lower Hudson River Basin Habitats

The lower Hudson River estuary contains a variety of habitats, including tidal marshes, intertidal mudflats, and subtidal aquatic beds. These habitats exist throughout the length of the river and can be freshwater, brackish, or saline. The freshwater communities are generally located north of Newburgh (CHGEC 1999), with brackish communities found farther south. There are four locations within the estuary designated as National Estuarine Research Reserve System Sites by the National Oceanic and Atmospheric Administration (NOAA) and NYSDEC, including, from north to south, Stockport Flats, Tivoli Bay, Iona Island, and Piermont Marsh (NOAA 2008), as shown in Figure 2-11. The lower Hudson River basin also contains Haverstraw Bay, shown in Figure 2-11, a significant nursery area for a variety of fish, including striped bass, white perch, Atlantic tomcod, and Atlantic sturgeon, and a wintering area for the federally listed endangered shortnose sturgeon (FWS 2008a).



1 Source: Abood et al. 2006

2 **Figure 2-10. Hudson study area and river segments**



1 **Figure 2-11. Hudson river area and national estuarine research sites**

Community type and habitat characteristics are influenced by the extent of tidal excursions, which are controlled by tidal stage and river flow. During drought periods, the 100 milligrams per liter (mg/L) (0.1 parts per thousand (ppt)) salinity front can extend up to 130 km (81 mi) above the ocean entrance (Abood et al. 2006).

In general, narrow, shallow river reaches with high current flow have extensive bottom scour and low organic carbon levels. The coarse gravel substrate provides spawning habitat for some species. Similar characteristics can also be found where tributaries to the main river stem join the Hudson. High current speeds through deep basins can generate turbulent flow that keeps weakly swimming zoo- and icthyoplankton suspended in the water column and away from silty nearshore locations and potential predators. Shallow, shore-zone habitats often support submerged aquatic vegetation that provides habitat and protection for juvenile fish and other aquatic communities. Broad, shallow basins often create depositional environments where fine sediments, high levels of organic carbon, and nutrients are present. These environments are generally highly productive and may serve as nursery areas for juvenile fish species (CHGEC 1999).

Human activities, however, have significantly affected the lower Hudson River estuary. Increasing human populations along the estuary throughout recent history have contributed to increased habitat alteration. (Section 2.2.5.2 examines human influences in greater detail.)

The construction of railroad lines along the banks of the river disrupted the connection of the river to marshland and wetland habitats. Construction of causeways interfered with or completely blocked tributary inlets, disrupting sediment transport and other natural phenomena. Anthropogenic activities also resulted in the dredging of some habitats and the filling of others. The historical impacts to the lower Hudson River habitats are discussed later in this section.

To describe the predominant habitat features associated with the lower Hudson River estuary, Central Hudson Gas and Electric Corporation (CHGEC 1999) divided the lower river from the Troy Dam to the Battery into five subsections of roughly comparable volume consisting of one or more of the regions and river segments identified in Figure 2-10. Beginning at the Troy Dam, the first subsection extends from RM 152 to 94 (RKM 245 to 151) and includes the Albany, Catskill, and Saugerties study areas. This subsection of the river is relatively narrow and has extensive shoals and numerous tributaries. Within this subsection and approximately 6.2 mi (10 km) south of the Troy Dam, the river is about 574 ft (175 m) wide—the narrowest part of the lower Hudson (Abood et al. 2006). The slope of the river is also greatest in this subsection and generates current velocities greater than in other areas.

The second subsection of the river extends from RM 93 to 56 (RKM 150 to 90) and includes the Kingston, Hyde Park, Poughkeepsie, and Cornwall study areas. This subsection contains a series of progressively deeper basins, and the volume of this area is approximately 1.5 times larger than that of the adjacent upriver areas. Shallow shoreline and shoal areas are common only in the southernmost end of this subsection.

The third subsection defined by CHGEC (1999) extends from RM 55 to 39 (RKM 89 to 63), and includes the West Point and IP2 and IP3 study areas. At this location, the Hudson Highlands land mass forced glaciers through a narrow constriction, resulting in the deepest and most turbulent flow observed in the lower Hudson. Within this subsection, the river channel narrows abruptly, bends sharply to the east, and reaches a depth of over 150 ft (46 m). At the lower portions of this subsection, the river bottom consists of a series of progressively shallower

gouges that result in a corrugated bottom that ends in shallow water behind the Hudson Highlands. The IP2 and IP3 and Bowline Point power stations (along with the no-longer-operating Lovett station) are located within this river subsection.

The fourth subsection of the river identified by CHGEC (1999) is located from RM 38 to 24 (RKM 62 to 39) and includes the Croton-Haverstraw and Tappan Zee study areas (Figure 2-6). This is the widest and shallowest portion of the lower Hudson River and has the most extensive shoal and shore zone areas. The presence of slow-moving currents and shoal areas results in the deposition of suspended sediment, organic carbon, and nutrients. The major source of suspended sediment to the Hudson is associated with watershed basin runoff and erosion, and basin-wide loads have been estimated at 800,000 t/yr (726,000 MT/yr) (Abood et al. 2006). The presence of slow-moving currents, shoal and shore-zone habitat, and high carbon and nutrient inputs makes this a highly productive portion of the lower Hudson River and provides important spawning and nursery areas for juvenile fish.

The fifth subsection of the river begins at RM 24 (RKM 38) and extends to the river's entrance into New York Harbor, encompassing the Yonkers and Battery study areas. In this subsection, the river again constricts and gradually deepens as it enters New York Harbor. In this location, the river is generally straight and contains few shoal areas or shore-zone habitats. The final 12 mi (19 km) of the lower Hudson have extensive armoring and contain little remaining natural shoreline (CHGEC 1999).

Sampling Strata Definitions

To effectively sample and study the lower Hudson, researchers have attempted to define specific zones, habitats, or locations within the river. These specific locations, often called strata, provide researchers with a quantitative way to sample the environment and integrate the resulting information. A variety of attempts have been made to define the channel morphology and thus the potential strata of the lower Hudson. Miller et al. (2006) describe three major habitat areas in the lower Hudson:

(1) Intertidal: Areas exposed at low tide and submerged at high tide that include mud flats, sand, broadleaf marsh, and emergent intertidal vegetation.

(2) Shallows: Areas of the river less than 6.6 ft (2.0 m) deep at mean low tide. This habitat supports submerged aquatic vegetation (SAV) in the river and is considered one of the most productive habitats in the estuary and of great ecological importance.

(3) Deepwater: Areas of the river greater than 6.6 ft (2.0 m) deep at mean low tide. This area represents the limit of light penetration and generally does not support SAV.

During the development of the Hudson River Utilities studies of the lower Hudson River in the 1970s, the study areas and river segments were divided into four primary strata to support fish and plankton investigations. These strata provide a geomorphological basis for partitioning the river and are still used to define sampling locations (ASA 2007):

(4) Shore: The portion of the Hudson River estuary extending from the shore to a depth of 10 ft (3.0 m). This area was primarily sampled by beach seine.

(5) Shoal: The portion of the Hudson River extending from the shore to a depth of 20 ft (6.1 m) at mean low tide.

(6) Bottom: The portion of Hudson River extending from the bottom to 10 ft (3.0 m) above the bottom where the river depth is greater than 20 ft (6.1 m) mean low tide.

(7) Channel: The portion of the Hudson River not considered bottom where river depth is greater than 20 ft (6.1 m) at mean low tide.

Hydrodynamics and Flow Characteristics

In the lower Hudson River, freshwater flow is one of the most important factors in determining and influencing the physical, chemical, and biological processes in the estuary and the resulting interactions within the food web. Hydrodynamics and flow characteristics are controlled by a complex series of interactions that include short- and long-term fluctuations in meteorological conditions, precipitation and runoff in the upstream portion of the watershed, the influence of tides and currents in downstream portions of the river, and the presence of a "salt wedge" that moves up- or downstream depending on river flow and tidal fluctuation (Blumberg and Hellweger 2006). Freshwater flow varies throughout the year, with maximum flow occurring during the months of March through May, with low-flow conditions beginning in June and continuing until November (Abood et al. 2006). Under normal conditions, approximately 75 percent of the total freshwater flow enters the lower Hudson River at Troy, with the remaining portion contributed by tributaries discharging into the upper reach of the estuary (CHGEC 1999; Abood et al. 2006). Because of tidal oscillation in the estuary, it is not possible to accurately measure freshwater flow in the lower estuary. Freshwater flow is, however, monitored by the U.S. Geological Survey (USGS) at Green Island, the farthest downstream USGS gauge above tidewater (CHGEC 1999; Abood et al. 2006). Data recorded from this gauge from 1948 to 2006 show that the mean annual flow was approximately 14,028 cfs (397.23 m^3/s). The lowest recorded annual flow was 6400 cfs (180 m^3/s) in 1965; the highest was 22,100 cfs (626 m^3/s) in 1976. Measured flows from Green Island from 1996 to 2006 ranged from 11,400 cfs (323 m^3/s) in 2002 to over 18,000 cfs (510 m^3/s) in 1996 (USGS 2008).

Salinity

CHGEC (1999) describes four salinity habitat zones in the Hudson River:

(1) polyhaline (high salinity): RM 1–19 (RKM 2–31)

(2) mesohaline (moderate salinity): RM 19–40 (RKM 31–64)

(3) oligohaline (low salinity): RM 40–68 (RKM 64–109)

(4) tidal freshwater: RM 68–152 (RKM 109–245)

The IP2 and IP3 and Bowline Point facilities are located in the oligohaline zone and generally experience salinities of 0.5 to 5 ppt. The actual salinity present at a given time and place can vary considerably in the lower regions of the river because of salinity intrusion, which occurs throughout the year. The typical tidal excursion in the lower Hudson River is generally 3 to 6 mi (5 to 10 km), but can extend up to 12 mi (19 km) upstream. During the spring, the salt front is located between Yonkers and Tappan Zee and moves upstream to just south of Poughkeepsie during the summer (Blumberg and Hellweger 2006). Abood et al. (2006) report that, during drought periods, the salt front (defined as water with a salinity of 100 mg/L (0.1 ppt)) can extend up to RM 81. Stratification also occurs within this salt-intruded reach. Studies by Abood et al. (2006) suggest that from 1997–2003, salinity in the Hudson River has increased approximately 15 percent for a given flow rate. The authors suggest that this conclusion be viewed with

caution and that further analysis is required to confirm this finding. Real-time monitoring of the salt front position on the lower Hudson River is provided by USGS and can be accessed via its Web site (USGS 2008).

Temperature

Water temperatures in the Hudson River vary seasonally, with a maximum temperature of 25 degrees C (77 degrees F) occurring in August and a minimum temperature of 1 degree C (34 degrees F) occurring in January–February. The magnitude and distribution of water temperatures in the estuary are influenced by a variety of factors and complex relationships. Abood et al. (2006) identified four categories of parameters that play a significant role in water temperature—(1) atmospheric conditions, including radiation, evaporation, and conduction, (2) hydrodynamic conditions, including channel geometry, flow, and dispersion, (3) boundary conditions associated with the temperature of the ocean and freshwater, and (4) anthropogenic inputs, including those associated with activities that use river water for cooling purposes. The four parameters are interrelated and collectively influence temperature ranges and distributions in the estuary. Anthropogenic influences are of particular concern because they generally represent a constant influence on the system that may be controlled or managed, unlike those influences associated with climate, river morphology/geometry, and natural interactions between the river and ocean. Abood et al. (2006) indicate that the greatest percentage of artificial (anthropogenic) heat input into the lower Hudson River estuary is associated with the use of river water for condenser cooling in support of electrical power generation. The authors indicate that there are currently six power plants operating in the lower Hudson River estuary, with a total electrical generation of approximately 6000 MW(e), that use the Hudson River as cooling water. These plants collectively use 4.6 million gpm (290 m^3/s) and reject approximately 8×10^{11} British thermal units per day (Btu/day) (2.3×10^8 kilowatt-hours per day (kWh/day)), or 9800 MW of thermal power output). Anthropogenic activities can also result in a net cooling effect on the river. An example given by Abood et al. (2006) suggests that a 1-million-gallon-per-day (mgd) (3800-m^3/day) sewage effluent facility discharging water at 18 degrees C (64 degrees F) during the summer would cool the river because river ambient temperatures are higher.

Attempts to determine long-term changes to the temperature of the lower Hudson River are often confounded by changes in measurement locations and procedures, especially in long-term studies.

An analysis of long-term temperature trends in the lower Hudson River was attempted by Ashizawa and Cole (1997), using data obtained from the Poughkeepsie Water Works (PWW), which processes drinking water. This facility is located in the Poughkeepsie study area approximately 30 mi (48 km) upstream from IP2 and IP3 (Figure 2-6). A nearly continuous data set is available from PWW, beginning in 1908 and continuing to the present day. The data set represents water withdrawn from the Hudson River approximately 14 ft (4.3 m) below low tide. The results of the study show that the overall mean annual water temperature at the intake location was 12.2 degrees C (54 degrees F), and that water temperatures were highly correlated with air temperature during the winter and spring months. Although the overall trends in temperature suggested a gradual warming, the authors concluded that the relationship was not monotonic (i.e., showing change in only one direction over time). Rather, there were periods of both increasing and decreasing temperatures, with episodes of statistically significant warming occurring approximately 22.7 percent of the time and episodes of significant cooling occurring 11.5 percent of the time. During the period from 1918 to 1990, the authors observed

a significant increase in temperature, with a rate of warming of 0.12 degrees C (0.22 degrees F) per decade. The sharpest increase during that time occurred from 1971 to 1990 at 0.46 degrees C (0.83 degrees F) per decade; the sharpest cooling occurred from 1908 to 1923 at 0.79 degrees C (1.42 degrees F) per decade. The authors noted that there has been only one cooling event since 1923 (1968 to 1977), which occurred during a time of greater than average rainfall and record-setting freshwater flows, illustrating the complex relationships between weather, river flow, hydrodynamic connections, and anthropogenic effects discussed earlier.

Dissolved Oxygen

As discussed above, obtaining reliable data and trends associated with temperature and dissolved oxygen (DO) can be problematic in dynamic, open-ended systems. Measurements obtained during routine sampling within the river provide only a snapshot of actual conditions; measurements taken continuously from fixed, known locations provide long-term records, but only for the point or area of interest. Declines in DO can be caused by both natural and anthropogenic activities and may be transient or persist episodically or continually through time.

In some cases, observed declines in DO at specific times and locations in the Hudson River have been at least partially attributed to the appearance of invasive species, such as zebra mussels (Caraco et al. 2000). Even episodic events can have serious implications for fish and invertebrate communities and dramatically alter marine and estuarine food webs. To evaluate long-term DO trends in the lower Hudson River, Abood et al. (2006) examined two long-term data sets of DO observations collected by the New York City Department of Environmental Protection (NYCDEP) and covering the lower reaches of the river. Measurements of DO taken in August from 1975 to 2000 during the Long River Surveys indicate the lowest percent saturation (less than 75 percent) at West Point and the highest (greater than 90 percent) at the Kingston and Catskill reaches (Figure 2-6). Percent saturation at the river segment encompassing IP2 and IP3 was approximately 76 percent. Based on the NYCDEP data set, the authors concluded that there has been a substantial increase in DO since the early 1980s, probably resulting from the significant upgrades to the Yonkers and North River Sewage Treatment Plants in the lower reach of the Hudson.

Organic Matter

Organic matter can enter and influence a food web from two sources—autochthonous inputs, which are produced within the aquatic system, and allochthonous inputs, which are imported to the aquatic system from the surrounding terrestrial watershed (Caraco and Cole 2006). In the lower Hudson River, autochthonous sources of carbon originating within the river are associated with the primary production of phytoplankton and macrophyte communities. Studies by Caraco and Cole (2006) of the Hudson River from Albany to Newburgh during May–August 1999 and 2000 concluded that runoff from the upper Hudson and Mohawk River watershed was responsible for the majority of the allochthonous sources of carbon, represented as dissolved organic carbon (DOC) and particulate organic carbon (POC). Inputs from sewage, adjoining marshes, and tributaries accounted for less than 25 percent of the inputs. Total organic carbon (TOC) inputs were on average highest at the uppermost stretch of the Hudson and decreased down river by over twofold. Allochthonous loads were approximately fourfold lower in 1999 than in 2000 for all three river sections studied. The authors noted that the importance of allochthonous and autochothonous loads varied more than thirtyfold across space and time and that the variation was related to hydrologic inputs. During the summer of 1999 (the driest in

15 years), loadings of allochthonous inputs were low, but phytoplankton biomass and primary productivity were high. The resulting ratio of autochthonous/allochthonous inputs was tenfold greater than that measured during the summer of 2000 (the wettest in 15 years). These data suggest to the NRC staff that variations in sources and the importance of carbon inputs can be influenced by a variety of nonanthropogenic factors and result in changes to food web structure and function that directly impact higher trophic levels.

Nitrogen loading to rivers and estuaries comes primarily from forest and agricultural drainage, discharge from sewage treatment plants, and from nonpoint sources associated with urbanization. The most common forms of nitrogen in these systems are amino compounds originating from plant and animal proteins (CHGEC 1999). In the Hudson River, nitrate is the major contributor to the total nitrogen load, and in the lower Hudson River, approximately half of the total inorganic nitrogen loading is attributed to wastewater treatment systems and urban runoff (CHGEC 1999).

Total nitrogen and ammonia concentrations in the Hudson from Troy to Yonkers (obtained from EPA STORET) show differing trends from 1975 through 1992. Total nitrogen concentrations appear to vary without trend, while ammonia concentrations appear to be highest in river stretches near Yonkers and at locations upstream of Poughkeepsie (CHGEC 1999).

Phosphorus, in the form of phosphates, enters river systems as leachates from rock formations and soil. Additional inputs are associated with wastewater treatment plant discharges. Inorganic phosphates are used by plants and converted to organic forms that are used by animals (CHGEC 1999). Total phosphorus concentrations in the Hudson River during August 1974 suggest that the highest concentrations are associated with the lower 25 RM (40 RKM). Ortho-phosphorus concentrations from the EPA STORET database from 1975 through 1992 suggest that the highest concentrations are associated with the Yonkers-Piermont and Glenmont-Troy areas of the upper river.

The distribution and ratios of allochthonous and autochthonous nutrient inputs form the basis of complex food webs that can have large influences on upper trophic levels. Macronutrients such as carbon, nitrogen, phosphorus, and silicon are used by plants as raw materials to produce new biomass through photosynthesis. In some freshwater systems, the lack or excess of a specific macronutrient can limit growth or contribute to eutrophication and result in basinwide impacts to aquatic resources.

2.2.5.2 Significant Environmental Issues Associated with the Hudson River Estuary

Early Settlement

Anthropogenic impacts to the Hudson River ecosystem have existed for many centuries, with a possible origin approximately 11,000 years ago, after the retreat of the Wisconsin-stage ice sheet (CHGEC 1999). Swaney et al. (2006) categorized changes in watershed characteristics and effects based on four broad time scales—pre-European settlement, precolonial and colonial settlement, 19th century, and 20th century (Table 2-1). To put the scale of the anthropogenic impacts to the Hudson River watershed in context, the human population within the watershed has grown from approximately 230,000 at the time of the first census in 1790 to approximately 5 million today (not including parts of the boroughs of New York City outside the watershed, such as Queens). In 1609, the Hudson River watershed was almost entirely forested; by 1880, 68 percent of the watershed was farmland. Available records show that from the early 18th century to 1993, nearly 800 dams were constructed in the watershed, ranging in height from 2 to

700 ft (0.6 to 213 meters) (Swaney et al. 2006). A brief chronology of significant events that occurred from pre-European settlement to modern times is presented below.

Before settlement by European explorers, impacts associated with aboriginal populations were restricted to those from activities associated with hunting and gathering, and localized fires. During precolonial and colonial settlement, immigrants cleared large portions of forest cover to accommodate agriculture. These activities altered watershed dynamics and increased settlement loads and temperature in streams and rivers. Dramatic anthropogenic impacts occurred during the 19th century as populations along rivers, streams, and coastal areas increased, land clearing continued, and construction of roads, bridges, railroads, canals, and industrial centers occurred to support the emerging industrial revolution. The emergence of tanning and logging activities resulted in large-scale clearing of forests, construction of roads that were later expanded into highways and railroad lines, and the development of dams and canals to control floods and divert water for human needs. All of these activities resulted in profound changes to the dynamics of the Hudson River watershed. In some cases, the presence of railroad lines or highways effectively isolated nearby wetland communities from the main stem of the river; in other cases, wetland and marsh areas were filled and destroyed. Dredging and dam development significantly altered the flow characteristics of the Hudson River and influenced the migratory patterns of many species. (Swaney et al. 2006)

During the latter part of the 19th century, the growing human population created increased pollution and nutrient loading, which remained unregulated until the mid-20th century. Anthropogenic impacts occurring during the 20th century include the expansion of human population centers, further development of infrastructure to support industrial development (highways, roads, rail lines, factories), and a gradual shift in agricultural practices from traditional methods to new technologies that used specialized fertilizers, pesticides, and other agrochemicals. Industrialization during the 19th and 20th centuries also provided pathways for invasive species and nuisance organisms to colonize new habitats via canals, ship ballast water, and accidental or deliberate agricultural introductions. (Swaney et al. 2006)

During the latter part of the 20th century, environmental awareness of degraded conditions resulted in the creation of important environmental laws and monitoring programs and significant improvements to wastewater treatment facilities. The laws and activities resulted in significant improvements to some water-quality parameters and a new awareness of emerging threats (e.g., the presence of endocrine-disrupting pharmaceuticals, nanomaterials, and other contaminants or constituents). A brief description of some of the significant environmental issues and anthropogenic events is presented below. (Swaney et al. 2006)

<u>Dredging, Channelization, and Dam Construction</u>

As described above, dredging, channelization, and dam construction within the Hudson River watershed has occurred for over 200 years. The U.S. Army Corps of Engineers (USACE) has maintained a shipping channel from the ocean to the Port of Albany since the late 18th century and dredges the channel on an as-needed basis (CHGEC 1999). Dredging in some river segments occurs every 5 years (Miller et al. 2006). In some cases, dredging has significantly changed the hydrodynamic characteristics of the river and resulted in significant losses of intertidal and shallow water nursery habitats for fish (Miller et al. 2006). As described above, from the early 18th century to 1993, nearly 800 dams were constructed in the watershed, ranging in height from 2 to 700 ft (0.6 to 213 m) (Swaney et al. 2006). A study of the inorganic

and organic content of marshes within the watershed by Peteet et al. (2006) revealed a pattern of decreasing inorganic content with the arrival of the Europeans to the present day that was probably the result of the construction of tributary dams. The presence of dams, river channelization, and shoreline armoring to protect road and rail lines disconnects or interferes with normal river processes and often results in an overall decrease of sediment transport into and through the estuary. Because these structures are now an existing part of the landscape, in most cases, it is extremely difficult or impossible to restore historical river structure and function.

Industry and Water Use Impacts

As described above, anthropogenic impacts on the watershed from aboriginal cultures were generally small and restricted to effects associated with hunter-gatherer community activities and the presence of fires. Before the 1900s, the dominant industries were those of the primary sector (agriculture, forestry, fishing, mining). During the 1900s, there was an increase in the use of the Hudson River to provide transportation, drinking water, and water for industrial activities. During the development of industrial activity, there was a progressive increase in secondary sector industries, including the manufacture of food products, textiles, pulp and paper products, chemical, machinery, and transportation-related goods (CHGEC 1999).

The Hudson River was and is used as a source of potable water, a location for permitted waste disposal, a mode of transportation, and a source of cooling water by industry and municipalities. As of 1999, at least five municipalities use the lower Hudson as a source of potable water, and Rohmann et al. (1987) identified 183 separate industrial and municipal discharges to the Hudson and Mohawk rivers. 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 (CHGEC 1999).

Table 2-1. Historical Impacts on the Hudson River Watershed

Pre-European Settlement	
Aboriginal agriculture	Localized fires and associated changes in biomass, habitat, and nutrient dynamics
Precolonial and Colonial Settlement	
Land clearing	Removal of forest cover and changes in habitat and streamflow characteristics
19th Century	
Tanning	Preferential clearing of forests leading to increased sediment and organic loads to water bodies
Logging	Extensive clearing of forests that affects water quality and habitat
Agriculture	Clearing of forests, use of fertilizers and nitrogen-fixing crops
Canal and dam development	Increase of waterborne invasive species, wetland drainage, flow alterations, habitat fragmentation
Railroad development	Increased access to forests leading to risk of fire; terrestrial, wetland, and aquatic habitat loss
Road development	Increases in impervious surfaces and runoff
Urbanization and industrialization	Increased pollution from unregulated sewage and factory waste discharges
Dam development for water supply infrastructure needs	Changes in flow regime and sediment transport
Highway and road development	Increase in impervious surfaces and runoff, impacts to terrestrial communities
Agriculture decline	Changes in land use practices (reforestation or increased land development)
Changing agricultural practices	Increased inorganic nutrients (fertilizers) and changes in organic (manure) loads
Urban development and sprawl	Impervious surface impacts, increased runoff, construction impacts, stream channelization

Adapted from: Swaney et al. 2006

At present, there are 11 facilities along the lower Hudson River with water discharges of 50 mgd (189,000 m^3/day) or greater (Table 2-2). Of these, two are associated with wastewater discharge, and nine are associated with power generation. Between Poughkeepsie and Yonkers (RM 24–77 (RKM 39–124)), there are four steam power generating stations that use water from the Hudson River for condenser cooling (Danskammer Point, Roseton, IP2 and IP3, and Bowline Point). Of these, IP2 and IP3 have traditionally used the greatest quantity of water for cooling (2800 mgd, or 10.6 million m^3/day), and Danskammer Point the least. Presently, Roseton operates intermittently, based on energy needs and the current prices of oil and natural gas. Excluding the water use of this facility, the IP2 and IP3 facility accounts for 60 percent of the water use from RM 24–77 (RKM 39–124). Impacts associated with industrial water use can include impingement or entrainment of fish, larval forms, and invertebrates from water intake; heat or cold shock associated with water discharges; and the cumulative effects of the discharge of low levels of permitted chemicals (CHGEC 1999).

Municipal Wastewater Treatment Plants

Wastewater collection and sewage treatment construction began in New York City in the late 17th century, and many of the sewer systems were connected in lower and central Manhattan Island between 1830 and 1870. The first wastewater treatment system was constructed in 1886 and included a screen system designed to protect bathers on Coney Island (Brosnan and O'Shea 1996.)

In 2004, the NYSDEC identified 610 municipal wastewater treatment plants in New York State (NYSDEC 2004a). These facilities produce a total discharge flow of approximately 3694 mgd (13.98 million m^3/day). In the lower Hudson River basin, there are 78 secondary treatment facilities with a total flow of 556 mgd (2.1 million m^3/day), 41 tertiary facilities with a total flow of 11 mgd (42,000 m^3/day), and 10 other/unknown facilities with a total flow of approximately 1 mgd (3800 m^3/day). The total flow associated with all 129 facilities is approximately 568 mgd (2.15 million m^3/day). There are 33 facilities that use what is described as less than primary, primary, or intermediate treatment. A total of 404 facilities employ secondary treatment, and 173 employ tertiary treatment (NYSDEC 2004a).

As discussed above, the increasing populations along the river and within the watershed resulted in an increased discharge of sewage into the Hudson and an overall degradation of water quality. Beginning in 1906 with the creation of the Metropolitan Sewerage Commission of New York, a series of studies was conducted to formulate plans to improve water quality within the region (Brosnan and O'Shea 1996). In the freshwater portion of the lower Hudson River, the most dramatic improvements in wastewater treatment were made between 1974 and 1985, resulting in a decrease in the discharge of suspended solids by 56 percent.

Improvements in the brackish portion of the river were even greater. In the New York City area, the construction and upgrading of water treatment plants reduced the discharge of untreated wastewater from 450 mgd (1.7 million m^3/day) in 1970 to less than 5 mgd (19,000 m^3/day) in 1988 (CHGEC 1999). The discharge of raw sewage was further reduced between 1989 and 1993 by the implementation of additional treatment programs (Brosnan and O'Shea 1996).

During the 1990s, three municipal treatment plants located in the lower Hudson River converted to full secondary treatment—North River (1991), North Bergen MUA-Woodcliff (1991), and North Hudson Sewerage Authority West New York (1992). In addition, the North Hudson Sewerage Authority-Hoboken plant, located on the western bank of the Hudson River opposite

Manhattan Island, went to full secondary treatment in 1994 (CHGEC 1999). Upgrades to the Yonkers Joint Treatment plant in 1988 and the Rockland County Sewer District #1 in 1989 also resulted in improvements in water quality in the brackish portion of the Hudson River. In the mid-1990s, the Rockland County Sewer District #1 and Orangetown Sewer District plants were also upgraded. (CHGEC 1999)

Table 2-2. Facilities Discharging at Least 50 mgd (190,000 m^3/day) into the Lower Hudson River

Facility	Activity	Location			Discharge (mgd)
		Region	RM	RKM	
59th Street Station	Power generation	Battery (BT)	7	11	70
North River	Wastewater discharge	Battery (BT)	10	16	170
Yonkers	Wastewater discharge	Yonkers (YK)	17	27	92
Bowline Point	Power generation	Croton-Haverstraw (CH)	37	60	912
Lovett	Power generation	Indian Point	42	68	496
Indian Point	Power generation	Indian Point	43	69	2,800
Westchester Resource Recovery	Power generation	Indian Point	43	69	55
Danskammer Point	Power generation	Poughkeepsie (PK)	66	106	457
Roseton[a]	Power generation	Poughkeepsie (PK)	67	108	926
Bethlehem	Power generation	Albany (AL)	140	225	515
Empire State Plaza	Power generation	Albany (AL)	146	235	108

[a] Roseton currently operates intermittently based on availability and cost of oil and natural gas.

Adapted from: Entergy 2007a

A review of long-term trends in DO and total coliform bacteria concentrations by Brosnan and O'Shea (1996) has shown that improvements to water treatment facilities have improved water quality. The authors noted that, between the 1970s and 1990s, DO concentrations in the Hudson River generally increased. The increases coincided with the upgrading of the North River plant to secondary treatment in spring 1991. DO, expressed as the average percent saturation, exceeded 80 percent in surface waters and 60 percent in bottom waters during summers in the early 1990s. DO minimums also increased from less than 1.5 mg/L in the early 1979s to greater than 3.0 mg/L in the 1990s, and the duration of low DO (hypoxia) events was also reduced (Brosnan and O'Shea 1996). Similar trends showing improvements in DO were noted by Abood et al. (2006) from an examination of two long-term data sets collected by NYCDEP in the lower reaches of the river. Brosnan and O'Shea (1996) also noted a strong

decline in total coliform bacteria concentrations that began in the 1970s and continued into the 1990s, coinciding with sewage treatment plant upgrades.

Chemical Contaminants

The lower Hudson River currently appears on the EPA 303-d list as an impaired waterway because of the presence of PCBs and the need for fishing restrictions (EPA 2004). The following is a description of the chemical contaminants in the river.

Chemical contaminants in the Hudson River and surrounding watershed generally fall into three major categories—(1) pesticides and herbicides, including dichloro-diphenyl-trichloroethane (DDT) and its metabolites, aldrin, lindane, chlordane, endrin, heptachlor, and toxaphene, (2) heavy metals, including arsenic, cadmium, chromium, copper, inorganic and methylated mercury, lead, and zinc, and (3) other organic contaminants, including PCBs, and polycyclic aromatic hydrocarbons (PAHs) (CHGEC 1999). In addition, there is a growing concern that the discharge of pharmaceuticals and hormones via wastewater may pose a risk to aquatic biota and human communities (NOAA 2008b). There is also a concern that waste products or residuals associated with the emerging nanotechnology market could create a new source of environmental risk (EPA 2007b).

Pesticides and herbicides generally enter the Hudson River via runoff from agricultural activities in the upper watershed and have a high affinity to binding with organic carbon. In the Hudson and Raritan River basins, the use of DDT, once a common pesticide, peaked in 1957 and subsequently decreased until the compound was banned in the early 1970s (Phillips and Hanchar 1996). Sediment contaminant trends suggest that the concentration of DDT in sediment has generally decreased since the 1970s and is currently at or near the effects-range-median (ER-M), which is the median sediment concentration for a particular chemical or contaminant at which adverse biological effects have been observed (Steinberg et al. 2004). In the lower Hudson River, comparison of the EPA-sponsored regional environmental monitoring and assessment program (R-EMAP) results from 1993 to 1994 and 1998 show that the concentrations of the metals cadmium, nickel, lead, and silver have generally declined and are at or below ER-M. The concentrations of mercury, however, continue to be above ER-M at many locations in the lower river (Steinberg et al. 2004).

Contamination of the sediment, water, and biota of the Hudson River estuary resulted from the manufacture of capacitors and other electronic equipment in the towns of Fort Edward and Hudson Falls, New York, from the 1940s to the 1970s. Investigations conducted by EPA and others over the past 25 years have delineated the extent and magnitude of contamination, and numerous cleanup plans have been devised and implemented. Recently, EPA Region 2 released a "Fact Sheet" describing a remedial dredging program designed to remove over 1.5 million cubic yards (1.15 million m^3) of contaminated sediment covering 400 acres (160 ha) extending from the Fort Edwards Dam to the Federal Dam at Troy (EPA 2008a). Concentrations of PCBs in river sediments below the Troy Dam are much lower. Work summarized by Steinberg et al. (2004) suggests that the sediment-bound concentrations of PCBs and dioxins have generally declined in the lower Hudson River since the 1970s and are now at or below ER-M limits.

Chemical contaminants present in the tissues of fish in the Hudson River estuary have been extensively studied for many years and resulted in the posting of consumption advisories by the States of New York and New Jersey. Current information summarized in Steinberg et al. (2004)

suggests that many recreationally and important fish and shellfish still contain levels of metals, pesticides, PCB, and dioxins above U.S. Food and Drug Association (FDA) guidance values for commercial sales. Tissue concentrations of mercury were of concern only for striped bass; other fish and shellfish, including flounder, perch, eels, blue crab, and lobster, contained concentrations of mercury in their tissues well below the FDA limit for commercial sale of 2 parts per million (ppm). Concentrations of chlordane in white perch, American eels, and the hepatopancreas (green gland) of blue crab were also above FDA guidelines. Concentrations of DDT in the tissues of most recreationally and commercially valuable fish and shellfish in the estuary were below the 2 ppm FDA limit with the exception of American eel. The concentrations of 2,3,7,8-TCDD (commonly referred to as dioxin) and total PCBs in fish and shellfish tissues were often above FDA guidance limits, suggesting that fish and shellfish obtained from some locations within the estuary should be eaten in moderation or not at all. A detailed list of fish consumption advisories for both New York and New Jersey may be found in the *Health of the Harbor* report published by the Hudson River Foundation in 2004 (Steinberg et al. 2004).

Steinberg et al (2004) found that although a wide variety of contaminants still exists in sediment, water, and biota in the lower Hudson River, the overall levels appear to be decreasing because of the imposition of strict discharge controls by Federal and State regulatory agencies and improvements in wastewater treatment. These trends appear to be confirmed by the results of a NOAA-sponsored toxicological evaluation of the estuary in 1991, as described in Wolfe et al. (1996). Employing a combination of bioassay tests using amphipods, bivalve larvae, and luminescent bacteria and measurements of contaminants in a variety of environmental media, the NOAA study showed that spatial patterns of toxicity generally corresponded to the distributions of toxic chemicals in the sediments. Areas that exhibited the greatest sediment toxicity were the upper East River, Arthur Kill, Newark Bay, and Sandy Hook Bay. The lower Hudson River adjacent to Manhattan Island, upper New York Harbor, lower New York Harbor off Staten Island, and parts of western Raritan Bay generally showed lower toxicity. The supporting sediment chemistry, including acid-volatile sulfide and simultaneously extracted metals, suggests that metals were generally not the cause of the observed toxicity, with the possible exception of mercury. Among all contaminants analyzed, toxicity was most strongly associated with PAHs, which were substantially more concentrated in toxic samples than in nontoxic samples, and which frequently exceeded sediment quality criteria (Wolfe et al. 1996).

There is continuing concern, however, that legacy PCB waste may still pose a threat to invertebrate, fish, and human populations. A study by Achman et al. (1996) suggests that PCB concentrations in sediment measured at several locations in the lower Hudson River from the mouth to Haverstraw Bay are above equilibrium with overlying water and may be available for transfer within the food web. The authors concluded in some locations within the lower river, the sediments could act as a source of PCBs and pose a long-term chronic threat, but that fate and transport modeling would be required to fully understand the implications of this potential contaminant source.

<u>Nonpoint Pollution</u>

Nonpoint pollution can include the intentional or unintentional discharges of chemicals and constituents into rivers, streams, and estuaries. This section briefly summarizes three types of nonpoint pollution that may affect fish and shellfish resources in the Hudson River estuary—coliform bacteria that affect shellfish resources or swimmers, floatable debris, and surface slicks. All information is derived from Steinberg et al. (2004).

Levels of coliform bacteria in the Hudson River estuary have generally decreased from 1974 to 1998, primarily in response to wastewater treatment improvements. At present, only stretches of the river near the southern end of the island of Manhattan have geometric mean coliform concentrations of 201–2000 coliform cells/100 mL. The incidence of shellfish-related illness in New York State has also decreased from a high of over 100 reported cases per year in 1982 to only a few in 1999. Steinberg et al. (2004) caution, however, that the incidence of shellfish-related illness is probably underreported and likely misdiagnosed when reported.

Common floatable debris found on New York beaches includes cigarette butts, food containers and wrappings, plastic and glass, and medical waste. The amount of debris removed from New York Harbor annually has generally exceeded 5000 t (4500 MT) since 1988, with no apparent downward trend. The presence of surface slicks in the harbor has appeared to decline since 1994.

Invasive or Exotic Species

The presence of invasive or exotic species in the Hudson River estuary has been documented for over 200 years and probably began occurring after the Wisconsin-stage ice sheet receded over 10,000 years ago. In a compilation of information concerning the distribution of exotic organisms in the freshwater portions of the Hudson River basin, Mills et al. (1996) determined that at least 113 nonindigenous species of vertebrates, plants, and large invertebrates have established populations in the basin. The list would undoubtedly be larger if better information was available concerning the historical populations of small invertebrates and algae. Most invasive species arrive through unintentional releases (e.g., from ship ballast water or agricultural cultivation activities) or via vectors introduced by the construction of canals.

While the presence of new or exotic species can result in a benefit (e.g., the largemouth and smallmouth bass recreational fishery), many have had a negative impact on their new environment. A classic example of the latter is the appearance of the zebra mussel in the freshwater portion of the Hudson River in 1991. Beginning in early fall 1992, zebra mussels have been dominant in the freshwater tidal Hudson, constituting more than half of heterotrophic biomass and filtering a volume of water equal to all of the water in the estuary every 1–4 days during the summer (Strayer 2007). The impacts of this species on the freshwater portions of the Hudson River are presented in Section 2.2.5.6.

The impacts of other invasive aquatic species are discussed elsewhere in this chapter. The issue is of magnitude significant enough to result in Federal actions to control future introductions. In 1992, the U.S. Congress passed an amendment to Public Law 101-646, the "Nonindigenous Aquatic Nuisance Species Act," extending some of the Great Lakes-oriented provisions of that Act and the regulations that followed from it to the Hudson River. In particular, as of late 1994, vessels entering the Hudson River with foreign ballast water must have exchanged that water in midocean and must arrive with a salinity of at least 30 ppt (Mills et al. 1996).

2.2.5.3 Regulatory Framework and Monitoring Programs

The regulatory framework, actions, and authorities governing environmental permitting and monitoring on the Hudson River are complex and have evolved significantly over time. The following is a chronological description of the major activities that have occurred over the past four decades.

Early Environmental Investigations

Early biological studies of the Hudson River began as a river survey program known as the Hudson River Fisheries Investigation (HRFI) which occurred from 1965 to 1968 under the direction of the Hudson River Policy Committee (HRPC) (Barnthouse and Van Winkle 1988). The investigations were intended to address the potential entrainment impacts of the proposed Cornwall pumped storage facility on striped bass. The objective of the HRFI program was to define the spatial and temporal distribution of striped bass eggs, larvae, and juveniles in relation to the intake to better understand the potential impacts of facility operation. The summary report produced by HRPC concluded that entrainment impacts associated with the operation of the Cornwall facility would be negligible, and this conclusion formed the basis of the decision by the Federal Power Commission (FPC) to license the facility in 1971. These conclusions were challenged on the grounds that an erroneous method had been used to estimate striped bass entrainment. This challenge ultimately resulted in a halt to the construction of the Cornwall facility in 1974 pending resolution of this issue (Barnthouse and Van Winkle 1988; Christensen and Englert 1988).

During this period, IP1 was in operation, IP2 and IP3 were under construction, and a modest fish sampling program was being conducted in the area of Indian Point by New York University and Raytheon (Barnthouse and Van Winkle 1988). The enactment of the National Environmental Policy Act of 1969 (NEPA) on January 1, 1970, and the interpretation that it required the Atomic Energy Commission (AEC) to explicitly consider nonradiological impacts in its licensing decisions had immediate and dramatic impacts on IP2 and IP3. During the permitting process for IP2, the major point of contention again centered on whether facility operation would significantly affect striped bass eggs, larvae, and juveniles because of entrainment. The Consolidated Edison Company of New York, the owner of IP2 at the time, concluded in its ER that entrainment impacts would be insignificant. The environmental impact statement (EIS) prepared by the AEC staff in 1972 expressed concern about the impacts of thermal discharges, entrainment, and impingement associated with cooling system operation and concluded that "The operation of IP1 and IP2 with the present once-through cooling system has the potential for a long-term environmental impact on the aquatic biota inhabiting the Hudson River which [sic] would result in permanent damage to and severe reduction in the fish population, particularly striped bass, in the Hudson River, Long Island Sound, the adjacent New Jersey coast, and the New York Bight" (USAEC 1972). The final conclusion reached by AEC for IP2 was a recommendation that an operating license be issued with the following conditions to protect the environment—(1) once-through cooling was permitted only until January 1, 1978, and thereafter a closed-cycle system would be required, (2) the applicant would evaluate the economic and environmental impacts of an alternative closed-cycle system and submit this evaluation to AEC by July 1, 1973, (3) after approval by AEC, the required closed-cycle system would be designed, built, and placed in operation no later than January 1, 1978 (USAEC 1972).

The USAEC results published in 1972 were influenced to a great extent by the results of an entrainment model developed by C.P. Goodyear of the Oak Ridge National Laboratory (described in Hall 1977), and during subsequent years, the use of numerical simulation models to assess the impacts of entrainment from once-through facilities received a great deal of attention. As the models were developed, there was much debate concerning the assumptions used by the modelers, and the predictive ability of the models was the subject of numerous scientific symposia, peer-reviewed journal articles, and hearings. This information formed the

basis of the decisions handed down by the Atomic Safety and Licensing Board in 1973 and the Atomic Safety and Licensing Appeals Board in 1974. These decisions stipulated that IP2 would be allowed to operate using once-through cooling but only until May 1, 1979. Unless the operator of the facility could demonstrate through new studies that the environmental impacts of once-through cooling were negligible, cooling towers would have to be installed (Barnthouse and Van Winkle 1988).

In late 1974, FPC held hearings to reconsider the Cornwall facility application. Recent data and numerical models that had been developed for IP2 were also evaluated. Because the information and assessment presented at the hearings provided conflicting conclusions concerning impacts, FPC was unable to determine the magnitude of potential environmental impacts, and the hearings were adjourned without resolution concerning plant licensing. In 1975, the NRC, the successor agency to AEC, published an EIS for IP3 that once again expressed concern associated with the impacts of the once-through cooling system, including impacts associated with entrainment, impingement, and thermal releases. Using a combination of entrainment modeling and an improved striped bass life-cycle model, the NRC concluded that impingement and entrainment impacts were "likely to result in a substantial decrease in the Hudson River spawned striped bass population" (NRC 1975). The NRC indicated that the applicant, who had used different parameters in its impingement and entrainment simulation modeling, did not share this conclusion. The NRC agreed to allow IP3 to operate as a once-through facility but required the applicant to comply with a variety of technical specifications including the collection of additional environmental data to evaluate the impact of entrainment, impingement, and thermal discharges. The applicant was also required to comply with the license conditions agreed to in 1974 that required a cessation of once-through cooling by 1979 unless new evidence demonstrated that environmental impacts were negligible (NRC 1975; Barnthouse and Van Winkle 1988).

<u>Pollutant Discharge Elimination System Permitting</u>

On October 28, 1975, EPA gave its approval to NYSDEC to issue SPDES permits in the State of New York. Before that time, national pollutant discharge elimination system (NPDES) (the federally administered analog to SPDES for States in which EPA has not granted authority to discharge to waters of the United States) permits were issued directly by EPA. Issues considered by EPA before the issuance of the 1975 permits included the thermal impacts of once-through cooling and fish mortalities associated with the cooling water intakes. During this time, scientists representing both the applicants and the regulatory agencies had embarked on ambitious programs to better understand the impacts of once-through cooling systems on sensitive fish species. This included a large-scale field program and the use and refinement of numerical simulation models to better understand entrainment impacts.

Depending on the model used and the assumptions employed, the impacts of once-through cooling ranged from negligible to catastrophic (Barnthouse and Van Winkle 1988). Further, although field collections were occurring, the amount of information available to be used as input data or to calibrate model output was limited. As a result, the EPA deemphasized the use of simulation modeling to estimate entrainment impacts and, in 1975, issued permits for IP2 and IP3, Bowline Units 1 and 2, and Roseton Unit 1 that required the construction of cooling towers. The utility companies contested the permits and requested adjudicatory hearings. In 1977, the owners of IP2 and IP3, Bowline, and Roseton facilities sought an administrative adjudicatory hearing against the EPA NPDES permits issued in 1975 to overturn the cooling water intake

conditions and other requirements. The EPA hearings began in 1977 and ended in 1980 with the Hudson River Settlement Agreement (HRSA).

Hudson River Settlement Agreement

After a number of years of adjudicatory proceedings, the owners of IP2 and IP3, Roseton, and Bowline facilities signed the HRSA. The 10-year agreement was intended to resolve the disputes related to the issuance of the 1975 NPDES permits and provide the necessary funding to support a long-term investigation of the lower Hudson River estuary. Parties to the agreement, which was effective for the 10-year period from May 10, 1981, to May 10, 1991, included EPA, the New York State Attorney General, NYSDEC, the Scenic Hudson Preservation Conference (Scenic Hudson), the Hudson River Fishermen's Association (the predecessor to Riverkeeper), and the Natural Resources Defense Council (NYSDEC 2003a). HRSA provided for mitigative measures to reduce fish mortalities at each generation station from impingement and entrainment during once-through cooling operation, seasonal outages during sensitive aquatic life stages, and the installation of variable speed pumps at IP2 and IP3 within 3½ years of the effective date of the agreement to allow for more efficient use of cooling water. In addition, HRSA established a biological monitoring program of fish species at various life stages within the lower Hudson River to better understand spatial and temporal trends.

In 1982, NYSDEC, under authority from EPA, issued SPDES permits to each of the facilities covered by HRSA. The permits included limitations on thermal releases and incorporated the terms of HRSA in the permit language to ensure that the environmentally protective mitigative measures stipulated in the agreement were included as conditions. These permits expired in 1987, and NYSDEC issued SPDES permit renewals to each of the three HRSA facilities. Permits for IP2 and IP3, Bowline Point 1 and 2, and Roseton 1 and 2 became effective on October 1, 1987, and expired on October 1, 1992 (NYSDEC 2003a). HRSA conditions were incorporated into the permit language as before. Before the expiration of the permits in 1992, NYSDEC received timely renewal applications, and the department and the applicants executed an agreement on May 15, 1991, to continue the mitigative measures described in HRSA until the SPDES renewal permits were issued. The agreement also stipulated that the parties would negotiate in good faith to resolve issues associated with impingement, entrainment, and thermal discharges, and to resolve issues associated with mitigation and alternatives (NYSDEC 2003a).

In response to a lawsuit filed in 1991 by Riverkeeper, Scenic Hudson, and the Natural Resources Defense Council, a consent order was signed by all parties on March 23, 1992, which stipulated that the operators of IP2 and IP3, Roseton, and Bowline would continue the HRSA mitigative measures, such as timed outages to reduce impacts to fish, and continue to fund the ongoing environmental studies of the lower Hudson River. The 1992 consent order was extended by the parties on four separate occasions, with the fourth extension expiring on February 1, 1998. At present, there has been no agreement on a fifth consent order because of the ongoing SPDES renewal process, but the operators of IP2 and IP3, Roseton, and Bowline have agreed to continue the mitigative measures included in their existing SPDES permit and to follow the provisions of the fourth consent order until new SPDES permits are issued (NYSDEC 2003b). The major monitoring and assessment programs conducted under HRSA that form the basis for the staff's assessment of impacts are discussed below.

Environmental Studies in the Lower Hudson Estuary

Numerous environmental studies were conducted in the Hudson River in support of HRSA and by other organizations to develop a baseline and to assess changes to key components of the ecosystem over time. A general description of the studies evaluated during the development of this draft SEIS is presented in Table 2-3. Other studies are cited throughout the description and historical assessment of impacts; however, only the data obtained from these studies were made available for further analysis.

Impingement losses associated with IP2 and IP3 were studied annually from 1975 to 1990. Data from 1975 to 1980 provided for analysis were weekly estimates of the total number impinged, organized by operating unit and taxon. From 1979 to 1980, estimates were further delineated by life stage (young of the year, yearling, yearling or older). Data from 1981 to 1990 included seasonal estimates of the total number impinged by operating unit, taxon, and life stage.

As a part of HRSA, IP2 and IP3 were required to replace the existing debris screens in 12 of the intake bays with angled screens and fish bypass systems. A subsequent analysis, however, showed that the angled screen system did not significantly reduce impingement mortality, and so the HRSA settlement parties rejected this mitigation option (Fletcher 1990). Con Edison and the New York Power Authority elected to install and test a Ristroph screen system at IP2 and IP3. The trial machine, referred to as “screen version 1” by Fletcher (1990), was installed in a single intake bay of IP2 and IP3 and evaluated from January 16 to April 19, 1985. At the request of the Hudson River Fishermen’s Association, Fletcher (1990) evaluated the design of the trial machine, conducted flume tests, and suggested improvements to the design that were incorporated into “screen version 2.” This final design, also known as a modified Ristroph screen, was installed in all intake bays of IP2 and IP3. No further studies were conducted after the installation of the modified Ristroph system at IP2 and IP3 to determine actual mortality of key species, and no additional impingement monitoring was conducted.

Ichthyoplankton entrainment losses associated with IP2 and IP3 were studied between May and August in 1981, 1983 through 1985, and in 1987, as well as between January and August 1986. Data provided for this analysis were the combined IP2 and IP3 weekly mean densities (number/1000 m^3) of each life stage (egg, yolk-sac larvae, post-yolk-sac larvae, and juvenile) by taxon.

Data from the three field surveys from the Hudson River Estuary Monitoring Program were also provided for this analysis (Long River Survey (LRS), Fall Juvenile Survey (FJS), and the Beach Seine Survey (BSS)). All three data sets include the annual total catch and volume sampled per taxon from 1974 through 2005, the annual abundance index per taxon and life stage from 1974 through 2005, and the weekly regional density of each life stage by taxon from 1979 through 2005.

Table 2-3. Table 2-3 Hudson River Environmental Studies Table
(Information used in draft SEIS to assess impacts; data provided by Entergy)

Study	Study Dates	Information Available
Impingement Abundance	1975–1990	Number of fish impinged at IP2 and IP3.

Entrainment Abundance Studies	1981 1983–1987	Entrainment density by species and life stage for IP2 and IP3 combined.
Longitudinal River Ichthyoplankton Surveys	1974–2004	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 Surveys	1974–2005	Standing crop and temporal and geographic indices for young-of-the-year 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 Surveys	1974–2005	Abundance and distribution of young-of-the-year 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.

2.2.5.4 Potentially Affected Fish and Shellfish Resources

The Hudson River estuary is home to a large and diverse assemblage of fish and shellfish. Species richness and abundance vary according to season and location and can be influenced by climatological changes that affect water temperature, salinity, and sediment load. Waldman et al. (2006) report that 212 species of fish have been recorded north of the southern tip of Manhattan Island, with the largest contributions associated with temperate marine strays (65), introduced species (28), and freshwater species surviving the Pleistocene glaciations in the Atlantic coast refugia (21). The authors also note that only 10 diadromous (traveling between fresh- and salt-water) species are known to occur in the estuary.

The NRC staff identified 18 representative important species (RIS) to use in assessing the impacts of IP2 and IP3 (Table 2-4). This list contains RIS 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. The distribution of each RIS is presented in Table 2-5.

Table 2-4. Representative Important 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. 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	*Notropis*	Freshwater	Species eats aquatic insect larvae,

shiner	*hudsonius*		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.

Table 2-5. Locations in the Hudson River Estuary (see Figure 2-6) Where the Presence of RIS Life Stages Represented at Least 10 Percent of the Total Number Collected in Referenced Surveys or Studies (adapted from ASA 2007; river segment abbreviations from Figure 2-10)

<table>
<tr><th>Species</th><th>Lifestage</th><th>BT</th><th>YK</th><th>TZ</th><th>CH</th><th>IP</th><th>WP</th><th>CW</th><th>PK</th><th>HP</th><th>KG</th><th>SG</th><th>CS</th><th>AL</th></tr>
<tr><td rowspan="5">Alewife</td><td>Eggs</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">LRS[c]</td></tr>
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<tr><td>PYSL[e]</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="5">LRS</td><td></td></tr>
<tr><td>YOY[f]</td><td></td><td></td><td colspan="2">BSS[a]</td><td></td><td></td><td>BSS</td><td></td><td></td><td></td><td colspan="2">BSS</td><td></td></tr>
<tr><td>Year +[g]</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="5">Atlantic menhaden[h]</td><td>Eggs</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>YOY</td><td colspan="4">ASMFC 2006a</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Year +</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="5">American shad</td><td>Eggs</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">LRS</td></tr>
<tr><td>YSL</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">LRS</td></tr>
<tr><td>PYSL</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="4">LRS</td></tr>
<tr><td>YOY</td><td></td><td></td><td></td><td></td><td></td><td></td><td>BSS</td><td colspan="3">LRS</td><td colspan="2">LRS/BSS</td><td>BSS</td></tr>
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1 **Table 2-5** (continued)

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Table 2-5 (continued)

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<tr><td>Year +</td><td colspan="13">FJS/LRS: Only 32 fish caught in 2005</td></tr>
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1 **Table 2-5** (continued)

Species	Lifestage	BT	YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
Weakfish	Eggs													
	YSL													
	PYSL													
	YOY			FJS										
	Year +			FJS			FJS							
White catfish	Eggs													
	YSL													
	PYSL													
	YOY								FJS				FJS	
	Year +			FJS									FJS	
White perch	Eggs												LRS	
	YSL											LRS		
	PYSL										LRS			
	YOY			BSS					LRS				BSS	
	Year +			BSS									BSS	
Blue crab[i]	Eggs													
	Zoea													
	Megalops													
	Juvenile													
	Year +													

2 [a] BSS: Beach Seine Survey (1974–2005)
3 [b] FJS: Fall Juvenile Survey (also known as Fall Shoals Survey) (1979–2004)
4 [c] LRS: Long River Survey (1974–2004)
5 [d] YSL: yolk-sac larvae
6 [e] PYSL: post-yolk-sac larvae
7 [f] YOY: young of year
8 [g] Year +: yearling and older
9 [h] Obtained from ASMFC 2006a distribution
10 [i] Obtained from ASMFC 2006a distribution
11 Source: NYSDEC 2004b

Alewife

The alewife (*Alosa pseudoharengus*, family Clupeidae) is a pelagic, anadromous species found in riverine and estuarine habitats along the Atlantic coast from Newfoundland to South Carolina; landlocked populations have also been introduced in the Great Lakes and Finger Lakes. The species is historically one of the most commercially important fish species in Massachusetts and continues to be harvested as a source of fish meal, fish oil, and protein for animal food industries (Fay et al. 1983). The commercial fishing industry does not differentiate between the alewife and the blueback herring (*Alosa aestivalis*) and refers to the two species collectively as river herring. Commercial landings of river herrings peaked in the 1950s at approximately 34,000 MT (37,500 t) and then declined to less than 4000 MT (4400 t) in the 1970s (Haas-Castro 2006a). Between 1996 and 2005, landings of river herring ranged from 300 to 900 MT (330 to 990 t) annually, with 90 percent of landings in Maine, North Carolina, and Virginia (Haas-Castro 2006a). The river herring fishery is one of the oldest fisheries in the United States; however, no commercial fisheries for river herring exist in the Hudson River today. River herring are often taken as bycatch in the offshore mackerel fishery; within New York and New Jersey, river herring accounted for 0.3 percent of annual landings on the Atlantic coast (CHGEC 1999).

Spawning adults enter the Hudson River from the Atlantic Ocean in early spring and spawn once per year between late May and mid-July in shallow, freshwater tributaries with low current at temperatures between 11 degrees C (52 degrees F) and 27 degrees C (81 degrees F) (Everly and Boreman 1999; Fay et al. 1983). Females first spawn at 3 to 4 years of age and produce 60,000 to 100,000 eggs. Alewives spawn 3 to 4 weeks before blueback herring in areas where the two species occur sympatrically, and the peak spawning of each species occurs 2 to 3 weeks apart from one another (Fay et al. 1983). Within the Hudson River estuary, peak abundance of river herring eggs generally occurs within the Catskill region of the upper estuary during mid-May (CHGEC 1999). Incubation time varies inversely with water temperature and ranges from 2 to 15 days, and eggs are semidemersal and are easily carried by currents (Fay et al. 1983; CHGEC 1999). The yolk sac larvae (YSL) stage lasts approximately 2 to 5 days, and the post-yolk-sac larvae (PYSL) stage lasts until transformation to the juvenile stage at approximately 20 millimeters (mm) (0.78 in.). Full development occurs at approximately 45 mm (1.8 in.) at the age of about 1 month (Fay et al. 1983; CHGEC 1999).

Young-of-the-year (YOY) have been found in both lower and upper regions of the river (Table 2-5). Juveniles migrate to the ocean between July and November of their first year. At sexual maturity, alewives weigh 153 to 164 grams (g) (0.34 to 0.36 pounds (lb)) and can weigh 325 to 356 g (0.72 to 0.78 lb) by their seventh year; the average length for males is 29 cm and for females is 31 cm (Fay et al. 1983). Alewives in the Hudson River estuary have a life span of up to 9 years (Haas-Castro 2006a). Juveniles in the lower Hudson River have been reported to feed on chironomid larvae and amphipods, and the diet of adult alewives consists primarily of zooplankton, amphipods, mysids, copepods, small fish, and fish eggs. After spawning, alewives feed heavily on shrimp (Fay et al. 1983; CHGEC 1999). The species fulfills an important link in the estuarine food web between zooplankton and top piscivores. Juvenile and adult alewife is prey for gulls, terns, and other coastal birds, as well as bluefish (*Pomatomus saltatrix*), weakfish (*Cynoscion regalis*), and striped bass (*Morone saxatilis*) (CHGEC 1999).

The annual abundance of YOY alewifes has been estimated to range from 110,000 to 690,000 individuals (CHGEC 1999). For each annual cohort, entrainment mortality for the combined abundance of alewife and blueback herring for all water withdrawal locations within the Hudson River varies widely, ranging from 8 to 41 percent for data taken between 1974 and 1997, while impingement mortality of the alewife is low, ranging from 1.1 to 1.9 percent for the same time period (CHGEC 1999). The Atlantic States Marine Fisheries Commission (ASMFC) implemented a Fisheries Management Plan for the American shad and river herring in 1985. Restoration efforts under the plan include habitat improvement, fish passage, stocking, and transfer programs; however, the abundance of river herring remains well below historic estimates (Haas-Castro 2006a).

Atlantic Menhaden

The Atlantic menhaden (*Brevoortia tyrannus*, family Clupeidae) is a euryhaline species found in inland tidal waters along the Atlantic coast from Nova Scotia to Florida (MRC 2006). Menhaden is commercially harvested as a high-grade source of omega-3 fatty acid, which is used in pharmaceuticals and processed food production (ASMFC 2006a). Atlantic menhaden make up between 25 and 40 percent of the combined annual landings of menhaden species along the Atlantic coast and Gulf of Mexico (Rogers and Van Den Avyle 1989). The Atlantic menhaden was first commercially fished in the late 1600s and early 1700s for use in agricultural fertilizer, and the species was later harvested for oil beginning in the early 1800s (Rogers and Van Den Avyle 1989). Fish meal from menhaden also became a staple component in swine and ruminant feed beginning in the mid-1900s and began to be used in aquaculture feed in the 1990s (ASMFC 2006a).

Atlantic menhaden migrate seasonally and exhibit north-south and inshore-offshore movement in large schools composed of individuals of a similar size and age (Rogers and Van Den Avyle 1989). Migration patterns are linked to spawning habits, and the species spawns year-round throughout the majority of its range, with spawning peaks in the spring and fall in mid-Atlantic and northern Atlantic regions (MRC 2006). Menhaden reach sexual maturity at lengths of 18 to 23 cm (7.1 to 9.1 in.), and female fecundity ranges from 38,000 eggs for a small female to 362,000 eggs for a large female (ASMFC 2006a; MRC 2006). Eggs are pelagic and hatch offshore in 2.5 to 2.9 days at an average temperature of 15.5 degrees C (59.9 degrees F) (ASMFC 2006a; Rogers and Van Den Avyle 1989). Larvae absorb the yolk sac within approximately 4 days of hatching and begin to feed on zooplankters (Rogers and Van Den Avyle 1989).

The survival of larvae is a function of temperature and salinity, with the highest survival rates occurring in laboratory experiments at temperatures greater than 4 degrees C (39 degrees F) and salinities of 10 to 20 ppt (ASMFC 2006a). Larvae migrate shoreward into estuaries at 1 to 3 months of age at a size of 14 to 34 mm (0.55 to 1.3 in.) (ASMFC 2006a). Metamorphosis to the juvenile stage occurs at approximately 38 mm (1.5 in.), and menhaden begin to filter feed on phytoplankton, zooplankton, copepods, and detritus (MRC 2006). Juveniles move into shallow portions of estuaries and are generally more abundant in areas of lower salinity (less than 5 ppt) and waters above the brackish-freshwater boundary in rivers. Juveniles leave estuaries in dense schools between August and November at lengths of 55 to 140 mm (2.2 to 5.5 in.) and migrate southward along the North Carolina coast as far south as Florida in late fall and early winter (Rogers and Van Den Avyle 1989). During the following spring and summer, menhaden move northward, redistributing in schools consisting of similarly sized individuals (ASMFC

2006a). Most menhaden reach maturity at 2 years of age, at which point approximately 90 percent of individuals are capable of spawning (Rogers and Van Den Avyle 1989). Menhaden lose their teeth as juveniles, and adults are strictly filter feeders, feeding on planktonic organisms (ASMFC 2006a). Atlantic menhaden can live 8 to 10 years; however, fish over 4 years of age are uncommon in commercial catches. Maximum adult length is 500 mm (19.7 in.) and maximum weight is 1500 g (3.3 lb) (Rogers and Van Den Avyle 1989). Menhaden are prey for a number of piscivorous fish, including bluefish (*P. saltatrix*), striped bass (*M. saxatilis*), bluefin tuna (*Thunnus thynnus*), as well as birds and marine mammals because of their abundance in nearshore and estuarine waters (ASMFC 2006a; Rogers and Van Den Avyle 1989).

Atlantic menhaden were not a focus of the Hudson River monitoring programs; therefore, historical records for the Hudson River population trends are unavailable. However, based on tagging studies, the Atlantic menhaden population appears to be composed of a single population that undergoes extensive seasonal migration (ASMFC 2006a). Menhaden are primarily harvested via reduction purse-seine fishing, and Virginia and North Carolina are the only States that currently permit this type of fishing for this species (ASMFC 2006a). Menhaden landings peaked during the late 1950s at an annual average of over 600,000 t (544,000 MT) and then declined during the 1960s from 576,000 t (523,000 MT) in 1961 to 162,000 t (147,000 MT) in 1969. Landings rose in the 1970s as the stock rebuilt, maintained moderate levels during the 1980s, and declined again in the 1990s. Landings have varied in the 2000s with average annual landings of 184,900 t (168,000 MT) from 2000 to 2004, and 146,900 t (133,000 MT) landed in 2005. Landings from the reduction purse-seine fishery accounted for 79 percent of total landings along the Atlantic coast in 2005 (ASMFC 2006a). Atlantic menhaden are also harvested for bait in many Atlantic coast States; however, no data are available for these landings as they are taken via cast net, pound net, gill net, and as bycatch.

<u>American Shad</u>

The American shad (*Alosa sapidissima*, family Clupeidae) is the largest of the anadromous herring species found in the Hudson River estuary and ranges from Newfoundland to northern Florida. The species is most abundant between Connecticut and North Carolina. The stock was introduced along the Pacific coast in the Sacramento and Columbia Rivers in 1871, and the population is now established from Cook Inlet, Alaska, to southern California (Facey and Van Den Avyle 1986). American shad has been commercially harvested via gillnets for meat and roe since the late 17th century (Haas-Castro 2006b). Before World War II, American shad was the most valuable fish along the east coast (Facey and Van Den Avyle 1986).

American shad spend most of their life at sea and only return to their natal rivers at sexual maturity (at the age of about 5 years) to spawn. Adult American shad have an average length of 30 in. (76.2 cm), weigh up to 12 lb (5.4 kg), and have a life span in the Hudson River of about 11 years (CHGEC 1999). Shad eggs have a high mortality rate, and fecundity of females changes with latitude, decreasing from south to north. Females in southern rivers produce 300,000 to 400,000 eggs, and females in northern rivers produce an average of 125,000 eggs (Haas-Castro 2006b). Spawning occurs at night in shallow waters of moderate current in sand, gravel, or mud substrates (Facey and Van Den Avyle 1986). The species can repeat annual spawning up to five times within their lifetime in northeastern rivers; however, most shad from southeastern rivers die after spawning (Facey and Van Den Avyle 1986; CHGEC 1999). Egg abundance in the Hudson River peaks in May, and once hatched, YSL transform into PYSL

within 4 days to 1 week in waters at a temperature of 17 degrees C (63 degrees F) (Everly and Boreman 1999; CHGEC 1999). Larvae inhabit riffle pools of moderate depth near spawning grounds and develop into juveniles 4 to 5 weeks after hatching when they are approximately 25 mm (1 in.) in length (Everly and Boreman 1999; Facey and Van Den Avyle 1986). American shad eggs, YSL, PYSL, and YOY are generally found between Kingston and Albany (Table 2-5), probably in response to food availability (Limburg 1996). Juveniles travel downriver in schools between June and July (Everly and Boreman 1999), utilize the middle estuary by September, and move to the lower estuary by late October (Limburg 1996). Adults spend the summer months in the northwestern Atlantic waters off the Gulf of Maine, the Bay of Fundy, and the coast of Nova Scotia. In the fall months, individuals migrate southward as far as North Carolina (CHGEC 1999).

Shad stop eating before running and spawning and resume feeding after spawning during their downriver migration back to the Atlantic Ocean (Everly and Boreman 1999). Larvae feed on *Bosmina* spp., cyclopoid copepodites, and chironomid larvae. Juveniles are opportunistic feeders and consume free-swimming organisms at the surface as well as insects (CHGEC 1999). The principal food source of the adult American shad is zooplankton, though the species also consumes small crustaceans, copepods, mysids, small fish, and fish eggs (Facey and Van Den Avyle 1986). The American eel (*Anguilla rostrata*) and catfish (*Ictalurus* spp.) prey upon American shad eggs, and bluefish (*Pomatomus saltatrix*) prey upon larvae (CHGEC 1999). Once juveniles migrate to the Atlantic Ocean, likely predators include sharks, tuna, and porpoises; adult shad are not thought to have many predators (Facey and Van Den Avyle 1986).

The estimated population of American shad in the Hudson River has declined from 2.3 million in 1980 to 404,000 in 1996 (ASMFC 1998). The decline of the species in the Hudson and Connecticut Rivers in the past century is attributed to overfishing, degradation of riverine habitat, and dam construction (Haas-Castro 2006b). Entrainment mortality has caused a 23.8 percent annual decrease in abundance of juvenile American shad, and impingement may reduce the population by an additional 1 percent annually. The majority of entrainment mortality is believed to occur in the Albany region as a result of the Albany Steam Station and Empire State Plaza (CHGEC 1999). ASMFC implemented a Fisheries Management Plan for the American shad and river herring in 1985. Restoration efforts under the plan include habitat improvement, fish passage, stocking, and transfer programs; however, abundance of the American shad remains well below historic estimates (Haas-Castro 2006b). Low DO conditions can affect the migration patterns of American shad and limit spawning. Improvements in sewage treatment facilities along the Hudson River in the late 1960s have eliminated the low DO conditions that were problematic in waters south of Albany and have allowed adult shad to spawn farther upriver (CHGEC 1999).

Atlantic Tomcod

The demersal, anadromous Atlantic tomcod (*Microgadus tomcod*, family Gadidae) is found in northwest Atlantic estuarine habitats, with a range extending from southern Labrador and northern Newfoundland to Virginia (Stewart and Auster 1987). The species is nonmigratory and inhabits brackish waters, including estuarine habitats, salt marshes, mud flats, eel grass beds, and bays. The species is short-lived, with an estimated mortality rate ranging from 81 to 98 percent by the age of 2 years (McLaren et al. 1988). Mean lifespan within the Hudson River is 3 years, though populations north of the Hudson River tend to be longer lived (Stewart and

Auster 1987). Most tomcod within the Hudson River are thought to remain within the estuary for life; however, a small number of individuals have been marked and recaptured in the lower New York Bay, the East River, and western Long Island Sound (Klauda et al. 1988). The tomcod has not been a commercially important species in the northeast within the past century, and no catch statistics have been recorded since the 1950s, as the species is generally a target for winter sport fishing only along the New England coast (Stewart and Auster 1987). Tomcod are particularly vulnerable to impingement and entrainment because of their high concentration near the lower portion of the Hudson River estuary (Barnthouse and Van Winkle 1988; Boreman and Goodyear 1988) (Table 2-5).

Spawning occurs under ice between December and January in shallow stream mouths (Stewart and Auster 1987). In the Hudson River, tomcod aged 11 to 13 months contribute approximately 85 to 97 percent of annual egg production, and the majority of tomcod in the Hudson River spawn only once in their lifetime (McLaren et al. 1988). Females produce an average of 20,000 eggs, and incubation time correlates inversely with salinity and ranges from 24 to 63 days (Dew and Hecht 1994; Stewart and Auster 1987). Once hatched, larvae float to the surface and are swept by currents into estuaries, where they develop into juveniles. YSL are found throughout the lower half of the estuary, and PYSL are concentrated in the Yonkers and Tappan Zee regions of the estuary (CHGEC 1999) (Table 2-5). Adults are found at all levels of salinity, but larvae and juvenile densities are highest within the 4.5 to 6.7 ppt salinity range (Stewart and Auster 1987). The Hudson River represents the southernmost major spawning area of the species, and the tomcod is the only major species within the freshwater region of the Hudson River to hatch between February and March (Dew and Hecht 1994). Because the species hatches earlier than herring species within the Hudson and larvae and juveniles are able to tolerate low temperatures, tomcod experience little interspecific competition for food until the fall of their first year (McLaren et al. 1988). Tomcod are found at temperatures as low as -1.2 degrees C (30 degrees F) and have not been observed to inhabit waters at temperatures higher than 26 degrees C (79 degrees F) (Stewart and Auster 1987). The species has also been observed at a wide range of depths varying from the surface to 69 m (226 ft) (Froese and Pauly 2007a). Tomcod have three visible stages of first year growth within the Hudson River population. Juveniles show rapid growth during the spring, little to no growth during the summer, and rapid growth again in the fall, which is highly correlated with prevailing water temperatures (McLaren et al. 1988). Growth has been found to slow at temperatures above 19 degrees C (66 degrees F), and growth essentially ceases at temperatures above 22 degrees C (72 degrees F) (CHGEC 1999).

The diet of tomcod consists primarily of small crustaceans but also may include polychaete worms, mollusks, and small fish. Because tomcod have a lipid-rich liver and prey on many benthic organisms, they are especially sensitive to contaminants in highly polluted waterways, including PCBs and other chlorinated hydrocarbons (Levinton and Waldman 2006). Recent work by Wirgin and Chambers (2006) has reported evidence of induction of hepatic expression of cytochrome P4501A1 and messenger ribonucleic acid (mRNA) in Hudson River tomcod, suggesting a potential for deoxyribonucleic acid (DNA) damage, somatic mutations, and initiation of carcinogenesis consistent with chemical exposure. Within the Hudson River estuary, juvenile tomcod serve as alternate prey in the summer months for yearling striped bass (*M. saxatilis*) during years when juvenile striped bass's main prey, the bay anchovy (*A. mitchilli*), is scarce (Dew and Hecht 1976 cited in Stewart and Auster 1987). Juvenile tomcod are also the prey of large juvenile bluefish (*P. saltatrix*) (Juanes et al. 1993).

The Hudson River tomcod population exhibits wide fluctuations in annual abundance because the species is relatively short lived, and a yearly population is generally composed of only one age class (Levinton and Waldman 2006). The population of tomcod aged 11 to 13 months has been estimated to vary year-to-year between 2 to 5 million individuals, and numbers of tomcod aged 23 to 25 months may vary from 100,000 to 900,000 individuals. A combined abundance index suggests that a population decline has occurred since 1989 (CHGEC 1999). Recent information provided by Entergy (2006c) estimated the population of Atlantic tomcod spawning in the Hudson River during the winter of 2003–2004 to be 1.7 million fish, with 95 percent confidence limits of 1.0 and 2.9 million fish. This estimate, derived by a Petersen mark-recapture technique, is based on the number of tomcod caught and marked between RM 25 and 76 (RKM 40 to 122) in box traps between December 15, 2003, and February 1, 2004, and recaptured in trawls in the Battery region from January 5 through April 11, 2004. The estimated 2003–2004 Atlantic tomcod spawning population in the Hudson River is the ninth lowest observed among 20 recent years of Petersen estimates (Entergy 2006c).

Bay Anchovy

The bay anchovy (*Anchoa mitchilli,* family Engraulidae) occurs along the Atlantic coastline from Maine to the Gulf of Mexico and the Yucatan Peninsula (Morton 1989) and is a common shallow-water fish in the Hudson River estuary. No commercial fishery for the bay anchovy exists on the Hudson River, but it is preyed upon by other fish, such as the striped bass (*M. saxatilis*), which is recreationally important on the Hudson River. Unless otherwise noted, the information below is from Morton (1989).

Considered a warm water migrant, the bay anchovy uses the Hudson River estuary for spawning and as a nursery ground. Adults are found in a variety of habitats, including shallow to moderately deep offshore waters, nearshore waters off sandy beaches, open bays, and river mouths. Studies conducted in the Hudson River from 1974–2005 suggest that eggs, YSL, PYSL, YOY, and older individuals occur in greatest abundance from the Battery to IP2 and IP3 (Table 2-5, Figure 2-6). There is also evidence from recent work by Dunning et al. (2006a) that the peak standing crops of bay anchovy eggs and larvae in New York Harbor, the East River, and Long Island Sound are approximately eight times larger than the population estimates for the lower Hudson River, probably because of the larger water volumes in those areas and the salinity preference of the species. Spawning generally occurs at water temperatures between 9 and 31 degrees C (48 and 88 degrees F). The spawning period for the species is long, typically ranging from May through October. Spawning generally occurs in the late evening or at night, and the eggs are pelagic. Schultz et al. (2006) has reported that anchovies that spawn in the Hudson River are mostly 2 years old, whereas yearlings predominate in other locations, such as Chesapeake Bay. Eggs are usually concentrated in salinities of 8 to 15 ppt and, at temperatures around 27 degrees C (81 degrees F), hatch in 24 hours. At hatching, the YSL are about 1.8 to 2.0 mm (0.07 to 0.08 in.) long. Within 24 hours of hatching, YSL consume the yolk sac and become PYSL. Fins begin to develop during the PYSL stage. Larvae are transparent and become darker as they develop into juveniles. PYSL eat copepod larvae and other small zooplankton.

Larvae metamorphose to juveniles at about a length of 16 mm (0.63 in.). Juveniles and adults travel and hunt in large schools. Juveniles acquire adult characteristics at about 60 mm (2.4 in.) in length and gain a silvery lateral band. Adults have a relatively high tolerance to fluctuations in both river temperature and salinity, and there is evidence in the Hudson River that early-stage

anchovies migrate up-estuary at a rate or 0.6 km/day (0.4 mi/day) and are capable of periodic vertical migration (Schultz et al. 2006). Adult and juvenile bay anchovy feed primarily on mysid shrimp, copepods, other small crustaceans, small mollusks, other plankton, and larval fish (Hartman et al. 2004). Important predators include birds, bluefish (*P. saltatrix*), weakfish (*C. regalis*), summer flounder (*Paralichthys dentatus*), and striped bass (*M. saxitilis*) (CHGEC 1999). The population trend in the Hudson River appears to show a population decline, although exact population counts are not available (Tipton 2003). Tipton (2003) also speculates that the reduction in bay anchovy may be linked to increased predation and overall populations of striped bass, bluefish, or other important commercial fish. Fishery statistics are not available for this species from National Marine Fisheries Service (NMFS) because of the lack of commercial and recreational fishing. The Mid-Atlantic Fishery Management Council has not identified bay anchovy as a managed species.

<u>Blueback Herring</u>

The blueback herring (*Alosa aestivalis*, family Clupeidae) is an anadromous species found in riverine and estuarine waters along the Atlantic coast ranging from Nova Scotia to St. Johns River, Florida. As noted in the life history of the alewife (*A. pseudoharengus*), commercial fisheries do not differentiate between the blueback herring (*A. aestivalis*) and alewife, and the two species are collectively referred to as river herring. River herring are harvested for fish meal, fish oil, and protein for animal food industries (Fay et al. 1983). Commercial landings of river herrings peaked in the 1950s at approximately 34,000 MT (37,000 t) and then declined to less than 4000 MT (4400 t) in the 1970s. Between 1996 and 2005, landings of river herring ranged from 300 to 900 MT (330 to 990 t) annually, with the majority of the landings in Maine, North Carolina, and Virginia (Haas-Castro 2006a). The river herring fishery is one of the oldest fisheries in the United States; however, no commercial fisheries for river herring exist in the Hudson River today. River herring are often taken as bycatch in the offshore mackerel fishery. Within New York and New Jersey, river herring accounted for 0.3 percent of annual landings on the Atlantic coast (CHGEC 1999).

Blueback herring spawn once per year between late May and mid-July in the main channels of estuaries or relatively deep freshwater with swift currents on sand or gravel substrate at temperatures between 14 degrees C (57 degrees F) and 27 degrees C (81 degrees F) (Everly and Boreman 1999; Fay et al. 1983). Female egg production varies greatly, ranging from 46,000 to 350,000 eggs per female (Fay et al. 1983), and incubation time is approximately 6 days (Bigelow and Schroeder 1953). Blueback herring spawn 3 to 4 weeks after alewives in areas where the two species occur sympatrically, and the peak spawning of each species occurs 2 to 3 weeks apart from one another (Fay et al. 1983). In the Hudson, blueback herring spawn most commonly within the Mohawk River and upper Hudson River (CHGEC 1999). The YSL stage exists 2 to 3 days before yolk-sac absorption, and the PYSL stage lasts until larvae reach approximately 20 mm (0.79 in.), with full development occurring at 45 mm (1.8 in.) (Fay et al. 1983). Eggs, YSL, PYSL, and YOY are generally found between Poughkeepsie and Albany (Table 2-5). Juvenile blueback herring assume adult characteristics within a month of hatching, at which point growth slows. Peak abundance of juveniles occurs during late June within the upper estuary (CHGEC 1999) (Table 2-5). Migration downriver to the Atlantic Ocean occurs in October, which is generally later than peak migration for both the American shad and the alewife within the Hudson River estuary (Fay et al. 1983). Some blueback herring do not migrate and tend to stay within the lower reaches of the estuary during their first 1 to 2 years

(CHGEC 1999). Average length for males is 23 cm (9.1 in.) and for females is 26 cm (10 in.) (Collette and Klein-MacPhee 2002).

Adult blueback herring feed mainly on copepods but also eat amphipods, shrimp, fish eggs, crustacean eggs, insects, and insect eggs. The diet of blueback herring in the lower Hudson River consists primarily of chironomid larvae and copepods. As described for the alewife, blueback herring is an important link in the estuarine food web between zooplankton and top piscivores. The blueback herring is prey for gulls, terns, and other coastal birds, as well as for bluefish (*Pomatomus saltatrix*), weakfish (*Cynoscion regalis*), and striped bass (*Morone saxatilis*) (CHGEC 1999).

Annual abundance of blueback herring YOY in the Hudson River estuary has been estimated to range from 1.2 million to 50.1 million individuals from sampling conducted with a Tucker trawl since 1979 (CHGEC 1999). Entrainment mortality for the combined abundance of blueback herring and alewife for all water withdrawal locations within the Hudson River varies widely, ranging from 8 to 41 percent in data taken between 1974 and 1997, while impingement mortality of the two species is low, ranging from 0.2 to 0.7 percent for the same time period (CHGEC 1999).

Bluefish

The bluefish (*Pomatomus saltatrix*, family Pomatomidae) is a migratory, pelagic species that occurs in temperate and tropical waters worldwide on the continental shelf and in estuaries. Along the Atlantic coast, the bluefish ranges from Nova Scotia to the Gulf of Mexico (Pottern et al. 1989). Bluefish are a highly sought-after sport fish along the North Atlantic Coast, and State and Federal regulations on the commercial catch of the species began in the early 1970s (CHGEC 1999; Pottern et al. 1989). The majority of the Atlantic coast bluefish catch occurs between New York and Virginia, and recreational fishing has accounted for 80 to 90 percent of the total bluefish catch in the past, with a peak in 1981 and 1985 of over 43,000 MT (47,000 t). Landings have since decreased, reaching a low of 3300 MT (3600 t) in 1999; landings in 2005 totaled 3500 MT (3300 t) (Shepherd 2006a). The bluefish is also harvested commercially for human consumption, and during peak years in 1981 to 1983, average annual landings were 7.4 million kg (16.3 million lb), accounting for 0.5 percent of the total Atlantic coast commercial finfish and shellfish landings (Pottern et al. 1989).

North American bluefish populations range from New England to Cape Hatteras, North Carolina, in the summer, and migrate to Florida and the Gulf Stream during the winter. Fisheries data also indicate the existence of small nonmigratory populations in southern Florida waters and the Gulf of Mexico (Pottern et al. 1989). Bluefish are generally not found in waters colder than 14 to 16 degrees C (57.2 to 60.8 degrees F) and exhibit signs of stress at temperatures below 11.8 degrees C (53.2 degrees F) and above 30.4 degrees C (86.7 degrees F) (Collette and Klein-MacPhee 2002).

Generally, bluefish have two major spawnings per year. The first spawning occurs during the spring migration as bluefish move northward to the South Atlantic Bight between April and May; the second spawning occurs in the summer in offshore waters of the Middle Atlantic Bight between June and August. Two distinct cohorts of juvenile bluefish in the fall result from the two spawning events, which mix during the year creating a single genetic pool (Shepherd 2006a). Females can produce 600,000 to 1.4 million eggs (CHGEC 1999). Larvae hatch in 46 to 48 hours at temperatures of 18 to 22 degrees C (64.4 to 71.6 degrees F) (Collette and Klein-

MacPhee 2002). Newly hatched larvae are pelagic and stay in offshore waters for the first 1 to 2 months of life before migrating shoreward to shallower waters (CHGEC 1999). Beach seine survey results indicate YOY bluefish are generally found between Yonkers and Croton-Haverstraw (Table 2-5). YSL typically consume the yolk sac by the time they reach 3 to 4 mm (0.12 to 0.16 in.) in length (Pottern et al. 1989). Bluefish larvae grow rapidly; spring-spawned juveniles reach lengths of 25 to 50 mm (0.99 to 2 in.) once they move to mid-Atlantic bays in the summer, grow to lengths of 175 to 200 mm (6.9 to 7.9 in.) by late September when migration begins, and reach lengths of about 260 mm (10.2 in.) by the following spring. Summer-spawned juveniles exhibit slower growth because they are unable to inhabit bays and estuaries until after their first migration, though summer-spawned juvenile growth rates exceed those of spring-spawned juveniles during the second year, at which point differences between the two stocks are less pronounced (Pottern et al. 1989). Adult bluefish can live up to 12 years and reach weights of 14 kg (31 lb) and lengths of 100 cm (39 in.) (Shepherd 2006a).

Bluefish are avid predators, and the Atlantic coast population is estimated to consume eight times its biomass in prey annually. Larvae feed on zooplankton and larvae of other pelagic-spawning fish (Pottern et al. 1989). In the Hudson River estuary, YOY feed on bay anchovy (*A. mitchilli*), Atlantic silverside (*M. menidia*), striped bass (*M. saxatilis*), blueback herring (*A. aestivalis*), Atlantic tomcod (*M. tomcod*), and American shad (*A. sapidissima*) (CHGEC 1999; Juanes et al. 1993). Adult bluefish diets are dominated by squids, clupeids, and butterfish. YOY bluefish are prey for birds including Atlantic puffin (*Fratercula arctica arctica*), Arctic tern (*Sterna paradioaea*), and roseate tern (*Sterna dougalli dougalli*) (Collette and Klein-MacPhee 2002). Sharks also prey on bluefish; species include the bigeye thresher (*Alopias superciliosus*), white shark (*Carcharodon carcharias*), shortfin mako (*Isurus oxyrinchus*), longfin mako (*I. paucus*), tiger shark (*Galeocerdo cuvier*), blue shark (*Prionace glauca*), sandbar shark (*Carcharhinus plumbeus*), smooth dogfish (*Mustelus canis*), spiny dogfish (*Squalus acanthias*), and angel shark (*Squatina* spp.) (Collette and Klein-MacPhee 2002).

The bluefish population data from the Hudson River estuary show a declining trend since the population peaked in 1981 and 1982 (CHGEC 1999). Bluefish populations along the east coast have historically fluctuated widely, though analysis by the NMFS of data between 1974 and 1986 did not find evidence of a systematic decline of the species (CHGEC 1999). Bluefish have not been found in entrainment samples from power plants along the Hudson River, which include Roseton Units 1 and 2, IP2 and IP3, or Bowline Point Units 1 and 2 (CHGEC 1999). Juvenile bluefish may be impinged, but the numbers are estimated to be relatively small (CHGEC 1999).

<u>Gizzard Shad</u>

The gizzard shad (*Dorosoma cepedianum*, family Clupeidae) is a pelagic herring species that is found in the waters of the Atlantic and Gulf coastal plains streams as well as in freshwater lakes and reservoirs ranging from New York to Mexico (MDNR 2007a). Gizzard shad are found mainly in freshwater rivers, reservoirs, lakes, and swamps, and in slightly brackish waters of estuaries and bays (Froese and Pauly 2007b). The gizzard shad is a relatively recent immigrant to the Hudson River estuary, though it is now considered a permanent resident, and the species is continuing to expand its range throughout the northeastern United States (CHGEC 1999; Levinton and Waldman 2006). No commercial or sport fishery for gizzard shad exists on the Hudson River (CHGEC 1999). Larvae have been observed in the tidal waters of the Hudson

River since 1989 (Levinton and Waldman 2006). A spawning population is believed to exist in the Mohawk River, but no spawning has been observed in the Hudson River (CHGEC 1999).

Adult gizzard shad grow to 23 to 36 cm (9 to 14 in.) in length with an average weight of 907 g (2 lb) and an average life span of 7 years in northern populations (CHGEC 1999; Morris 2001). Both males and females mature between 2 and 3 years of age, and females spawn between April and June in shallow waters between 10 and 21 degrees C (50 and 70 degrees F) (CHGEC 1999; MDNR 2007a). Fecundity is thought to be highly variable but does appear to increase with size of the female (CHGEC 1999). Females can produce between 50,000 and 379,000 eggs (MDNR 2007a). Eggs hatch in 1.5 to 7 days, depending on water temperature (CHGEC 1999). YSL transform into PYSL within 5 days of hatching and begin to feed on microzooplankton until they reach 2.5 cm (1 in.) in length. At this point, development of the digestive system supports a diet including plant material; juveniles eat a variety of daphnids, cladocerans, adult copepod, rotifers, algae, phytoplankton, and detritus (CHGEC 1999). Gizzard shad grow rapidly during the first 5 to 6 weeks of life, at which point growth slows; individuals reach a length of 10 to 25 cm (4 to 10 in.) by their first summer (CHGEC 1999). Adults are filter feeders, eating a variety of phytoplankton and zooplankton. Larvae are not an important prey species because of their size, but age 0 gizzard shad are consumed by a number of species including striped bass, largemouth bass (*Micropterus salmoides*), white crappie (*Pomoxis annularis*), black crappie (*Pomoxis nigromaculates*), white bass (*Morone chrysops*), and spotted bass (*Micropterus punctulatus*) (CHGEC 1999). Predators of adult gizzard shad include catfish (order Siluriformes) and striped bass (*M. saxatilis*) (Morris 2001).

Abundance data are not available for the gizzard shad from the Hudson River sampling programs because of the low capture rate of the species in these programs (CHGEC 1999). Beach seine surveys from 1974 to 2005 suggest YOY and older gizzard shad occur primarily from Cornwall north to Albany (Table 2-5). Impingement data are available at three power stations along the Hudson River (Danskammer, Roseton Units 1 and 2, and the now-shuttered Lovett Generating Station) and indicate year-to-year fluctuations with a general trend of increasing impingement and peak adult impingement during the winter months. Entrainment of early life stages is thought to be low, and small gizzard shad are rare in utility ichthyoplankton surveys (CHGEC 1999).

<u>Hogchoker</u>

The hogchoker (*Trinectes maculatus*, family Soleidae) is a right-eyed flatfish species found along the Atlantic coast in bays and estuaries from Maine to Panama (Dovel et al. 1969). The hogchoker is common in the Hudson River estuary and surrounding bays and coastal waters, and abundance indices from the annual Fall Juvenile Survey (also known as the Fall Shoals Survey) channel sampling in the Hudson River from 1974 to 1997 indicate that the hogchoker population has remained relatively stable with a nonsignificant 1 percent increase per year (CHGEC 1999). Because of its small size (adults range from 6 to 15 cm (2.4 to 5.9 in.) with a maximum size of 20 cm (7.9 in.)), the hogchoker is not commercially harvested in any area within its geographic range (Collette and Klein-MacPhee 2002). CHGEC (1999) indicates that hogchoker larvae are found mainly within deeper channel waters and are not often captured during the Longitudinal River Survey; low numbers of juveniles are captured during the Beach Seine and Fall Juvenile Surveys, and yearlings and adults are generally not exposed to Hudson River generating stations because they remain in the waters below RM 34 (CHGEC 1999). However, the Fall Juvenile Survey information reviewed by the NRC staff suggests that YOY

and older hogchokers have been collected from Tappan Zee to Poughkeepsie—an area that includes IP2 and IP3 (Table 2-5).

The majority of hogchokers in the Hudson River reach sexual maturity at the age of 2 years, though some faster growing males have been observed to spawn at age 1 year (Koski 1978). Spawning occurs in estuaries between May and October in the Hudson River estuary, which is a 5-week longer spawning period than that of the Chesapeake Bay population (Collette and Klein-MacPhee 2002; Koski 1978). Spawning occurs in waters 20 to 25 degrees C (68 to 77 degrees F) and a salinity of 10 to 16 ppt (Collette and Klein-MacPhee 2002). Eggs are observed in greatest numbers from the last week in May through July in lower estuary waters. Egg production is positively correlated with size, and females can produce between 11,000 and 54,000 eggs. Within the Hudson River, eggs are most common between RM 12 and 24 (RKM 19 and 39). Eggs hatch in 24 to 36 hours at temperatures between 23.3 and 24.5 degrees C (73.9 and 76.1 degrees F). YSL absorb the yolk sac within 48 hours of hatching, and eye migration occurs within 34 days of hatching or at lengths of 0.2 to 0.4 in. (0.51 to 0.02 cm) (Collette and Klein-MacPhee 2002; CHGEC 1999). Larvae have been observed to congregate upstream in waters with lower salinity than their hatching ground (Dovel et al. 1969). Within the Hudson River, YSL are most abundant between RM 24 and 33 (RKM 39 and 53), and PYSL are most abundant from RM 24 through RM 55 (RKM 39 and 89). Juveniles are found above RM 39 (RKM 63), while yearling and older individuals are found below RM 34 (RKM 55) (CHGEC 1999). Adult individuals inhabit nonvegetated waters with sandy or silty bottoms (Whiteside and Bonner 2007).

Adult hogchokers feed mainly on annelids, arthropods, and tellinid siphons (Derrick and Kennedy 1997). The species is a generalist and may also prey on midges, ostracods, aquatic insects, annelids, crustaceans, and foraminiferans (Whiteside and Bonner 2007). Larger striped bass (*M. saxatilis*) prey on yearling and older hogchokers within the Hudson River estuary, which may affect the abundance of those age groups (CHGEC 1999). The Northeast Fisheries Science Center also found the smooth dogfish (*Mustelus canis*) to be a predator of hogchoker (Roundtree 1999 as cited in Collette and Klein-MacPhee 2002).

<u>Rainbow Smelt</u>

Rainbow smelt (*Osmerus mordax*, family Osmeridae) is an anadromous species once found along the Atlantic coast from Labrador to the Delaware River, although the southern end of the range is now north of the Hudson River. NOAA (2007) lists rainbow smelt as a Species of Concern. Unless otherwise noted, information below comes from Buckley (1989).

Adult rainbow smelt along the east coast move into saltwater in summer, where they are found in waters less than 1 mi (1.6 km) from shore and usually no deeper than 6 m (20 ft). In spring, spawning adults typically move up the estuaries before ice breaks up to spawn above the head of tide in water temperatures of 4.0 to 9.0 degrees C (39 to 48 degrees F). They have been found to run up into coastal streams to spawn at night and then return to the estuary during the day. Females, depending on size, produce about 7,000 to 75,000 eggs (summarized in NOAA 2007a), which are from 1.0 to 1.2 mm (about 0.04 in.) in diameter. Eggs are typically deposited over gravel, and egg survival appears to be influenced by water flow, substrate type, and egg density. Exposure to salt or brackish water can cause egg mortality, as can sudden increases in temperature, diseases, parasites, contaminant exposure, and predation by other fish species. Incubation times can be 8 to 29 days and decrease with increasing water temperature.

Common mummichog (*Fundulus heteroclitus*) and fourspine stickleback (*Apeltes quadracus*) are reported to be major predators on smelt eggs.

YSL are 5 to 6 mm (0.20 to 0.24 in.) long at hatching. The yolk sac is absorbed by the time the larvae reach 7 mm (0.28 in.) and enter the PYSL stage. Larvae now concentrate near the surface and drift downstream. As they grow, they seek deeper water and congregate near the bottom. Vertical migration begins, and they move to the surface to feed during the day and deeper at night. The vertical migration patterns may maintain their position in two-layered estuarine systems. Larval and small juvenile smelt eat copepods and other small planktonic crustaceans as well as fish. In turn, larval and juvenile smelt are probably eaten by most estuarine piscivores.

Smelt grow fairly rapidly and begin to school when they reach a length of 19 mm (0.75 in.). As the smelt grow, they move down estuaries into higher salinity and, as adults, migrate to sea. They are mature and participate in spawning runs at age 1. Adults grow to average approximately 25.4 cm (10 in.) in length. Larger juveniles and adults feed on euphausiids, amphipods, polychaetes, and fish such as anchovies (family Engraulidae) and alewives (*A. pseudoharengus*). Adults also eat other fish species, including common mummichog, cunner (*Tautogolabrus adspersus*), and Atlantic silversides (*Menidia menidia*). Bluefish (*P. saltatrix*), striped bass (*M. saxatilis*), harbor seals (*Phoca vitulina*), and other large piscivores eat adult smelt.

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.

<u>Spottail Shiner</u>

The spottail shiner (*Notropis hudsonius*, family Cyprinidae) is a freshwater species which occurs across much of Canada, south to the Missouri River drainage, and in Atlantic States from New Hampshire to Georgia, with habitat ranging from small streams to large rivers and lakes, including Lake Erie (Smith 1985a). One of the most abundant fishes in the Hudson River, spottail shiners are commonly 3.9 in. (100 mm) in length, which is large for shiner species (Smith 1985a). The maximum length is approximately 5.8 in. (147 mm) (Schmidt and Lake 2006; Smith 1985a; Marcy et al. 2005a).

Spottail shiners spawn from May to June or July (typically later for the northern populations) over sandy bottoms and stream mouths (Smith 1985a; Marcy et al. 2005a); water chestnut (*Trapa natans*) beds provide important spawning habitat (CHGEC 1999). Individuals older than 3 years are seldom found, but there is evidence of individuals living up to 4 or 5 years (Marcy et

al. 2005a). Fecundity is a factor of age: the ovaries of younger females contain 1400 eggs, and ovaries of older females contain from 1300 to 2600 eggs; a correlation between fecundity and size does not appear to exist (Marcy et al. 2005a). In the Hudson River Estuary, beach seine survey data from 1974 to 2005 showed the largest abundances of YOY and Year 1+ individuals occurred from Poughkeepsie north to Albany (Table 2-5).

Spottail shiners are opportunistic feeders, typically eating insects, bivalve mollusks, and microcrustaceans throughout the water column (Marcy et al. 2005a). Aggregations of spottail shiners have been observed preying on eggs of alewives (*Alosa psedoharengus*) and mayflies (Marcy et al. 2005a). Striped bass (*M. saxatilis*) larvae are also prey for spottail shiners (McGovern and Olney 1988), as are spottail eggs and larvae (Smith 1985a). Spottail shiners are frequently used as bait (Smith 1985a), and they are an important prey species for some fish, including walleye (*Sander vitreus*), channel catfish (*I. punctatus*), northern pike (*Esox lucius*), and smallmouth bass (*Micropterus dolomieu*) (IDFG 1985). The Hudson River population of spottail shiners is known to be susceptible to impingement and entrainment at water intakes, and this could be affecting the survivorship of most life stages (CHGEC 1999).

<u>Striped Bass</u>

The striped bass (*Morone saxatilis*, family Moronidae) is an anadromous species, with a range extending from St. Johns River, Florida, to St. Lawrence River, Canada (ASMFC 2006b). Individual stocks of striped bass spawn in rivers and estuaries from Maine to North Carolina. When adults leave the estuaries to go to the Atlantic, the stocks mix; striped bass return to their natal rivers and estuaries to spawn. The Atlantic coast striped bass fishery has been one of the most important commercial fisheries on the east coast for centuries and has been regulated since European settlement in North America (ASMFC 2006b). In 1982, overfishing depleted the striped bass population to fewer than 5 million fish. Since that time, the Atlantic coast population has been restored to 65 million in 2005 (ASMFC 2006b). Striped bass have been important in both commercial and recreational fisheries, and while the majority of the stock spawns in the Chesapeake Bay, the Hudson River contributes to the stock as well. Fabrizio (1987) reported that of the age 2–5 individuals sampled from the Rhode Island commercial trap-net fishery in November 1982, 54 percent were from the Chesapeake Bay stock and 46 percent were from the Hudson River stock. Wirgin et al. (1993) estimated that the Chesapeake Bay and Hudson River stocks combined contributed up to 87 percent of the mixed fishery stock on the Atlantic coast.

The striped bass is a long-lived species, reaching 30 years of age, and spends the majority of its life in coastal estuaries and the ocean. Females reach maturity between 6 and 9 years, and then produce between .5 million and 3 million eggs per year, which are released into riverine spawning areas (ASMFC 2006b). The males, reaching maturity between 2 and 3 years, fertilize the eggs as they drift downstream (ASMFC 2006b). The eggs hatch into larvae, which absorb their yolk and then feed on microscopic organisms. PYSL mature into juveniles in the nursery areas, such as river deltas and inland portions of coastal sounds and estuaries, where they remain for 2 to 4 years, before joining the coastal migratory population in the Atlantic (ASMFC 2006b). Recent field investigations by Dunning et al. (2006b) have suggested that dispersal of age 2+ striped bass out of the Hudson River may be influenced by cohort abundance. In the spring or summer, adults migrate northward from the mouth of their spawning rivers up the Atlantic coast, and in the fall or winter they return south, in time to spawn in their natal rivers (Berggren and Lieberman 1978; ASMFC 2006b). Work by Wingate and Secor (2007), using

remote biotelemetry on a total of 12 fish, suggested that specific homing patterns are possible for this species, and these patterns may influence their susceptibility to localized natural and anthropogenic stressors. Based on long-term monitoring data, various life-stages associated with this species are found in the Hudson River from Tappan Zee to Albany (Table 2-5).

Several factors play a role in spawning, including water temperature, salinity, total dissolved solids concentration, and water velocity and flow. Peak spawning occurs in water temperatures of 15 to 20 degrees C (59 to 68 degrees F) but can occur between 10 and 23 degrees C (50 and 73 degrees F) (Shepherd 2006b). Striped bass reach 150 cm (59 in.) in length and 25 to 35 kg (55 to 77 lb) in weight (Shepherd 2006b). Adult striped bass are omnivores and prey on invertebrates and fish, especially clupeids, including menhaden (*B. tyrannus*) and river herring (*Alosa* spp.) (Shepherd 2006b). Diets vary by season and location, typically including whatever species are available (Bigelow and Schroeder 1953). YOY striped bass diet is made up of fish and mysid shrimp (Walter et al. 2003).

Compared to other anadromous species, striped bass appear to spend extended periods in the Hudson River, contributing to their PCB body burdens. In 1976, the Hudson River commercial fishery was closed because of PCB contamination, although shad fishermen continue to catch striped bass in their nets (CHGEC 1999). Commercial restrictions on harvesting the Atlantic coastal fishery, in part supported by the Atlantic Striped Bass Conservation Act of 1984 (16 U.S.C. 5151–5158), which allows coastal States to cooperatively regulate and manage the stock, have led to the declaration of full recovery of the population in 1995 (ASMFC 2006b). Abundance levels have continued to increase in the Atlantic population. Restrictions on both commercial and recreational fisheries have been relaxed because of the recovery of the population (ASMFC 2006b), but the fisheries continue to be limited to State waters (within 3 nautical miles of land), and New York State's commercial fishery remains completely closed. While commercial landings have remained lower than the levels seen in the early 1970s, recreational landings have increased, and in 2004 made up 72 percent of the total weight harvested from the Atlantic stock (Shepherd 2006b). Recreational fishing in the Hudson River during the spring generally occurs north of the Bear Mountain Bridge (RKM 75 (RM 46)) (Euston et al. 2006).

<u>Weakfish</u>

The weakfish (*Cynocsion regalis*, family Sciaenidae) is a demersal species found along the Atlantic coast ranging from Massachusetts Bay to southern Florida and is occasionally found as far north as Nova Scotia and as far south as the eastern Gulf of Mexico (Mercer 1989). The weakfish is one of the most abundant fish species along the Atlantic coast and is fished recreationally as well as commercially via gill-net, pound-net, haulseine, and trawl (Mercer 1989). ASMFC considers weakfish to be composed of one stock based on genetic analysis; however, more recent tagging studies have indicated that weakfish may return to their natal estuary to spawn (ASMFC 2006c). The stock as a whole is thought to be declining as evidenced by decreased landings in recent years. Landings peaked in 1981 and 1982 at 12,500 MT (13,800 t), declined from 1989 through 1993, peaked again in 1998 at over 5000 MT (5500 t), and then declined from 1999 through 2004, at which point a record low of less than 1000 MT (1100 t) was reported (ASMFC 2006c). Entrainment of eggs and larvae at power plants within the Hudson River is not common because weakfish spawn in waters with higher salinity, though movement of juveniles into the Hudson River estuary during late winter and

early spring results in some entrainment of young juveniles and impingement of larger juveniles (CHGEC 1999).

Weakfish are found at a depth range of 10 to 26 m (33 to 85 ft) and temperatures between 17 and 27 degrees C (63 and 81 degrees F) (Froese and Pauly 2007c). Adults favor shallow coastal waters with sandy substrate and a salinity of 10 ppt or higher, though they are found in a variety of estuarine environments (CHGEC 1999). Adult weakfish vary greatly in size, ranging from 6 to 31 in. (15 to 79 cm) in length, with a maximum weight of 20 lb (9.1 kg), and can live up to 11 years (CHGEC 1999). Most weakfish mature at the age of 2 during the late summer months, and almost all weakfish are mature by the end of their third summer (CHGEC 1999). Size at maturity varies with latitude: in northern populations, females have been observed to mature at 256 mm (10.1 in.) and males at 251 mm (9.9 in.), while in North Carolina populations, females have been observed to spawn at 230 mm (9.1 in.) and males at 180 mm (7.1 in.) (Mercer 1989). Weakfish migrate southward in the fall to the coastal waters of North Carolina and Virginia and then move northward in the spring to spawn (ASMFC 2006c).

Spawning takes place along the northeastern coast of the Atlantic between the Chesapeake Bay and Montauk, Long Island, New York, in nearshore coastal and estuarine waters during the spring and summer (CHGEC 1999). Within the New York Bight, two spawning peaks occur in mid-May, consisting of larger individuals that migrate northward earlier, and in June, consisting of smaller individuals (Mercer 1989). Fecundity estimates vary widely, though fecundity can be generally correlated with size and geographic area (from 4593 eggs for a 203-mm (8-in.) female to 4,969,940 eggs for a 569-mm (22.4-in.) female and from 306,159 eggs for a northern female to 2,051,080 eggs for a similarly sized female in North Carolina) (Collette and Klein-MacPhee 2002). Eggs can tolerate a temperature range of 12 to 31.5 degrees C (53.6 to 88.7 degrees F) and a salinity range of 10 to 33 ppt (Collette and Klein-MacPhee 2002). Larvae hatch within 36 to 40 hours at temperatures of 20 to 21 degrees C (68 to 69.8 degrees F) (Mercer 1989). Larvae move into bays and estuaries after hatching; in the Hudson River estuary, larvae are rarely observed north of the George Washington Bridge because of the lower salinity of these waters (CHGEC 1999). Larvae feed primarily on cyclopoid copepods, as well as calanoid copepods, tintinnids, and polychaete larvae (Collette and Klein-MacPhee 2002). Weakfish juveniles grow rapidly during their first year and reach lengths of 7.6 to 15.2 cm (3 to 6 in.) by the end of the summer (CHGEC 1999). Juveniles are typically distributed from Long Island to North Carolina in late summer and fall in waters of slightly higher salinity, sand or sand-grass substrates, and depths of 9 to 26 m (30 to 85 ft) (Mercer 1989). Juveniles are considered adults at approximately 30 mm (1.2 in.) (Collette and Klein-MacPhee 2002).

Adult weakfish feed on a variety of organisms, and their diet varies with locality and availability of food sources. Smaller weakfish (less than 20 cm (7.9 in.)) feed primarily on crustaceans, while larger weakfish feed primarily on anchovies, herrings, spot, and other fish (CHGEC 1999; Mercer 1989). Adult weakfish of all sizes also prey on decapod shrimps, squids, mollusks, and annelid worms (CHGEC 1999; Mercer 1989). Bluefish (*P. saltatrix*), striped bass (*M. saxatilis*), and older weakfish prey on younger weakfish, while weakfish of larger size are preyed on by dusky sharks (*Carcharhinus obscurus*), spiny dogfish (*Squalus acanthias*), smooth dogfish (*Mustelus canis*), clearnose skate (*Raja eglanteria*), angel sharks (*Squatina* spp.), goosefish (family Lophiidae), and summer flounder (*Paralichthys dentatus*) (Collette and Klein-MacPhee 2002).

YOY and older weakfish are generally found from Yonkers to West Point (Table 2-5). Weakfish abundance fluctuated from 1979 to 1990, and abundance was relatively low between 1990 and 1997; overall, abundance declined 6 percent between 1979 and 1997 (CHGEC 1999). The weakfish stock as a whole declined suddenly in 1999 and approached even lower levels by 2003, which ASMFC determined to be the result of higher natural mortality rates rather than the result of fishing mortality (ASMFC 2007b). A leading hypothesis suggests that insufficient prey species and increased predation by striped bass may contribute significantly to rising natural mortality rates in the weakfish population (ASMFC 2007b).

White Catfish

The white catfish (*Ictalurus catus*, family Ictaluridae) is a demersal species found in estuarine and freshwater habitats along the Atlantic coast from the lower Hudson River to Florida, though it has been introduced in other areas, including Ohio and California (Smith 1985b). The natural distribution of the species is thought to be in coastal streams from the Chesapeake Bay to Texas; limited recreational fishing for this species occurs in the Hudson River (CHGEC 1999). White catfish are the least common species of catfish in New York waters (NYSDEC 2008a). The New York State Department of Health has issued a fish advisory for the species because of the potential for elevated levels of PCBs (NYSDOH 2007). Additionally, the New Jersey Department of Environmental Protection (NJDEP) has issued a health advisory for the white catfish downstream of the New York-New Jersey border, which includes portions of the Hudson River and Upper New York Bay (NJDEP and NJDHSS 2006).

The white catfish is of intermediate size compared with other species in the family; adults grow to lengths of 8.3 to 24 in. (21 to 62 cm) and reach weights of 0.6 to 2.2 lb (0.25 to 1.0 kg) (Marcy et al. 2005b). The species has been reported to live 11 or more years as evidenced by individuals observed in South Carolina (Marcy et al. 2005b). White catfish prefer fresh or brackish water and, in the upper Hudson River, are most commonly found in channel borders, shoals, and vegetated backwaters (Marcy et al. 2005b). Though the white catfish is more salt tolerant than most catfish species, it is not typically found in waters with salinities above 8 ppt (CHGEC 1999; NJDEP 2005). Fall Juvenile Survey data from 1979 to 2004 suggests that YOY and older individuals were generally found from the Saugerties to Albany segments of the Hudson River (Figure 2-10, Table 2-5).

White catfish are sexually mature between 3 to 4 years of age at the size of 7 to 8 in. (18 to 20 cm). Adults move upstream for spawning between late June and early July when Hudson River water temperatures reach approximately 70 degrees F (21 degrees C) (CHGEC 1999). Before spawning, both males and females construct nests on sand or gravel bars, and males protect the nest once females lay eggs. Females that are 11 to 12 in. (28 to 30 cm) can lay 3200 to 3500 eggs. Eggs hatch in 6 to 7 days at temperatures between 75 to 85 degrees F (24 to 29 degrees C) (CHGEC 1999; Smith 1985b). Males continue to protect young until the juveniles form large schools and disperse from the nest (MDNR 2007b). YOY migrate downstream to deeper waters in September and October, and generally, yearling and older white catfish move out of the upper Hudson River estuary once the water temperatures drop below 59 degrees F (15 degrees C) to overwinter in the lower estuary. (Smith 1985b, CHGEC 1999).

White catfish have an especially varied diet. Adults collected from the North Newport River in Georgia were found to consume over 50 different species of prey (Marcy et al. 2005b).

Juveniles and smaller adults feed primarily on midge larvae and macroinvertebrates, while larger adults have a more diverse diet, which may consist of midge larvae, crustaceans, algae, fish eggs, and a number of fish species, including herring (*Clupea* spp.), menhaden (*Brevoortia* spp.), gizzard shad (*Dorosoma cepedianum*), and bluegills (*Lepomis macrochirus*) (CHGEC 1999; Smith 1985b). Amphipods are widely consumed by adult catfish and make up a large percentage (up to 80 percent) of the volume of food eaten (CHGEC 1999).

The white catfish population is considered stable throughout the majority of its range, though the Hudson River population appears to have been in decline since 1975 (CHGEC 1999). The decline may partially be a result of food-limited growth and survival of larvae and YOY as a result of resource depletion by PYSL and YOY striped bass (*Morone saxatilis*) (CHGEC 1999). Generally, early life stages of the species are not at risk of entrainment because spawning and early development occurs upstream near nests, which adult white catfish guard (CHGEC 1999). Juvenile and adult white catfish are infrequently impinged; the species has been recorded to consist of 0.42 percent of total fish impinged at IP2 and IP3 (CHGEC 1999).

<u>White Perch</u>

White perch (*Morone americana*) is endemic to the North American eastern coastal areas and range from Nova Scotia to South Carolina. It is not actually a perch, but a member of the temperate bass family Percichthyidae, along with striped bass (*M. saxatilis*). White perch are year-round residents in the Hudson River between New York City and the Troy Dam near Albany. They have never been a recreationally or commercially important resource for the Hudson River, and commercial fishing was closed in 1976 because of PCB contamination, but they are well represented in impingement collections of Hudson River power plants. In other parts of its range, white perch is intensively fished (Klauda et al. 1988).

Spawning habitats vary and can be clear or turbid, fast or slow, in water less than 7 m (23 ft) deep (Stanley and Danie 1983). In the Hudson River, most spawning occurs in the upper reaches (RKM 138 to 198 (RM 86 to 123)) in shallow embayments and tidal creeks, and adults move offshore and downriver after spawning (Klauda et al. 1988). Spawning in the Hudson begins in late April when water temperatures reach 10 to 12 degrees C (50 to 54 degrees F) and can continue until late May or early June when temperatures reach 16 to 20 degrees C (61 to 68 degrees F) (Klauda et al. 1988). Fecundity depends on age and size of the females and ranges from about 5,000 to over 300,000 eggs (Stanley and Danie 1983). The eggs are adhesive and sink and may stick to the substrate or each other.

Hatching takes place between 1 and 6 days following fertilization, and the incubation period is inversely related to water temperature but relatively unaffected by salinity and silt levels (Collette and Klein-MacPhee 2002; Stanley and Danie 1983). Newly hatched YSL are about 2 mm (0.08 in.) long, and after 5 to 6 days, the yolk sac is absorbed (Collette and Klein-MacPhee 2002). The YSL generally remain in the same area where they hatched for 4 to 13 days (Stanley and Danie 1983). PYSL eat zooplankton and grow rapidly.

Juveniles tend to stay in inshore areas of the estuary and in creeks until they are about a year old and 20 to 30 cm (8 to 12 in.) in length and then tend to move downstream to brackish areas (Stanley and Danie 1983). Although they may move offshore during the day, they tend to return to shoal areas at night. Most males and females mature at 2 years. Juveniles eat larger zooplankton. In the spring as water temperature rises, adults, which can reach maximum

lengths of 495 mm (19.5 in.), begin their spawning migration and start to move upstream into shallower, fresher waters and into tidal streams. After spawning, they return to deeper waters. In summer, large schools of white perch tend to move slowly without direction, and they tend not to travel very far. (Stanley and Danie 1983)

White perch are opportunistic feeders and have a broad range of prey. Young adults in freshwater environments feed on aquatic insects, crustaceans, and other smaller fishes (Stanley and Danie 1983). In brackish and estuarine environments, the white perch feed on fish eggs, the larvae of walleye (*Sander vitreus*) and striped bass, and other smaller adult fish (Chesapeake Bay Program 2006). Young adult white perch also consume amphipods, snails, crayfish, crabs, shrimp, and squid where available. White perch larger than 22 cm (9 in.) feed almost exclusively on other fish. White perch are consumed by many larger predatory fish species.

<u>Blue Crab</u>

Blue crab (Callinectes sapidus, family Portunidae) is an important commercial and recreational resource throughout much of its range, which in the western Atlantic is from Nova Scotia through the Gulf of Mexico to northern Argentina. The life history of blue crab in the Hudson River estuary is largely based on the Delaware and Chesapeake Bays where the most relevant information in the United States has been gathered. Unless otherwise noted, information below is from Perry and McIlwain (1986).

Spawning and mating in blue crabs occur at different times. Mating takes place when female crabs are in the soft condition after their terminal, or last, molt. Males then carry the soft-shelled females until their shell hardens. Females store the sperm, which is used to fertilize the eggs for repeated spawnings. After the shell hardens, the females move downstream to the mouths of estuaries to spawn. Females extrude fertilized eggs and attach them on the underside of their bodies as a bright orange “sponge” consisting of up to 2 million eggs. The eggs become darker as they mature, and the sponge is almost black at the time of hatching. The eggs hatch and release the first zoea stage after about 2 weeks.

Larval crabs go through seven zoeal stages (and sometimes eight) in 31 to 49 days, depending on temperature and salinity. The zoeae are planktonic and live in the ocean near shore. Zoeae eat small zooplankton, such as rotifers. The last zoeal stage metamorphoses with its molt to a megalops larva, which persists from 6 to 20 days. Megalops larvae have more crab-like features than zoeae and are initially planktonic but gradually become more benthic. Megalops larvae inhabit the lower estuary and nearshore areas (ASMFC 2004) and have been found as far as 40 mi (64 km) offshore. Winds, tides, and storms transport the larvae back in towards shore (Kenny 2002). Among others, jellyfish are predators on crab larvae.

The megalops larvae molt and metamorphose into the first crab stage, which has all the features of a blue crab, and, like all crustaceans, grows by molting. The early crab stages, which are 10 to 20 mm (0.4 to 0.8 in.) carapace width in size, migrate to fresher water. Although benthic, blue crabs are good swimmers. They feed less and cease molting as winter nears and bury themselves in the mud in winter. Because the Hudson River is at the northern end of the blue crab’s range, severe winters may affect over-winter survival (Kenney 2002).

In the Chesapeake Bay, blue crabs mature in 18 to 20 molts, at which time females undergo a final, or terminal, molt, and males continue to grow and molt (Kenney 2002). In the Hudson River, most females make the terminal molt before they reach a carapace width of about

125 mm (4.92 in.) (Kenney 2002). Adult males prefer the low salinity areas of upper estuaries, while females, after mating, move to and remain in the higher salinity areas of the lower estuary. Blue crabs can live about 3 or 4 years, although most probably do not live past the age of 2. Adult blue crabs are benthic predators that will lie in wait to catch small fish. They also eat other crabs and crustaceans, mollusks, dead organisms, zebra mussels, aquatic plants, and organic debris. They will also eat other blue crabs. Young and adult blue crabs are prey for many predators, including a variety of birds, including herons and diving ducks; humans; raccoons; and fish, including various members of the sciaenid (drum) family, American eel, and striped bass. Cannibalism is thought to be a major source of mortality. Environmental factors thought to affect juvenile and adult blue crab populations include drought, winter mortality, hypoxia, hurricanes, and the effects of human development (ASMFC 2004).

New York has a relatively small blue crab fishery, which reported a large decrease in landings in 1997; since then, the harvest has been about a million pounds a year (ASMFC 2004). Blue crab fishing in the Hudson River Estuary occurs mostly in the summer and fall (Kenney 2002). Egg-bearing females are returned to the river to help protect spawning stock (Kenney 2002).

2.2.5.5 Protected Aquatic Resources

Atlantic Sturgeon

The Atlantic sturgeon (*Acipenser oxyrhynchus*, family Acipenseridae) is an anadromous species, with a range extending from St. Johns River, Florida, to Labrador, Canada. Considered the "cash crop" of Jamestown before tobacco, the Atlantic sturgeon has been harvested for its flesh and caviar, as well as its skin and swim bladder. A long-lived, slowly maturing species, the Atlantic sturgeon can reach 60 years of age (ASMFC 2007c; Gilbert 1989). Maturity is reached at 7 to 30 years for females, and 5 to 24 for males, with fish in the southern range maturing earlier than those inhabiting the northern range (ASMFC 2007c). Fecundity is correlated with age and size, ranging from 400,000 to 8 million eggs per female (NMFS 2007). Individuals reach lengths of about 79 in. (200 cm), while the largest recorded sturgeon was 15 ft (4.5 m) and 811 lb (368 kg) (ASMFC 2007c).

In the spring, adult Atlantic sturgeons migrate to freshwater to spawn, with males arriving a few weeks before the females. In the Hudson, the males' migration occurs when water temperatures reach 5.6 to 6.1 degrees C (42 to 43 degrees F); the females appear when water temperatures warm to 12.2 to 12.8 degrees C (54 to 55 degrees F). Spawning occurs a few weeks later (Gilbert 1989). Eggs are deposited on hard surfaces on the river bottom, and hatch after 4 to 6 days (Shepherd 2006c). Individuals do not spawn annually—spawning intervals range from 1 to 5 years for males and 2 to 5 years for females (NMFS 2007). Females typically leave the estuary 4 to 6 weeks after spawning, but the males can remain in the estuary until the fall. Larvae feed from their yolk sac for 9 to 10 days, and then the PYSL begin feeding on the river bottom (Gilbert 1989). In the fall, the juveniles move downstream from freshwater to the estuaries, where they remain for 3 to 5 years, and then migrate to the ocean as adults (Shepherd 2006c). Individuals return to their natal river for spawning, and so the species is divided into five distinct population segments (ASSRT 2007). Juveniles and adults are bottom feeders, subsisting on mussels, worms, shrimp, and small fish (Gilbert 1989; ASMFC 2007c).

Before 1900, landings of Atlantic sturgeon reached 3500 MT (3860 t) per year. This number dropped in the 20th century, and from 1950 to 1990, landings ranged from 45 to 115 MT (50 to 127 t)) per year (Shepherd 2006c). ASMFC placed a moratorium on harvesting wild Atlantic

sturgeon for the entire coast in 1997, in an attempt to allow the population to recover. In 1999, the Federal Government banned the possession and harvest of sturgeon in the Exclusive Economic Zone (Shepherd 2006c; ASMFC 2007c). Using a Petersen mark–recapture population estimator, Peterson et al. (2000) estimated that the Hudson River population of age 1 Atlantic sturgeon had declined about 80 percent between 1977 and 1985. The authors suggested that the then-current recruitment could be too low to sustain the population. As of October 2006, NMFS has listed Atlantic sturgeon as a candidate species for listing under the Endangered Species Act (71 *Federal Register* (FR) 61022). Threats such as bycatch, water quality, and dredging continue to affect Atlantic sturgeon (ASMFC 2007c). In the Hudson River, the Federal Dam (the southernmost obstruction in the river) is upstream of the northern extent of the Atlantic sturgeon spawning habitat and therefore is not a limiting factor (ASSRT 2007).

Average levels of PCBs in Hudson River sturgeon tissue exceeded FDA guidelines for human consumption in the 1970s and 1980s; since then, levels of PCBs have dropped below FDA guidelines (ASSRT 2007). Although the State placed a moratorium on harvesting Atlantic sturgeon in 1996 when it became apparent that the Hudson River stock was overfished, the American shad gill net fishery continues to take subadult sturgeon as bycatch. The Status Review Team for Atlantic Sturgeon concluded in 2007 (ASSRT 2007) that the Hudson River subpopulation has a moderate risk (less than 50 percent) of becoming endangered in the next 20 years as a result of the threat of commercial bycatch. Despite this, the Hudson River supports the largest subpopulation of spawning adults and juveniles, and some long-term surveys indicate that the abundance has been stable since 1995 or is even increasing (ASSRT 2007). Recent work by Sweka et al. (2007) has suggested that a substantial population of juvenile Atlantic sturgeon are present in Haverstraw Bay and that future population monitoring should focus on this area to obtain the greatest statistical power for assessing population trends.

Shortnose Sturgeon

The shortnose sturgeon (*Acipenser brevirostrum*, family Acipenseridae) is amphidromous, with a range extending from St. Johns River, Florida, to St. John River, Canada. Unlike anadromous species, shortnose sturgeons spend the majority of their lives in freshwater, moving to saltwater periodically, without relation to spawning (Collette and Klein-MacPhee 2002). From colonial times, shortnose sturgeons have rarely been the target of commercial fisheries but have frequently been taken as incidental bycatch in Atlantic sturgeon and shad gillnet fisheries (Shepherd 2006c; Dadswell et al. 1984). The shortnose sturgeon was listed on March 11, 1967, as endangered under the Endangered Species Act of 1973, as amended. In 1998, a recovery plan for the shortnose sturgeon was finalized by NMFS (NMFS 1998) not in list. The threats to the species include dams, water pollution, and destruction or degradation of habitat (Shepherd 2006c).

Shortnose sturgeon can grow up to 143 cm (56 in.) in total length, and can weigh up to 23 kg (51 lb). Females are known to live up to 67 years, while males typically do not live beyond 30 years (Dadswell et al. 1984). As young adults, the sex ratio is 1:1; however, among fish larger than 90 cm (35 in.), measured from nose to the fork of the tail, the ratio of females to males increases to 4:1. Throughout the range of the shortnose sturgeon, males and females mature at 45 to 55 cm (18 to 22 in.) fork length, but the age at which this length is achieved varies by geography. At the southern extent of the sturgeon's range, males reach maturity at age 2, and females reach maturity at 6 years or younger; in Canada, males can reach maturity

as late as age 11, and females at age 13 (Dadswell et al. 1984; OPR undated). One to two years after reaching maturity, males begin to spawn at 2-year intervals, while females may not spawn for the first time until 5 years after maturing, and thereafter spawn at 3- to 5-year intervals (Dadswell et al. 1984; OPR undated). Shortnose sturgeon migrate into freshwater to spawn during late winter or early summer. Eggs adhere to the hard surfaces on the river bottom before hatching after 4 to 6 days. Larvae consume their yolk sac and begin feeding in 8 to 12 days, as they migrate downstream away from the spawning site (Kynard 1997; Collette and Klein-MacPhee 2002). The juveniles, which feed on benthic insects and crustaceans, do not migrate to the estuaries until the following winter, where they remain for 3 to 5 years. As adults, they migrate to the nearshore marine environment, where their diet consists of mollusks and large crustaceans (Shepherd 2006c; OPR undated).

In the Hudson River, shortnose sturgeon use the lower Hudson and are dispersed throughout the river estuary from late spring to early fall and then congregate to winter near Sturgeon Point (RKM 139 (RM 86)). They then spawn in the spring, just downstream of the Federal Dam at Troy. The population of shortnose sturgeons in the Hudson River has increased 400 percent since the 1970s, according to Cornell University researchers (Bain et al. 2007). Recent work by Woodland and Secor (2007) estimates a fourfold increase in sturgeon abundance over the past three decades, but reports that the population growth slowed in the late 1990s, as evidenced by the nearly constant recruitment pattern at depressed levels relative to the 1986–1992 year classes. Although the Hudson River appears to support the largest population of shortnose sturgeons, Bain et al. (2007) report that other populations along the Atlantic coast are also increasing, and some appear to be nearing safe levels, suggesting that the overall population could recover if full protection and management continues.

2.2.5.6 Other Potentially Affected Aquatic Resources

<u>Phytoplankton and Zooplankton</u>

Phytoplankton and zooplankton communities often form the basis of the food web in rivers and estuaries. The phytoplankton in the Hudson River generally fall into three major categories—diatoms, green algae, and blue-green algae. Diatoms are abundant through most of the year, but reach peak densities when water temperatures are low and watershed runoff and river flows are high. Green algae are present in highest abundances during the summer, when river flows are low and water temperatures are relatively high. Blue-green algae are generally present in late summer and early fall (CHGEC 1999).

Zooplankton populations in the Hudson River are divided into two major categories—holoplankton, which spend their entire live cycle as plankton, and meroplankton, which include the eggs and larvae of fish and shellfish that spend only a part of their life cycle in the planktonic community. Holoplankton in the brackish areas of the Hudson River from approximately IP2 and IP3 downstream (RM 40 (RKM 64)) are generally dominated by marine species; holoplankton from Poughkeepsie north (RM 68 (RKM 109)) are generally dominated by freshwater forms (Figure 2-6). Zooplankton sampling from Haverstraw Bay to Albany from April to December 1987–1989 identified five numerically dominant taxa—the cyclopoid copepod, *Diacyclops bicuspidatus thomasi*; the cladoceran, *Bosmina longirostris*; and the rotifers *Keratella* spp., *Polyarthra* spp., and *Trichocera* spp. (CHGEC 1999). Work by Lonsdale et al. (1996) suggests that larger (greater than 64 microns (0.0025 in.)) zooplankton species that include both mesozooplankton and micrometazoa have a minimal role in controlling total

phytoplankton biomass in the lower Hudson River estuary. Grazing pressure sufficient to contribute to the decline of the phytoplankton standing crop occurred only during the month of October.

Phytoplankton communities in the freshwater portion of the Hudson River are susceptible to predation by the zebra mussel, *Dreissena polymorpha*. Work by Roditi et al. (1996) suggests that the mussels are able to remove Hudson River phytoplankton effectively in the presence of sediment and can do so at rapid rates. The authors indicate that, based on their measurements and unpublished estimates of the size of the zebra mussel population, the mussels present in the upper stretches of the river can filter a volume equivalent to the entire freshwater portion of the Hudson River every 2 days. Strayer suggests that they filter a volume of water equal to all of the water in the estuarine Hudson every 1–4 days during the summer (2007). Significant declines in zooplankton biomass were also reported after the introduction of the mussel (Pace et al. 1998). Work by Strayer et al. (2004) suggests that the long-term impacts of zebra mussel removal of phytoplankton and zooplankton have profoundly affected the food web in the Hudson River, resulting in a shift of open-water species to downriver locations away from the mussels and a shift of littoral species upriver. The resulting changes affected a variety of commercially and recreationally important species, including American shad and black bass, illustrating the importance of zooplankton and phytoplankton in food webs associated with the freshwater portion of the Hudson River (Strayer et al. 2004).

Aquatic Macrophyte Communities

Aquatic macrophyte communities provide food and shelter to a variety of fish and invertebrate communities and are an important component of the Hudson River ecososystem. Macrophyte communities are generally divided into three broad groups that include emergent macrophytes, floating-leaved macrophytes, and submerged macrophytes (also known as SAV). Emergent macrophytes in the Hudson River generally occur near the shoreline to a water depth of about 5 ft (1.5 m) and have leaves that rise out of the water. Floating leaved macrophytes are attached to the bottom and have floating leaves and long, flexible stems. Submerged macrophytes are found beneath the water surface at a depth related to the clarity of the water (CHGEC 1999). The composition and distribution of aquatic macrophyte communities vary along the river and is controlled by physical characteristics and season. Work by Findlay et al. (2006) shows that the densities of macroinvertebrates in SAV beds were more than three times as high as densities on unvegetated sediments, suggesting that SAV beds may be the richest feeding grounds in the Hudson River estuary for fish. Further, the authors also noted that many species of macroinvertebrates that are common in aquatic macrophyte beds are rare or absent from unvegetated sites.

SAV beds in the Hudson are represented by two predominant species—the native submerged eel grass *Vallisneria americana* and the introduced water chestnut, *Trapa natans* (Findlay et al. 2006). CHGEC (1999) identified 18 species of submergent aquatic vegetation between Kingston and Nyack, including nine species of *Potamogeton* (pondweed), and *Elodea* sp. (common pondweeds used in aquaria), and a variety of other species. Historical and recent work has shown that SAV occupies major portions of some reaches of the Hudson River, when present, and can cover as much as 25 percent of the river bottom (Findlay et al. 2006). New York State has been studying the SAV in the Hudson River estuary from the Troy Dam south to Yonkers since 1995. Using true color aerial photography, researchers from Cornell University and the New York Sea Grant Extension inventoried the spatial extent of the SAV and water

chestnut (*T. natans*) beds from 1995 to 1997 and in 2002. They determined that vegetated area constitutes roughly 8 percent of total river surface area with *V. americana* three times as abundant as *T. natans.* Plant coverage over the entire study area from the Troy Dam to Yonkers was about 6 percent of the river bottom area for *V. americana* and 2 percent for *T. natans,* although the distribution of both plants varies greatly among reaches of the tidal freshwater Hudson River (Nieder et al. 2004). According to NYSDEC (2007a), there has been a 9-percent decline in all SAV and a 7-percent gain in water chestnut.

<u>Coastal Marshes, Wetlands, and Riparian Zones</u>

Coastal marshes, tidal wetlands, and associated riparian zones are found along the lower Hudson River. Vegetation in these areas includes emergent grasses, sedges, and other plants adapted to nearshore conditions that often experience changes in runoff, salinity, and temperature. FWS has identified the area extending from the Battery north to Stony Point at the northern end of Haverstraw Bay as Lower Hudson River Estuary Complex #21 (FWS 2008a). Within this complex there are many significant wetland habitats, including a regionally significant nursery and wintering habitat for a variety of anadromous, estuarine, and marine fish, as well as a migratory area for birds and fish that feed on abundant prey items.

Recognizing the importance of coastal wetlands, tidal marshes, and riparian zones, NOAA, partnering with NYSDEC, identified four locations along the lower Hudson River estuary for inclusion in the National Estuarine Research Reserve System in 1982 (NOAA 2008a). The areas, from north to south, are Stockport Flats, Tivoli Bay, Iona Island, and Piermont Marsh; they collectively represent over 4800 acres (1900 ha) of protected habitat.

Stockport Flats is the northernmost site in the Hudson River Reserve and is located on the east shore of the river in Columbia County near the city of Hudson. This site is a narrow, 5-mi-long landform that includes Nutten Hook, Gay's Point, Stockport Middle Ground Island, the Hudson River Islands State Park, a portion of the upland bluff south of Stockport Creek, and dredge spoils and tidal wetlands between Stockport Creek and Priming Hook. The dominant features of Stockport Flats include freshwater tidal wetlands that contain subtidal shallows, intertidal mudflats, intertidal shores, tidal marshes, and floodplain swamps (NOAA 2008a).

Tivoli Bay extends for 2 mi along the east shore of the Hudson River between the villages of Tivoli and Barrytown, in the Dutchess County town of Red Hook. The site includes two large coves on the east shore—Tivoli North Bay, a large intertidal marsh, and Tivoli South Bay, a large, shallow cove with mudflats. The site also includes an extensive upland buffer area bordering North Tivoli Bay. Habitats at this site include freshwater intertidal marshes, open waters, riparian areas, shallow subtidal areas, mudflats, tidal swamps, and mixed forest uplands (NOAA 2008a).

Iona Island is located near the Town of Stony Point in Rockland County, 6 mi south of West Point. This bedrock island is located in the vicinity of the Hudson Highlands and is bordered to the west and the southwest by Salisbury and Ring Meadows. In the early 20th century, filling activities connected Round Island to the south end of Iona Island. There is approximately 1 mi of marsh and shallow water habitat between Iona Island and the west shore of the Hudson River, and the area includes brackish intertidal mudflats, brackish tidal marsh, freshwater tidal marsh, and deciduous forested uplands.

Piermont Marsh lies at the southern edge of the village of Piermont, 4 mi south of Nyack. The marsh is located on the west shore of the Tappan Zee region near the town of Orangetown in

Rockland County. The site includes 2 mi of shoreline south of the mile-long Erie Pier and the mouth of Sparkill Creek. Habitats at this location include brackish tidal marshes, shallows, and intertidal mud flats.

2.2.5.7 Nuisance Species

<u>Zebra Mussel</u>

In the early 1990s, the nonnative zebra mussel, *Dieissena polymorpha,* made its first appearance in the freshwater portions of the Hudson River estuary. Beginning in early fall 1992, zebra mussels have been dominant in the freshwater tidal Hudson, constituting more than half of heterotrophic biomass, and filtering a volume of water equal to all of the water in the estuary every 1-4 days during the summer (Strayer 2007). The mussel's range extends from Poughkeepsie to the Troy Dam, with the highest densities occurring between Saugerites and Albany (CHGEC 1999; Strayer et al. 2004; Caraco et al. 1997). The presence of the mussels resulted in a decrease in phytoplankton biomass of 80 percent (Caraco et al. 1997) and a decrease of zooplankton abundance of 70 percent (Pace et al. 1998). Water chemistry was also altered, as phosphate and nitrate concentrations increased and DO concentrations decreased after the mussels were established (CHGEC 1999; Caraco et al. 2000). Caraco et al. (2000) indicated that these effects fundamentally changed food web relationships in the river and may have had a significant impact on many fish species.

Work by Strayer et al. (2004) found that open-water species such as *Alosa* spp. (shad and herring) exhibited a decreased abundance in response to Zebra mussel introduction, while the abundance of littoral species such as centrarchids (sunfish) increased. The median decrease in abundance of open-water species was 28 percent, and the median increase in abundance of littoral species was 97 percent. The authors also noted that populations of open-water species shifted downriver, away from the zebra mussel population, while littoral species shifted upriver.

Growth rates of open-water and littoral species were also affected by the mussels. Strayer and Smith (1996) found impacts to unionid bivalve mussels (*Elliptio complanata, Anodonta implicata, Leptodea ochracea*) such as decreasing densities and incidences of infestations. After the arrival of the zebra mussel, the authors reported that densities of these three unionid clam species fell by 56 percent, recruitment of YOY unionids fell by 90 percent, and the biological condition of unionids fell by 20–50 percent, with *E. complanata* less severely affected than the other two. Strayer and Smith (1996) suggest that the impacts to these species may be associated with both competition for food and biofouling by zebra mussels.

The work of Strayer, Caraco, Pace, and others has raised important questions and issues concerning the nature of impacts to fish communities from exotic or introduced species, the management of fish populations affected by these species, and the need to carefully consider all potential environmental stressors present when assessing the reasons for fish or invertebrate population declines. Changes in abundance and distribution in the freshwater portion of the Hudson River estuary involved many recreationally and commercially important species, including striped bass (*M. saxatilis)*, American shad (*A. sapidissima*), redbreast sunfish, and black bass (*Micropterus* spp.*)*. The changes Strayer et al. (2004) documented since 1992 include overall decreases in abundance, redistribution of species up- or downriver in relation to the mussels and fundamental changes to food webs because of the filtration activity of the mussels.

Recent work by Strayer and Malcom (2006) suggests that there are still significant gaps in understanding about the biology and life cycle of the zebra mussel in the Hudson River. The researchers used a combination of long-term data and simulation modeling. The authors evaluated mussel population size, adult growth, and body condition and found considerable interannual variation in these factors that was not strongly correlated with phytoplankton population. The data suggested a 2- to 4-year population cycle that was driven by large interannual variations in recruitment. Strayer and Malcolm's (2006) work indicates that a complete understanding of the potential effects of this species on aquatic food webs, and thus recreationally, commercially, or ecologically important fish and invertebrate species and communities requires a better understanding of the factors affecting the zebra mussel life cycle in the Hudson River than currently exists.

Water Chestnut

The water chestnut, *Trapa natans*, was first observed in North America in 1859 near Concord, Massachusetts (FWS 2004). Currently, the plant is found in Maryland, Massachusetts, New York, and Pennsylvania. The most problematic populations are found in the Connecticut River Valley, Lake Champlain region, and the Hudson, Potomac and Delaware Rivers (FWS 2004). Water chestnut impacts to water bodies can include increasing sedimentation and reducing DO, as well as developing dense mats that cause competition for nutrients and space with other species (IPCNYS 2008).

According to CHGEC (1999), the water chestnut was introduced into the upper Hudson River in the late 1880s and was established by the 1930s. An eradication program was begun by the NYSDEC using the herbicide 2,4-D, but the program was discontinued in 1976. Since 1976, the water chestnut beds have expanded into dense stands in available habitat in the fresh and low-salinity brackish areas of the estuary, and as of 1999, the exotic water chestnut was the dominant form of rooted vegetation in shallow areas of the estuary upstream of Constitution Island (RM 53 (RKM 85)). CHGEC (1999) indicates that water chestnut beds in some parts of the Hudson River are now so dense that they have adversely affected water circulation, lowered DO concentrations, and altered fish communities.

Ctenophores

Members of the phylum Ctenophora, variously known as comb jellies, sea gooseberries, sea walnuts, or Venus's girdles, are genatinous marine carnivores that are present in marine and estuarine waters from the sea surface to depths of several thousand meters. Ctenophores are characterized by eight rows of cilia that are used for locomotion. Cilia rows are organized into stacks of "combs" or "ctenes"; hence the name comb jellies. Ctenophore morphology can range from simple sac-like shapes without tentacles, to large, multilobed individuals equipped with adhesive cells called colloblasts. Worldwide, there are probably 100 to 150 species, but most are poorly known and are challenging to collect and study because of their fragility. (Haddock 2007)

As members of the zooplankton community, ctenophores influence marine and estuarine food webs by preying on a variety of eggs and larvae. Predator-prey relationships between the ctenophore *Mnemiopsis leidyi* and eggs of the bay anchovy (*A. mitchelli)* have been described by Purcell et al. (1994) in the Chesapeake Bay, and Deason (1982) described a similar relationship between *M. leidyi* and *Acartia tonsa*, a copepod prey species. Similarly, the NRC staff finds it possible that during certain times of the year, ctenophore predation may influence

zooplankton abundance in the higher salinity portions of the Hudson River. Laboratory studies evaluating the feeding and functional morphology of *M. mccradyi* by Larson (1988) provided new information concerning how prey are captured by ctenophores, but there is little field information available on predator-prey dynamics in natural systems, primarily because of the difficulties associated with field collections. At present, the impact of ctenophores on zooplankton, eggs, and larvae in the lower portions of the Hudson River is unknown.

2.2.6 Terrestrial Resources

This section describes the terrestrial resources of the IP2 and IP3 site and its immediate vicinity, including plants and animals of the upland areas, an onsite freshwater pond, and riparian areas along the river shoreline.

2.2.6.1 Description of Site Terrestrial Environment

As mentioned at the beginning of this chapter, the IP2 and IP3 site includes 239 acres (96.7 ha) on the east bank of the Hudson River. The property is bordered by the river on the west and the north (Lents Cove), a public road (Broadway) on the east, and privately owned industrial property on the south. The site is hilly, with elevations rising to about 150 ft (46 m) above the level of the river at the highest point. The site is enclosed by a security fence that follows the property line. Developed areas covered by facilities and pavement occupy over half of the site (134 acres (54.2 ha)), predominantly in the central and southern portions. Outside the central portion of the site where the reactors and associated generator buildings are located, small tracts of forest totaling approximately 25 acres (10 ha) are interspersed among the paved areas and facilities. Maintained areas of grass cover about 7 acres (2.8 ha) of the site. The northern portion of the site is covered by approximately 70 acres (28 ha) of forest (Entergy 2007a). Within this forested area is a 2.4-acre (0.97-ha) freshwater pond (Entergy 2007a; NRC 1975). The New York State Freshwater Wetlands Map for Westchester County indicates that there are no streams or wetlands on the site (NYSDEC 2004c).

The site is within the northeastern coastal zone of the eastern temperate forest ecoregion (EPA 2007). The forest vegetation of the site and adjacent areas was characterized by a survey performed in the early 1970s, before the completion of construction of IP3 (NRC 1975). At that time, the canopy of this forest included a mixture of hardwoods such as red oak (*Quercus rubra*), white oak (*Q. alba*), black oak (*Q. velutina*), chestnut oak (*Q. prinus*), shagbark hickory (*Carya ovata*), black cherry (*Prunus serotina*), tulip tree (*Liriodendron tulipifera*), river birch (*Betula nigra*), and maple (*Acer* spp.), as well as conifers such as eastern hemlock (*Tsuga canadensis*) and white pine (*Pinus strobus*). The subcanopy included sassafras (*Sassafras albidum*) and sumac (*Rhus* spp.). The shrub layer included swamp juneberry (*Amelanchier intermedia*), summer grape (*Vitis aestivalis*), poison ivy (*Toxicodendron radicans*), and Virginia creeper (*Parthenocissus quinquefolia*); and the herbaceous layer included forbs such as wildflowers and ferns (NRC 1975). This forest community covers the riverfront north of the reactor facilities, surrounds the pond in the northeast corner of the site, and exists in fragmented stands in the eastern and southern areas of the site. The vegetation in the developed areas of the site consists mainly of turf grasses and planted shrubs and trees around buildings, parking areas, and roads.

The animal community of the site has not been surveyed but likely consists of fauna typical of mixed hardwood forest habitats in the region. Birds that have been observed breeding in the

area of northwestern Westchester County and that utilize habitats such as the forest, pond, and riverfront habitats present on and adjacent to the site include the great blue heron (*Ardea herodias*), Canada goose (*Branta canadensis*), mallard (*Anas platyrhynchos*), wood duck (*Aix sponsa*), wild turkey (*Meleagris gallopavo*), Cooper's hawk (*Accipiter cooperii*), pileated woodpecker (*Dryocopus pileatus*), blue jay (*Cyanocitta cristata*), American robin (*Turdus migratorius*), and scarlet tanager (*Piranga olivacea*) (NYSDEC 2005, Dunn and Alderfer 2006). Numerous waterfowl utilize the lower Hudson River in winter. In the region of southeastern New York that includes Westchester County, waterfowl counts in January 2007 identified at least 22 species of ducks and geese, as well as loons, grebes, and cormorants (NYSOA 2007). In addition to the waterfowl that use the Hudson River, raptors also forage and nest along the river. For example, the bald eagle (*Haliaeetus leucocephalus*), which preys on fish and waterfowl, congregates along the lower Hudson River in winter (NYSDEC 2008b, 2008c), and the peregrine falcon (*Falco peregrinus*), which preys on waterfowl and other birds, nests on bridges over the lower Hudson (NYSDEC 2008d, 2008e).

Mammals likely to occur in the forest habitats on and adjacent to the site include the gray fox (*Urocyon cinereoargenteus*), mink (*Mustela vison*), raccoon (*Procyon lotor*), Virginia opossum (*Didelphis viginiana*), white-tailed deer (*Odocoileus virginianus*), red squirrel (*Tamiasciurus hudsonicus*), white-footed mouse (*Peromyscus leucopus*), and northern short-tailed shrew (*Blarina brevicauda*). Aquatic mammals that may occur along and within the river include the river otter (*Lutra canadensis*) and muskrat (*Ondatra zibethicus*) (NYSDEC 2007b; Whitaker 1980).

Reptiles and amphibians likely to occur on and in the vicinity of the site include species that typically inhabit upland forest habitats of the region, including the black rat snake (*Elaphe obsoleta*), eastern box turtle (*Terrapene carolina*), and American toad (*Bufo americanus*). Species likely to inhabit aquatic habitats such as the 2.4-acre (0.97-ha) pond and river shoreline include the northern water snake (*Nerodia sipedon*) and bullfrog (*Rana catesbeiana*) (NYSDEC 2007b, Conant and Collins 1998). The pond historically was used for fishing and is likely to contain minnows (family Cyprinidae) and sunfishes (family Centrarchidae).

There are no State or Federal parks, wildlife refuges, wildlife management areas, or other State or Federal lands adjacent to the site. The closest such lands to the site are two State parks, Bear Mountain State Park and Harriman State Park, which are located across the Hudson River approximately 1 mi and 2 mi, respectively, northwest of the site at their closest points (Entergy 2007a). In addition, a Significant Coastal Fish and Wildlife Habitat, referred to as "Hudson RM 44–56," begins approximately 1 mi north of the site and extends upriver. Significant Coastal Fish and Wildlife Habitats are designated by the New York Department of State, Division of Coastal Resources. Hudson RM 44–56 provides important habitat for wintering bald eagles as well as waterfowl (NYSDOS 2004).

Of the total 4000 ft (1220 m) of transmission line, approximately 3500 ft (1070 m) traverses buildings, roads, parking lots, and other developed areas. As a result, the total length of the ROWs that is vegetated is only about 500 ft (150 m). The ROWs are approximately 150 ft (46 m) wide, and the vegetation within the ROWs is mainly grasses and forbs. The transmission lines included in this draft SEIS are those that were originally constructed for the purpose of connecting IP2 and IP3 to the existing transmission system. These two lines are described in more detail in Section 2.1.7. Each line is approximately 2000 ft (610 m) in length, all of which is within the site except for a terminal, 100-ft (30-m) segment of each that crosses

the facility boundary and Broadway to connect to the Buchanan substation (Entergy 2005b; NRC 1975).

2.2.6.2 Threatened and Endangered Terrestrial Species

Two species that are federally listed as threatened or endangered and one candidate species have been identified by FWS as known or likely to occur in Westchester County. These are the endangered Indiana bat (*Myotis sodalis*), the threatened bog turtle (*Clemmys muhlenbergii*), and the candidate New England cottontail (*Sylvilagus transitionalis*) (FWS 2008b). In addition, 194 species that are listed by the State of New York as endangered, threatened, species of special concern (animals), or rare (plants) have a potential to occur in Westchester County based on recorded observations or their geographic ranges. The identities, listing status, and preferred habitats of these federally and State-listed species are provided in Table 2-6.

Federally Listed Species

The three federally listed species are discussed below. In addition to these species that currently have a Federal listing status, a recently delisted species, the bald eagle, also occurs in Westchester County. On July 9, 2007, FWS issued a rule in the *Federal Register* (72 FR 37346) removing the bald eagle from the Federal List of Endangered and Threatened Wildlife, effective August 8, 2007. As discussed above, bald eagles winter in substantial numbers in the vicinity of the site, particularly in a Significant Coastal Fish and Wildlife Habitat area upstream of the site from RM 44 to 56 (RKM 70 to 90) (NYSDOS 2004). Bald eagles also have nested in recent years at locations along the Hudson River in the vicinity of the site. In New York, the breeding season generally extends from March to July, and in the southeastern part of the state, wintering eagles begin to arrive in November and congregate in greatest numbers in February. Adult bald eagles are dark brown with a white head and tail and a yellow bill. Juveniles are completely brown with a gray bill until they are mature at about 5 years of age. The bald eagle feeds primarily on fish but also preys on waterfowl, shorebirds, small mammals, and carrion (NYSDEC 2008b).

Indiana Bat

The Indiana bat (*Myotis sodalis*) currently is listed as endangered under the Endangered Species Act of 1973 as amended (16 U.S.C. 1531 *et seq*.). Critical habitat for the Indiana bat was designated in 1976 (41 FR 41914) at eleven caves and two mines in six States (Missouri, Illinois, Indiana, Kentucky, Tennessee, and West Virginia). There is no designated critical habitat in New York.

The Indiana bat is a medium-sized bat with a head and body length slightly under 2 in. (5.1 cm), a wing span of 9 to 11 in. (23 to 28 cm), a weight of approximately 0.3 ounces (8.5 g), and a life span of about 10 years (FWS 2002, FWS 2007a). It feeds on flying insects captured in flight at night as it forages in forested areas, forest edges, fields, riparian areas, and over water. Indiana bats are migratory and hibernate in large colonies in caves or mines (hibernacula). Hibernacula may support from fewer than 50 to more than 10,000 Indiana bats (FWS 2007a). In New York, hibernation may last from September to May. After emerging in spring, the bats may migrate hundreds of miles to summer habitats, where they typically roost during the day under bark separating from the trunks of dead trees or in other tree crevices (FWS 2007a). Reproductive females congregate in maternity colonies of up to 100 or more bats, where they give birth and care for their single young until it can fly, usually at 1 to 2 months of age (FWS 2007a). Males

and nonreproductive females generally roost individually or in small colonies and may remain near their hibernaculum rather than migrating (FWS 2007a).

The Indiana bat occurs in 20 States in the eastern United States from New England to the Midwest, mainly within the central areas of this region from Vermont to southern Wisconsin, eastern Oklahoma, and Alabama. In summer, Indiana bat maternity colonies and individuals may occur throughout this range. In winter, populations are distributed among approximately 280 hibernacula in 19 States (FWS 2007a). New York has a total of 10 known hibernacula in caves and mines in Albany, Essex, Jefferson, Onondaga, Ulster, and Warren Counties (NYNHP 2008a). The nearest of these counties to the site is Ulster County, which is about 20 mi (32 km) to the north of the site at its closest point. The two largest hibernating colonies in New England (estimated populations in 2005 of over 11,300 and 15,400) are in two abandoned mines located in Ulster County approximately 45 mi (72 km) north of the site near the Town of Rosendale (FWS 2007a; Sanders and Chenger 2001). The larger of these is among the 10 largest Indiana bat hibernacula in the country (NYNHP 2008a). There are 13 general areas in the State where maternity and bachelor colonies are known to occur in summer. Hibernacula, maternity colonies, and bachelor colonies are not known to be present in Westchester County or the vicinity of the site, although Westchester County is within the potential range of the Indiana bat in New York (NYNHP 2008a). Given the presence of large hibernacula within migration distance of the site and the presence of suitable foraging habitat and possible roosting trees in the forest at the north end of the site, the NRC staff finds it possible that Indiana bats may use this area as summer habitat.

Bog Turtle

The northern population of the bog turtle (*Clemmys muhlenbergii*), which occurs in Connecticut, Delaware, Maryland, Massachusetts, New Jersey, New York, and Pennsylvania, was federally listed as threatened in 1997 under the ESA (16 U.S.C. 1531 *et seq*.). The southern population was listed as threatened because of its similarity of appearance to the northern population. The two populations are discontinuous. The southern population occurs mainly in the Appalachian Mountains from southern Virginia through the Carolinas to northern Georgia and eastern Tennessee (FWS 2001). In New York, the bog turtle occurs in the central and southeastern parts of the State, primarily in the Hudson Valley region (NYSDEC 2008f, 2008g).

The bog turtle is one of the smallest turtles in North America. Its upper shell is 3 to 4 in. (7.6 to 10 cm) long and light brown to black in color, and each side of its black head has a distinctive patch of color that is bright orange to yellow. Its life span may be 40 years or longer. The bog turtle is diurnal and semiaquatic; it forages on land and in water for its varied diet of insects and other invertebrates, frogs, plants, and carrion (FWS 2001; NYNHP 2008b). In southeastern New York, the bog turtle usually is active from the first half of April to the middle of September and hibernates the remainder of the year underwater in soft mud and crevices (FWS 2001). Northern bog turtles primarily inhabit wetlands fed by ground water or associated with the headwaters of streams and dominated by emergent vegetation. These habitats typically have shallow, cool water that flows slowly and vegetation that is early successional, with open canopies and wet meadows of sedges (*Carex* spp.). Other herbs commonly present include spike rushes (*Eleocharis* spp.) and bulrushes (*Juncus* spp. and *Scirpus* spp.) (FWS 2001). Bog turtle habitats in the Hudson River Valley also frequently include sphagnum moss (*Sphagnum* spp.) and horsetail (*Equisetum* spp.) (NYNHP 2008b). Commonly associated woody plants include alders (*Alnus* spp.) and willows (*Salix* spp.) (FWS 2001; NYNHP 2008b).

Of the 74 historic bog turtle locations recorded in New York, over half still may provide suitable habitat. However, populations are known to exist currently at only one-fourth of these locations, principally in southeastern New York (NYSDEC 2008f). The New York Natural Heritage Program (NYNHP) database contains locations in northwestern Westchester County where the bog turtle has been recorded as occurring historically. Although there were a few records during the 1990s of bog turtles in Westchester County, the NYNHP states that "it is not known if any extant populations remain in this county" (NYNHP 2008b). According to the data collected for the New York State Reptile and Amphibian Atlas for the period 1990 to 2007, the only reported occurrence of the bog turtle in Westchester County was near the eastern border of the State (NYSDEC 2008g). The New York State Freshwater Wetlands Map for Westchester County (NYSDEC 2004c) indicates that there are no wetlands on the IP2 and IP3 site. The nearest offsite wetland, which is adjacent to the north end of the site, is located on the east side of Broadway and drains under the roadway to Lent's Cove. Its potential to provide bog turtle habitat was not evaluated. The 2.4-acre (0.97-ha) pond in the northern portion of the site is surrounded by mature forest with a closed canopy and does not provide the highly specialized wetland habitat (early successional wet meadows) required by the bog turtle. While acknowledging that the wetland nearest to the site has not been evaluated for the presence of the bog turtle, the NRC staff notes that there is no suitable habitat on the site and there are no recently recorded occurrences of the bog turtle in portions of Westchester County near the plant site. Thus, the NRC staff finds that the bog turtle is unlikely to occur on the site or in the immediate vicinity of the site.

New England Cottontail

The New England cottontail (*Sylvilagus transitionalis*) is a Federal candidate for listing as an endangered or threatened species (72 FR 69034) and is State-listed as a species of special concern in New York (NYSDEC 2008h). It is similar in appearance to the more common and widespread eastern cottontail (*S. floridanus*). The New England cottontail can often be distinguished from the eastern cottontail by its slightly smaller size, shorter ears, darker fur, black spot between the ears, and black line at the front edge of the ears (NYNHP 2008c). Cottontails have short life spans and reproduce at an early age. Breeding season for the New England cottontail typically is from March to September (NYNHP 2008c). There may be two to three litters per year, with a usual litter size of five young and a range from three to eight (FWS 2007b). The diet of the species consists mainly of grasses and other herbaceous plants in spring and summer and the bark, twigs, and seedlings of shrubs and other woody plants in autumn and winter (NYNHP 2008c).

The New England cottontail is native only to the northeastern United States. Populations historically were found throughout New England. The range of this species has become fragmented and currently is approximately 14 percent of its historical extent (72 FR 69034). In New York, the New England cottontail currently is thought to occur only in separate populations east of the Hudson River within Columbia, Dutchess, Putnam, and Westchester Counties (NYNHP 2008c). The dramatic decreases in population and range are primarily the result of loss of suitable habitat. The New England cottontail requires a specialized habitat of early successional vegetative growth such as thickets, open wooded areas with a dense understory, and margins of agricultural fields (NYNHP 2008c). Land development associated with the growth of urban and suburban areas and the maturation of early successional forests have been the primary causes of the loss of these types of habitat (69 FR 39395).

The known locations of the New England cottontail in Westchester County are in the central and northeastern areas of the county (NYNHP 2008c), not in the northwestern area where the IP2 and IP3 site is located. The forests on the site consist mainly of mature hardwoods and do not contain early successional habitats, such as thickets, that are required by the New England cottontail. Therefore, the New England cottontail is considered unlikely to occur on or in the immediate vicinity of the site.

State-Protected Species

The only State-listed terrestrial species identified by NYNHP as currently occurring in the vicinity of the IP2 and IP3 site is the bald eagle (NYSDEC 2007c). The only other documented occurrences in the NYNHP database for the site vicinity were historical records for four plant species that have not been documented in the site vicinity since 1979 or earlier (NYSDEC 2007c). None of the State-listed species potentially occurring in Westchester County (Table 2-6) are known to occur on the site currently or to have occurred there historically.

Table 2-6. Federally and State-Listed Terrestrial Species Potentially Occurring in Westchester County

Scientific Name	Common Name	Federal Status [(a)]	New York State Status [(b)]	Habitat [(c)]
Amphibians				
Ambystoma jeffersonianum	Jefferson salamander	-	SSC	Deciduous woodlands with a closed canopy and riparian habitats [(1)]
Ambystoma laterale	blue-spotted salamander	-	SSC	Marshes, swamps, and adjacent upland areas with loose soils [(1)]
Ambystoma opacum	marbled salamander	-	SSC	Near swamps and shallow pools, rocky hillsides and summits, and wooded sandy areas [(1)]
Rana sphenocephala utricularus	southern leopard frog	-	SSC	Wet, open areas such as grasslands, marshes, and swales with slow-flowing water [(2)]
Reptiles				
Carphophis amoenus	eastern worm snake	-	SSC	Mesic, wooded or partially wooded areas, often near wetlands or farm fields [(1)]
Clemmys guttata	spotted turtle	-	SSC	Small ponds surrounded by undisturbed vegetation, marshes, swamps, and other small bodies of water [(1)]
Clemmys insculpta	wood turtle	-	SSC	Hardwood forests, fields, wet pastures, woodland marshes, and other areas adjacent to streams [(1)]
Clemmys muhlenbergii	bog turtle	FT	SE	Wet meadows with an open canopy or open boggy areas [(2)]
Crotalus horridus	timber rattlesnake	-	ST	Mountainous or hilly areas with rocky outcrops and steep ledges in deciduous or deciduous-coniferous forests [(2)]
Heterodon platyrhinos	eastern hognose snake	-	SSC	Open woods and margins, grasslands, agricultural fields, and other habitats with loose soils [(1)]
Sceloporus undulatus	northern fence lizard	-	ST	Open, rocky areas on steep slopes surrounded by oak-dominated forests [(2)]

1 **Table 2-6** (continued)

Scientific Name	Common Name	Federal Status [a]	New York State Status [b]	Habitat [c]
Terrapene carolina	eastern box turtle	-	SSC	Forests, grasslands, and wet meadows [1]
Birds				
Accipiter cooperii	Cooper's hawk	-	SSC	Mixed hardwood-coniferous forests, commonly near water [1]
Accipiter gentilis	northern goshawk	-	SSC	Mature mixed hardwood-coniferous forests [1]
Accipiter striatus	sharp-shinned hawk	-	SSC	Forests, open woods, and old fields [1]
Ammodramus maritimus	seaside sparrow	-	SSC	Coastal tidal marshes with emergent vegetation [2]
Ammodramus savannarum	grasshopper sparrow	-	SSC	Grasslands and abandoned fields [1]
Buteo lineatus	red-shouldered hawk	-	SSC	Open, moist forests and swamp margins [3]
Caprimulgus vociferous	whip-poor-will	-	SSC	Dry to moist open forests [1]
Chordeiles minor	common nighthawk	-	SSC	Open coniferous woods, grasslands, and near populated areas [1]
Circus cyaneus	northern harrier	-	ST	Salt and freshwater marshes, shrubland, and open grassy areas [2]
Cistothorus platensis	sedge wren	-	ST	Moist meadows with small bushes, boggy areas, and coastal brackish marshes [2]
Dendroica cerulea	cerulean warbler	-	SSC	Wet, mature hardwood forests with a dense canopy [1]
Falco peregrinus	peregrine falcon	-	SE	Holes or ledges in the rock on cliff faces, and on top of bridges or tall buildings in urban areas [2]
Haliaeetus leucocephalus	bald eagle	-	ST	Shorelines of large water bodies, such as lakes, rivers, and bays [2]

1 **Table 2-6.** (continued)

Scientific Name	Common Name	Federal Status [a]	New York State Status [b]	Habitat [c]
Icteria virens	yellow-breasted chat	-	SSC	Thickets, overgrown pastures, woodland understory, margins of ponds and swamps, and near populated areas [1]
Ixobrychus exilis	least bittern	-	ST	Large marshes with stands of emergent vegetation [2]
Melanerpes erythrocephalus	red-headed woodpecker	-	SSC	Open forests and developed areas with trees, such as parks and gardens [1]
Pandion haliaetus	Osprey	-	SSC	Large bodies of water such as lakes, rivers, and seacoasts [1]
Podilymbus podiceps	pied-billed grebe	-	ST	Marshes and shorelines of ponds, shallow lakes or slow-moving streams in areas with emergent vegetation and open water [2]
Rallus elegans	king rail	-	ST	Shallow fresh to salt marshes with substantial emergent vegetation [2]
Vermivora chrysoptera	golden-winged warbler	-	SSC	Recently abandoned agricultural fields surrounded by trees, open areas of dense herbaceous vegetation [1]
Mammals				
Myotis sodalis	Indiana bat	FE	SE	Wooded areas with living, dying, and dead trees during the summer; caves and mines in the winter [2]
Sylvilagus transitionalis	New England cottontail rabbit	FC	SSC	Disturbed areas, open woods, areas with shrubs and thickets, marshes [2]
Insects				
Callophrys henrici	Henry's elfin	-	SSC	Borders and clearings of pine-oak woods [4]
Erynnis persius	Persius duskywing	-	SE	Stream banks, marshes, bogs, mountain prairies, and sand plains [4]

1 Table 2-6 (continued)

Scientific Name	Common Name	Federal Status [a]	New York State Status [b]	Habitat [c]
Pontia protodice	checkered white	-	SSC	Dry, open habitats such as fields, roads, railroad tracks, weedy vacant lots, and sandy areas [4]
Speyeria idalia	regal fritillary	-	SE	Wet fields and meadows, marshes [4]
Tachopteryx thoreyi	gray petaltail	-	SSC	Rocky gorges in forests with small streams fed by seepage areas or fens [2]
Plants				
Acalypha virginica	Virginia three-seeded mercury	-	SE	Dry upland forests, thickets, and prairies [5]
Agastache nepetoides	yellow giant hyssop	-	ST	Open wooded areas, roadsides, railroads, thickets, and fencerows [2]
Ageratina aromatica var. *aromatica*	small white snakeroot	-	SE	Upland forests, roadsides, fencerows, and old fields [6]
Agrimonia rostellata	woodland agrimony	-	ST	Slopes, streambanks, and thickets in rich, mesic forests and wooded pastures [2]
Amaranthus pumilus	seabeach amaranth	-	SE	Sparsely vegetated areas of barrier island beaches and inlets [1]
Aplectrum hyemale	Puttyroot	-	SE	Upland to swampy forests [2]
Arethusa bulbosa	dragon's mouth orchid	-	ST	Sphagnum swamps and wet meadows [2]
Aristolochia serpentaria	Virginia snakeroot	-	SE	Well-drained, rocky slopes of rich wooded areas [2]
Asclepias variegata	white milkweed	-	SE	Open wooded areas and thickets [7]
Asclepias viridiflora	green milkweed	-	ST	Dry, rocky hillsides, grasslands, and open areas [2]
Bidens beckii	water marigold	-	ST	Slow-moving or still waters [6]

1 **Table 2-6** (continued)

Scientific Name	Common Name	Federal Status [a]	New York State Status [b]	Habitat [c]
Bidens bidentoides	Delmarva beggar-ticks	-	SR	Borders of freshwater tidal marshes and mudflats [2]
Bidens laevis	smooth bur-marigold	-	ST	Freshwater to brackish tidal marshes and mudflats [2]
Blephilia ciliata	downy wood mint	-	SE	Shallow soils of disturbed areas such as fields and powerline ROWs [2]
Bolboschoenus maritimus paludosus	seaside bulrush	-	SE	Alkaline or saline marshes, pond edges, and transient wet areas [8]
Bolboschoenus novae-angliae	saltmarsh bulrush	-	SE	Brackish tidal marshes [2]
Botrychium oneidense	blunt-lobe grape fern	-	SE	Rich, moist soils of deciduous forests [2]
Bouteloua curtipendula var. *curtipendula*	side-oats grama	-	SE	Dry, open areas and disturbed lands such as powerline ROWs, pastures, and bluffs along rivers [2]
Callitriche terrestris	terrestrial starwort	-	ST	Exposed, muddy ground in pastures, forests, and on the banks of ponds [2]
Cardamine longii	Long's bittercress	-	ST	Shady tidal creeks, swamps, and mudflats [2]
Carex abscondita	thicket sedge	-	ST	Swamps, wooded streambanks, mesic forests, and shrublands [2]
Carex arcta	northern clustered sedge	-	SE	Edges of reservoirs and rivers, wooded swamps, swales, and wet meadows [2]
Carex bicknellii	Bicknell's sedge	-	ST	Open woods, dry to mesic prairies, rocky areas with sparse vegetation [6]
Carex conjuncta	soft fox sedge	-	SE	Edges of streams, thickets, swales, and wet meadows [2]
Carex cumulata	clustered sedge	-	ST	Open rocky areas with shallow soils, such as powerline ROWs, recently burned areas, or other successional habitats [2]

Table 2-6 (continued)

Scientific Name	Common Name	Federal Status [a]	New York State Status [b]	Habitat [c]
Carex davisii	Davis' sedge	-	ST	Near rivers, on open gravel bars of large rivers, in wet meadows, and disturbed areas [2]
Carex hormathodes	marsh straw sedge	-	ST	Coastal salt and brackish tidal marshes, swales on beaches, edges of swamps, and wet forests near the coast [2]
Carex lupuliformis	false hop sedge	-	SR	Swamps, marshes, and floodplain forests [2]
Carex mesochorea	midland sedge	-	SE	Dry prairies, oak forests, and roadsides [2]
Carex mitchelliana	Mitchell's sedge	-	ST	Edges of streams and ponds, swamps, and wet meadows [2]
Carex molesta	troublesome sedge	-	ST	Open wooded areas and fields [2]
Carex nigromarginata	black edge sedge	-	SE	Dry to mesic rocky areas in deciduous forests [2]
Carex retroflexa	reflexed sedge	-	SE	Rocky ledges, openings and edges of dry to mesic deciduous forests, and along paths and railroads [2]
Carex seorsa	weak stellate sedge	-	ST	Hardwood or conifer swamps and thickets [6]
Carex straminea	straw sedge	-	SE	Edges of swamps and marshes [2]
Carex styloflexa	bent sedge	-	SE	Wet areas of streambanks, thickets, and pine barrens; swampy woods [2]
Carex typhina	cattail sedge	-	ST	Wetlands, floodplain forests, sedge meadows, and flats along rivers [2]
Carya laciniosa	big shellbark hickory	-	ST	Rich soils in floodplains and along the banks of rivers and marshes [2]
Castilleja coccinea	scarlet Indian paintbrush	-	SE	Open areas, including on limestone bedrock in prairies, and fields with moist, sandy soils [2]
Ceratophyllum echinatum	prickly hornwort	-	ST	Quiet lakes, ponds, streams, and swamps [1]

1 **Table 2-6** (continued)

Scientific Name	Common Name	Federal Status [a]	New York State Status [b]	Habitat [c]
Chamaelirium luteum	fairy wand	-	ST	Moist woodlands, thickets, meadows, and swamps [2]
Cheilanthes lanosa	woolly lip fern	-	SE	Dry areas on rock outcrops and ledges [2]
Chenopodium berlandieri var. *macrocalycium*	large calyx goosefoot	-	SE	Coastal sands and beaches [6]
Chenopodium rubrum	red pigweed	-	ST	Brackish marshes and developed lands [5]
Crassula aquatica	water pigmyweed	-	SE	Rocky shores of rivers, marshes, and tidal mudflats [2]
Crotalaria sagittalis	Rattlebox	-	SE	Sandy soils in pastures and pine plantations [2]
Cyperus echinatus	globose flatsedge	-	SE	Inland disturbed areas such as roadsides and pastures [6]
Cyperus flavescens	yellow flatsedge	-	SE	Wet, sandy soils of roadsides, coastal pond margins, and salt marshes [2]
Cyperus retrorsus var. *retrorsus*	retrorse flatsedge	-	SE	Moist to dry sandy soils in open woods and thickets [6]
Cypripedium parviflorum var. *parviflorum*	small yellow ladyslipper	-	SE	Rich humus and decaying leaves on wooded slopes and river bluffs, moist swales, and creek margins [1]
Desmodium ciliare	little leaf tick-trefoil	-	ST	Dry upland forests and glades [5]
Desmodium humifusum	spreadi ng tick-trefoil	-	SE	Dry, sandy soils in open pine and oak forests [9]
Desmodium laevigatum	smooth tick-trefoil	-	SE	Dry, upland forests [5]
Desmodium nuttallii	Nuttall's tick-trefoil	-	SE	Dry, upland forests; acidic gravel seeps; and dry to mesic grasslands [5]

1 **Table 2-6** (continued)

Scientific Name	Common Name	Federal Status [a]	New York State Status [b]	Habitat [c]
Desmodium obtusum	stiff tick-trefoil	-	SE	Open woods, old fields, and grasslands [2]
Desmodium pauciflorum	small-flowered tick-trefoil	-	SE	Upland forests [5]
Dichanthelium oligosanthes var. *oligosanthes*	few-flowered panic grass	-	SE	Upland forests, prairies, lake margins, and glades [5]
Digitaria filiformis	slender crabgrass	-	ST	Sandy soils in dry forests and prairies, sandstone glades, and agricultural fields [5]
Diospyros virginiana	Persimmon	-	ST	Rocky slopes, dry woodlands, open pastures, and swamp margins [8]
Draba reptans	Carolina whitlow grass	-	ST	Open areas with limestone outcrops, dry sandy soils, and cedar glades [2]
Eclipta prostrata	false daisy	-	SE	Lake margins, mesic to wet prairies, and fields and other developed lands [5]
Eleocharis equisetoides	knotted spikerush	-	ST	Shallow ponds in coastal areas [2]
Eleocharis ovata	blunt spikerush	-	SE	Marshy areas near rivers, shallow ponds [2]
Eleocharis quadrangulata	angled spikerush	-	SE	Lake margins and shallow ponds [2]
Eleocharis tricostata	three-ribbed spikerush	-	SE	Wet depressions, edges of ponds, pine barrens, and grasslands [6]
Eleocharis tuberculosa	long-tubercled spikerush	-	ST	Lake margins, ponds, streams, marshes, grasslands, and disturbed lands [6]
Equisetum palustre	marsh horsetail	-	ST	Wet areas such as marshes, stream margins, meadows, and wooded areas [2]
Equisetum pratense	meadow horsetail	-	ST	Rocky soils, riverbanks, roadsides, and railroad ditches [2]

Table 2-6 (continued)

Scientific Name	Common Name	Federal Status [(a)]	New York State Status [(b)]	Habitat [(c)]
Euonymus americanus	American strawberry bush	-	SE	Wooded areas, stream banks, and thickets in sandy soils [(8)]
Fimbristylis castanea	marsh fimbry	-	ST	Brackish and salt marshes [(6)]
Fuirena pumila	dwarf umbrella sedge	-	SR	Pond margins, seeps, and wet grasslands and swales [(6)]
Gamochaeta purpurea	purple everlasting	-	SE	Open, disturbed areas such as fields, roadsides, and edges of forests [(6)]
Geranium carolinianum var. *sphaerospermum*	Carolina cranesbill	-	ST	Dry upland forests and prairies, limestone glades, agricultural fields, and pastures [(5)]
Geum vernum	spring avens	-	SE	Organic soils of forested hillsides, thickets, and floodplains [(1)]
Geum virginianum	rough avens	-	SE	Hardwood forests, roadsides, wooded swamps, and riverbanks [(2)]
Hottonia inflata	Featherfoil	-	ST	Ponds and swales in coastal areas [(2)]
Houstonia purpurea var. *purpurea*	purple bluets	-	SE	Well-drained hillsides in mesic forests [(10)]
Hylotelephium telephioides	live forever	-	SE	Rocky cliffs and outcrops [(7)]
Hypericum prolificum	shrubby St. John's wort	-	ST	Disturbed areas such as roadsides and powerline ROWs, fields, thickets, and margins of swamps [(2)]
Iris prismatica	slender blue flag	-	ST	Rich, mucky soils [(6)]
Jeffersonia diphylla	twin leaf	-	ST	Calcareous soils in mesic forests, semishaded rocky hillsides, and exposed limestone [(2)]
Lechea pulchella var. *moniliformis*	bead pinweed	-	SE	Dry to mesic upland forests [(5)]
Lechea racemulosa	Illinois pinweed	-	SR	Infertile or sandy soils [(11)]

1 **Table 2-6** (continued)

Scientific Name	Common Name	Federal Status [a]	New York State Status [b]	Habitat [c]
Lechea tenuifolia	slender pinweed	-	ST	Dry, open, grassy areas, wooded areas with pines or oaks, rocky hillsides, and disturbed areas [2]
Lemna perpusilla	minute duckweed	-	SE	Still waters in ponds and lakes [6]
Lespedeza angustifolia	narrow-leaved bush clover	-	SR	Dry sandy soil [12]
Lespedeza repens	trailing bush clover	-	SR	Dry upland forests and dry to mesic grasslands [5]
Lespedeza stuevei	velvety bush clover	-	ST	Dry, rocky areas in woodlands and clearings, old fields, and roadsides [1]
Lespedeza violacea	violet bush clover	-	SR	Dry to mesic grasslands, thickets, and upland forests [5]
Liatris scariosa var. *novae-angliae*	northern blazing star	-	ST	Dry, sandy grasslands, rocky hilltops, and sandy roadsides [2]
Lilaeopsis chinensis	eastern grasswort	-	ST	Margins of peaty or rocky intertidal and brackish marshes [2]
Limosella australis	Mudwort	-	SR	Edges of freshwater pools and intertidal fresh to brackish water bodies [1]
Linum striatum	stiff yellow flax	-	SR	Sandy soils in mesic to wet forests, swamps, seeps, and lake margins [5]
Liparis liliifolia	large twayblade	-	SE	Peaty soils in hardwood swamps, dry wooded slopes, and railroad ditches [2]
Lipocarpha micrantha	dwarf bulrush	-	SE	Sandy soils along pond margins and riverbanks [2]
Listera convallarioides	broad-lipped twayblade	-	SE	Wet sandy soils in white cedar swamps [2]
Ludwigia sphaerocarpa	globe-fruited ludwigia	-	ST	Margins of shallow ponds and wetland channels in pine barrens, clearings in shrub swamps [2]
Lycopus rubellus	gypsy wort	-	SE	Marshes and inundated swamps [2]

1 **Table 2-6** (continued)

Scientific Name	Common Name	Federal Status [a]	New York State Status [b]	Habitat [c]
Lysimachia hybrida	lance-leaved loosestrife	-	SE	Wet upland and floodplain forests, wet prairies, lake margins, swamps, and seeps [5]
Magnolia virginiana	sweetbay magnolia	-	SE	Along bays; in swamps; in wet, forested lowlands; and in grasslands [6]
Melanthium virginicum	Virginia bunchflower	-	SE	Railroad ditches, grasslands, marshes, and wet wooded areas [6]
Mimulus alatus	winged monkey-flower	-	SR	Muddy shores of lakes, swamps, and wet forests [5]
Monarda clinopodia	basil balm	-	SE	Ravines in mesic forests, thickets, and lakeshores [5]
Oldenlandia uniflora	clustered bluets	-	SE	Sandy soils in swamps, bogs, and margins of streams and reservoirs [13]
Oligoneuron rigidum var. *rigidum*	stiff leaf goldenrod	-	ST	Dry open areas such as rocky slopes, thickets, edges of forests, and grasslands [2]
Onosmodium virginianum	Virginia false gromwell	-	SE	Open coastal uplands, inland rocky wooded areas in dry soils [2]
Orontium aquaticum	golden club	-	ST	Freshwater swamps and tidal marshes, and sphagnum swamps, fens, and coastal ponds [2]
Oxalis violacea	violet wood sorrel	-	ST	Rich, rocky soils on steep hillsides and open summits [2]
Panicum rigidulum var. *elongatum*	tall flat panic grass	-	SE	Mesic flatwoods and forested lowlands, prairies, and edges of lakes [5]
Paspalum laeve	field beadgrass	-	SE	Sandy soils in open woodlands and prairies [1]
Pinus virginiana	Virginia pine	-	SE	Areas of poor soils such as maritime oak forests, pine/oak barrens, and rocky summits [2]

1 **Table 2-6** (continued)

Scientific Name	Common Name	Federal Status [a]	New York State Status [b]	Habitat [c]
Platanthera ciliaris	orange fringed orchid	-	SE	Wide range of habitats from wet, rich soils to dry, rocky mountainous areas [1]
Platanthera hookeri	Hooker's orchid	-	SE	Pine or poplar forests with open understories in dry to moist soils [2]
Podostemum ceratophyllum	Riverweed	-	ST	In fast-flowing streams and rivers with rocky bottoms [2]
Polygala lutea	orange milkwort	-	SE	Wet, sandy soils and marshes in pine barrens [14]
Polygonum douglasii douglasii	Douglas' knotweed	-	ST	Disturbed, dry areas such as rocky outcrops with sandy soils [6]
Polygonum erectum	erect knotweed	-	SE	Developed areas such as roadsides, sidewalks, and lawns and floodplain forests [5]
Polygonum glaucum	seabeach knotweed	-	SR	Coastal beaches [6]
Polygonum tenue	slender knotweed	-	SR	Dry, acidic soils in open areas such as rocky summits, scrubby wooded sites, and abandoned agricultural fields [5]
Potamogeton diversifolius	water thread pondweed	-	SE	Marshes and pond margins [2]
Potamogeton pulcher	spotted pondweed	-	ST	Ponds, marshes, and slow-moving streams and rivers [2]
Pterospora andromedea	giant pine drops	-	SE	Thick humus of coniferous forests [14]
Pycnanthemum clinopodioides	basil mountain mint	-	SE	Rocky soils in dry forests and grasslands [2]
Pycnanthemum muticum	blunt mountain mint	-	ST	Wet sandy soils in coastal swales, pond margins, swamps, and roadside thickets [2]
Pycnanthemum torrei	Torrey's mountain mint	-	SE	Dry, open areas of rocky hilltops, roadside ditches, and red cedar barrens [2]

1 **Table 2-6** (continued)

Scientific Name	Common Name	Federal Status [a]	New York State Status [b]	Habitat [c]
Ranunculus micranthus	small-flowered crowfoot	-	ST	Partially shaded summits in forests [2]
Rhynchospora scirpoides	long-beaked beakrush	-	SR	Wet, sandy soils of pond margins in coastal pine barrens [2]
Sabatia angularis	rose pink	-	SE	Rocky soils in open woods, sandy soils, and pond margins [5]
Sagittaria montevidensis var. *spongiosa*	spongy arrowhead	-	ST	Mudflats in freshwater to brackish tidal marshes [2]
Salvia lyrata	lyre leaf sage	-	SE	Rich, rocky soils in open forests; pastures with sandy soils [14]
Scirpus georgianus	Georgia bulrush	-	SE	Moist grasslands and borders of wet forests and marshes [2]
Scleria pauciflora var. *caroliniana*	few-flowered nutrush	-	SE	Mesic to wet woods, grasslands, and bogs [6]
Scutellaria integrifolia	hyssop skullcap	-	SE	Fields and clearings in upland forests, roadside ditches, swamps, and pond margins [2]
Sericocarpus linifolius	flax leaf whitetop	-	ST	Open woods, roadside ditches, and fields [6]
Sisyrinchium mucronatum	Michaux's blue-eyed grass	-	SE	Fields, roadside ditches, edges of forests, and coastal grasslands [2]
Smilax pulverulenta	Jacob's ladder	-	SE	Rich, limestone soils in woods and thickets [6]
Solidago latissimifolia	coastal goldenrod	-	SE	Coastal freshwater to brackish swamps and thickets [6]
Solidago sempervirens var. *mexicana*	seaside goldenrod	-	SE	Sand dunes and brackish marsh margins [6]
Sporobolus clandestinus	rough rush grass	-	SE	Sandy soils in open forests, prairies, and limestone bluffs [5]
Suaeda linearis	narrow leaf sea blite	-	SE	Beaches and salt marshes [6]

1 **Table 2-6** (continued)

Scientific Name	Common Name	Federal Status [a]	New York State Status [b]	Habitat [c]
Symphyotrichum boreale	northern bog aster	-	ST	Fens, clearings within coniferous swamps, meadows, shores of ponds and lakes [2]
Symphyotrichum subulatum var. *subulatum*	saltmarsh aster	-	ST	Saltwater marshes, margins of tidal creeks and salt ponds, and brackish swales among sand dunes [2]
Trichomanes intricatum	Appalachian bristle fern	-	SE	Protected cracks and crevices in rock [1]
Trichostema setaceum	tiny blue curls	-	SE	Dry forests, old fields, rocky outcrops, and coastal sandy soils [13]
Tripsacum dactyloides	northern gamma grass	-	ST	Mesic grasslands and margins of streams and salt marshes [8]
Trollius laxus	spreading globeflower	-	SR	Limestone soils in meadows and open swamps [6]
Utricularia minor	lesser bladderwort	-	ST	Wet meadows and still waters of shallow ponds [5]
Utricularia radiata	small floating bladderwort	-	ST	Ponds and slow-moving waters [2]
Veronicastrum virginicum	Culver's root	-	ST	Moist prairies and woods, meadows, and banks of streams [1]
Viburnum dentatum var. *venosum*	southern arrowwood	-	ST	Moist soils in open woods and edges of streams [8]
Viburnum nudum var. *nudum*	possum haw	-	SE	Hardwood swamps [13]
Viola brittoniana	coast violet	-	SE	Wet soils in borders of woodlands, meadows, and near coastal streams and rivers [1]
Viola hirsutula	southern wood violet	-	SE	Shallow, rocky soils in rich woods [15]
Viola primulifolia	primrose leaf violet	-	ST	Sandy soils in marsh edges, meadows [5]

Table 2-6 (continued)

Scientific Name	Common Name	Federal Status [(a)]	New York State Status [(b)]	Habitat [(c)]
Vitis vulpine	winter grape	-	SE	Mesic to wet forests, lakeshores, agricultural fields [(5)]

[(a)]Federal listing status definitions: FC = Federal Candidate Species, FE = Federally Endangered, FT = Federally Threatened (FWS 2008b)
[(b)]State listing status definitions: SE = State Endangered, SC = Species of Special Concern in New York, SR = State Rare, ST = State Threatened (NYSDEC 2008h; NYNHP 2007)
[(c)] Habitat information sources:
[1] NatureServe 2007
[2] NYNHP 2008d
[3] NYSDEC 2008i
[4] Opler et al. 2006
[5] Iverson et al. 1999
[6] FNA Editorial Committee 1993+
[7] Niering and Olmstead 1979
[8] NRCS 2008
[9] CPC 2008
[10] NCSU 2008
[11] Nearctica 2008
[12] Britton and Brown 1913
[13] KSNPC 2008
[14] Lady Bird Johnson Wildflower Center Native Plant Information Network (NPIN) 2008
[15] Pullen Herbarium 2008

2.2.7 Radiological Impacts

The following discussion focuses on the radiological environmental impacts and the dose impacts to the public from normal plant operations at the IP2 and IP3 site. Radiological releases, doses to members of the public, and the resultant environmental impacts, are summarized in two IP2 and IP3 reports—the Annual Radioactive Effluent Release Report and the Annual Radiological Environmental Operating Report. Limits for all radiological releases are specified in the IP2 and IP3 ODCM and are used by Entergy to meet Federal radiation protection limits and standards.

Radiological Environmental Impacts

Entergy conducts a radiological environmental monitoring program (REMP) in which radiological impacts to the environment and the public around the IP2 and IP3 site are monitored, documented, and compared to NRC standards. Entergy summarizes the results of its REMP in an Annual Radiological Environmental Operating Report (Entergy 2007d; all items in this section also from Entergy 2007d). The objectives of the IP2 and IP3 REMPs are the following:

- to enable the identification and quantification of changes in the radioactivity of the area
- to measure radionuclide concentrations in the environment attributable to operations of the IP2 and IP3 site

Environmental monitoring and surveillance have been conducted at IP2 and IP3 since 1958, 4 years before the startup of IP1. The preoperational program was designed and implemented to determine the background radioactivity and to measure the variations in activity levels from

natural and other sources in the vicinity, as well as fallout from nuclear weapons tests. The preoperational radiological data include both natural and manmade sources of environmental radioactivity. These background environmental data permit the detection and assessment of current levels of environmental activity attributable to plant operations.

The REMP at IP2 and IP3 directs Entergy to sample environmental media in the environs around the site to analyze and measure the radioactivity levels that may be present. The REMP designates sampling locations for the collection of environmental media for analysis. These sampling locations are divided into indicator and control locations. Indicator locations are established near the site, where the presence of radioactivity of plant origin is most likely to be detected. Control locations are established farther away (and upwind/upstream, where applicable) from the site, where the level would not generally be affected by plant discharges or effluents. The use of indicator and control locations enables the identification of potential sources of detected radioactivity as either background or from plant operations. The media samples are representative of the radiation exposure pathways to the public from all plant radioactive effluents. A total of 1342 analyses was performed in 2006. This amount is higher than required because of the inclusion of additional sample locations and media.

The REMP is used to measure the direct radiation and the airborne and waterborne pathway activity in the vicinity of the IP2 and IP3 site. Direct radiation pathways include radiation from buildings and plant structures, airborne material that may be released from the plant, or from cosmic radiation, fallout, and the naturally occurring radioactive materials in soil, air, and water. Analysis of thermoluminescent dosimeters (TLDs), which measure direct radiation, indicated that there were no increased radiation levels attributable to plant operations.

The airborne pathway includes measurements of air, precipitation, drinking water, and broadleaf vegetation samples. The airborne pathway measurements indicated that there was no increased radioactivity attributable to 2006 IP2 and IP3 station operation.

The waterborne pathway consists of Hudson River water, fish and invertebrates, aquatic vegetation, bottom sediment, and shoreline soil. Measurements of the media constituting the waterborne pathway indicated that, while some very low levels of plant discharged radioactivity were detected, there was no adverse radiological impact to the surrounding environment attributed to IP2 and IP3 operations (Entergy 2007d).

<u>2006 REMP Results</u>

The following is a detailed discussion of the radionuclides detected by the 2006 REMP that may be attributable to current plant operations (all information summarized from Entergy 2007d).

During 2006, cesium-137, strontium-90, and tritium were the only potentially plant-related radionuclides detected in some environmental samples. Tritium may be present in the local environment because of either natural occurrence, other manmade sources, or plant operations. Small amounts of tritium were detected in one of four quarterly composite samples from the discharge mixing zone (386 picocuries per liter (pCi/L) (14.28 becquerel per liter (Bq/L)). This composite sample was detected at a value much lower than the required lower limit of detection of 3000 pCi/L (111 Bq/L).

In 2006, the detected radionuclide(s) attributable to past atmospheric weapons testing consisted of cesium-137 and strontium-90 in some media. The levels detected for cesium-137 were consistent with the historical levels of radionuclides resulting from weapons tests as measured

in previous years. Before 2006, strontium-90 analysis had not been conducted since 1984, so comparison to recent historical levels is not possible. However, the low levels detected in the environment are consistent with decayed quantities of activity from historic atmospheric weapons testing. Strontium-90 was detected in four fish and invertebrate samples, three in the control samples and one in the indicator samples. Since the levels detected were comparable in the indicator and control location samples, atmospheric weapons testing is the likely cause. Of 18 special water samples, 5 indicated strontium-90 at levels close to the level of detection, at an average of 0.78 pCi/L (0.028 Bq/L). All of these detections are considered to be residual levels from atmospheric weapons tests.

Iodine-131 is also produced in fission reactors but can result from nonplant-related manmade sources (e.g., medical administrations). Iodine-131 was not detected in 2006. Cobalt-58 and cobalt-60 are activation/corrosion products also related to plant operations. They are produced by neutron activation in the reactor core. As cobalt-58 has a much shorter half-life, its absence "dates" the presence of cobalt-60 as residual. When significant concentrations of cobalt-60 are detected but no cobalt-58, there is an increased likelihood that the cobalt-60 results from residual cobalt-60 from past operations. There was no cobalt-58 or cobalt-60 detected in the 2006 REMP, though cobalt-58 and cobalt-60 have been observed in previous years.

Data resulting from analysis of the special water samples for gamma emitters, tritium analysis, and strontium-90 show that 18 samples were analyzed for strontium-90, and 5 of them showed detectable amounts of strontium-90. All of the results were very low (with a range of 0.49–1.26 pCi/L (0.018–0.046 Bq/L)) and within the range considered to be residual levels from atmospheric weapons tests. Other than the above, only naturally occurring radionuclides were detected in the special water samples.

The results of the gamma spectroscopy analyses of the monthly drinking water samples and results of tritium analysis of quarterly composites showed that, other than naturally occurring radionuclides, no radionuclides from plant operation were detected in drinking water samples. The data indicate that operation of IP2 and IP3 had no detectable radiological effect on drinking water.

The results of the analysis of bottom sediment samples for cesium-137 showed that it was detected at 7 of 10 indicator station samples, and at 1 of 3 control station samples. Cesium-134 was not detected in any bottom sediment samples. The lack of cesium-134 suggests that the primary source of the cesium-137 in bottom sediment is from historical plant releases at least several years old and from residual weapons test fallout.

While not required by the ODCM, strontium-90 analysis was conducted at three indicator locations and one control location in August 2006. Strontium-90 was not identified in any of the samples. The detection of cesium-137 in bottom sediment has been generally decreasing over the last 10 years, and cesium-134 has not been detected in bottom sediment since 2002. The data for 2006 are consistent with but slightly lower than historical levels.

In summary, IP2- and IP3-related radionuclides were detected in 2006; however, residual radioactivity from atmospheric weapons tests and naturally occurring radioactivity were the predominant sources of radioactivity in the samples collected. The 2006 levels of radionuclides in the environment surrounding IP2 and IP3 are well below the NRC's reporting levels as a result of IP2 and IP3 operations. The radioactivity levels in the environment were within the historical ranges (i.e., previous levels resulting from natural and manmade sources for the

detected radionuclides). Further, IP2 and IP3 operations did not result in an adverse impact to the public greater than environmental background levels. (Entergy 2007d)

New York State Department of Health Monitoring

The New York State Department of Health (NYSDOH) also performs sampling and analysis of selected independent environmental media around IP2 and IP3. The NYSDOH environmental radiation monitoring program collects various types of samples to measure the concentrations of selected radionuclides in the environment. Samples of air, water, milk, sediment, vegetation, animals, and fish are typically obtained. In addition, TLDs are used to measure environmental gamma radiation levels in the immediate proximity of IP2 and IP3. The NRC staff reviewed the published data for the years 1993 and 1994, the most current publicly available reports. The data indicated that the radiation levels observed in the environment around IP2 and IP3 were low, or consistent with background radiation, and some samples were below the detection sensitivity for the analysis. No samples exceeded any of the New York State guidelines.

The following information was reported in the 1993 report (NYSDOH 1994):

- Radioactivity in air samples showed low levels of gross beta activity and levels of iodine-131 were usually below detection levels.
- No milk sample was collected, as the remaining nearby dairy farm had closed.
- Radioactivity in water samples showed low levels of gross beta activity.
- Tritium levels were at typical background levels.
- The levels for other radioisotopes were low with most samples below minimum detectable levels.
- Direct environmental radiation shows that the TLD data are typical of the normal background level in this area.

The following information was reported in the 1994 report (NYSDOH 1995):

- Radioactivity in air samples showed low levels of gross beta activity, and levels of iodine-131 were below detection levels.
- No milk samples were collected in 1994, as the last dairy farm closed in 1992.
- Radioactivity in water samples showed low levels of gross beta activity.
- Tritium levels were at typical background levels.
- The levels for other radioisotopes were low with most samples below minimum detectable levels.
- Radioactivity in fish samples showed that naturally occurring potassium-40 is responsible for most of the activity. All other isotopes are below detectable levels.
- Direct environmental radiation values for the TLD data are typical of the normal background level in this area.

Ground Water Contamination and Monitoring

In August of 2005, Entergy discovered tritium contamination in ground water outside the IP2 spent fuel pool (SFP). As a result, Entergy began an on-site and off-site ground water monitoring program (in September of 2005) in addition to the routine REMP. Entergy used this monitoring program to characterize the on-site contamination, to quantify and determine its on-site and off-site radiological impact to the workers, public and surrounding environment, and to aid in identification and repair of any leaking systems, structures or components (Entergy 2006d).

In Section 5.1 of its ER, Entergy identified release of radionuclides to ground water as a potentially new issue based on NRC staff analysis in a previous license renewal proceeding. In its discussion of the issue, Entergy concluded that the radionuclide release does not affect the onsite workforce, and that Entergy anticipated the leakage would not affect other environmental resources, such as water use, land use, terrestrial or aquatic ecology, air quality, or socioeconomics. In addition, Entergy asserted that no NRC dose limits have been exceeded, and EPA drinking water limits are not applicable since no drinking water exposure pathway exists (Entergy 2007a).

Entergy has taken measures to control releases from the IP1 and IP2 SFPs using waste management equipment and processes. Additional monitoring actions have also been developed as part of the site's ground water monitoring program, which supplements the existing REMP to monitor potential impacts of site operations throughout the license renewal term and to monitor potential impacts of site operations and waste and effluent management programs (Entergy 2007a).

In addition to Entergy's assertions in the IP2 and IP3 ER, Entergy provided the NRC additional information, by report dated January 11, 2008, that included the conclusions of a 2-year investigation of onsite leaks to ground water that it had initiated following the 2005 discovery of SFP leakage. Entergy stated that it had characterized and modeled the affected ground water regime, and that it had identified sources of leakage and determined the radiological impacts resulting from this leakage. In the same letter, Entergy reported that it had begun a long-term ground water monitoring program and initiated a remediation program to address the site ground water conditions. Entergy also stated that it had performed radiological dose impact assessments and that it will continue to perform them, and report results to the NRC in each annual Radiological Effluent Release Report. (Radiological Effluent Release Reports are publically available through the NRC.) Entergy's investigation indicates that the only noteworthy dose pathway resulting from contaminated ground water migration to the river is through the consumption of fish and invertebrates from the Hudson River. According to Entergy, the resultant calculated dose to a member if the public is below 1/100 of the federal limits (Entergy 2008c).

As part of the NRC's ongoing regulatory oversight program, the NRC staff performed an extensive inspection of Entergy's actions to respond to the abnormal leak as well Entergy's ground water monitoring program. This inspection focused on assessing Entergy's ground water investigation to evaluate the extent of contamination, as well as the effectiveness of actions taken or planned to effect mitigation and remediation of the condition. The NRC staff adopts the findings and content of the inspection report, released by letter dated May 13, 2008, in this SEIS (NRC 2008). The inspection findings include the following key points (NRC 2008):

Plant and the Environment

(1) Currently, there is no drinking water exposure pathway to humans that is affected by the contaminated ground water conditions at the IP2 and IP3 site. Potable water sources in the area of concern are not presently derived from ground water sources or the Hudson River, a fact confirmed by the New York State Department of Health. The principal exposure pathway to humans is from the assumed consumption of aquatic foods (i.e., fish or invertebrates) taken from the Hudson River in the vicinity of Indian Point that has the potential to be affected by radiological effluent releases. However, no radioactivity distinguishable from background was detected during the most recent sampling and analysis of fish and crabs taken from the affected portion of the Hudson River and designated control locations.

(2) The annual calculated exposure to the maximum exposed hypothetical individual, based on application of Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Release of Reactor Effluents for the Purpose of Evaluation Compliance with 10 CFR Part 50, Appendix I," relative to the liquid effluent aquatic food exposure pathway is currently, and expected to remain, less than 0.1 % of the NRC's "As Low As is Reasonably Achievable (ALARA)" guidelines of Appendix I of Part 50 (3 mrem/yr (0.03 mSv/yr) total body and 10 mrem/yr (0.1 mSv/yr) maximum organ), which is considered to be negligible with respect to public health and safety, and the environment.

Finally, by letter dated May 15, 2008, Entergy reaffirmed its January 11th letter and provided the NRC a list of commitments for further actions to address ground water contamination (Entergy 2008d). Entergy indicated they would remove spent fuel from the IP1 SFP, process remaining water and "bottoms" from the IP1 SFP, and incorporate aspects of the long-term ground water monitoring program in the site's ODCM and associated procedures. To date, NRC staff has observed that Entergy has removed all spent fuel from the IP1 SFP and drained the pool, as well as incorporated aspects of the monitoring program into the ODCM and associated procedures. Entergy has indicated that it would process remaining water and bottoms from the IP1 SFP by April 30, 2009, and inform the NRC if they deviate from the commitment timeline.

New York State Ground Water Investigations

New York State performed its own ground water investigation of the tritium leakage from IP2 and IP3 and reported its findings in a Community Fact Sheet (NYSDEC 2007d) as follows:

> The New York State Department of Environmental Conservation (DEC) and the New York State Department of Health (DOH) have been participating in the ongoing groundwater investigation of radionuclide contamination in groundwater under the plant, and the release of that water to the Hudson River. The purpose of our involvement is to protect the interests of the citizens and the environment of the State of New York by helping to ensure that Entergy performs a timely, comprehensive characterization of site groundwater contamination, takes appropriate actions to identify and stop the sources of the leak, and undertakes any necessary remedial actions.

The key findings reported by New York State are listed below:

- There are no residential or municipal drinking water wells or surface reservoirs near the plant.

- There are no known impacts to any drinking water source.
- No contaminated ground water is moving toward surrounding properties.
- Contaminated ground water is moving into the Hudson River.
- Public exposure can occur from the ground water entering the Hudson River through consumption of fish.
- NYSDOH has confirmed Entergy's calculated dose to humans from fish.
- Strontium-90 levels in fish near the site (18.8 pCi/kg (0.69 Bq/kg)) are no higher than in those fish collected from background locations across the State.
- Recent strontium-90 data in fish are limited. (The State plans to conduct additional sampling.)

<u>Dose Impacts to the Public</u>

The results of the IP2 and IP3 radiological releases into the environment are summarized in the IP2 and IP3 Annual Radioactive Effluent Release Reports. Limits for all radiological releases are specified in the IP2 and IP3 ODCMs and used to meet Federal radiation protection standards. A review of historical radiological release data during the period 2002 through 2006 and the resultant dose calculations revealed that the calculated doses to maximally exposed individuals in the vicinity of IP2 and IP3 were a small fraction of the limits specified in the IP2 and IP3 ODCM to meet the dose design objectives in Appendix I to 10 CFR Part 50, as well as the dose limits in 10 CFR Part 20 and EPA's 40 CFR Part 190, as indicated in the following summary list. The current results are described in "Indian Point Units 1, 2, and 3—2006 Annual Radioactive Effluent Release Report" (Entergy 2007c). A breakdown of the calculated maximum dose to an individual located at the IP2 and IP3 site boundary from liquid and gaseous effluents and direct radiation shine from IP1 and the two operating reactor units during 2006 is summarized below:

- The calculated maximum whole-body dose to an offsite member of the general public from liquid effluents was 8.80×10^{-4} mrem (8.80×10^{-6} mSv) for IP1 and IP2 and 1.27×10^{-4} mrem (1.27×10^{-6} mSv) for IP3, well below the 3-mrem (0.03-mSv) dose design objective in Appendix I to 10 CFR Part 50.
- The calculated maximum organ (adult bone) dose to an off-site member of the general public from liquid effluents was 1.26×10^{-3} mrem (1.26×10^{-5} mSv) for IP1 and IP2 and 1.60×10^{-4} mrem (1.60×10^{-6} mSv) for IP3, well below the 10 mrem (0.10 mSv) dose design objective in Appendix I to 10 CFR Part 50.
- The calculated maximum gamma air dose at the site boundary from noble gas discharges was 5.01×10^{-3} millirad (mrad) (5.01×10^{-5} milligray (mGy)) for IP1 and IP2 and 5.36×10^{-5} mrad (5.36×10^{-7} mGy) for IP3, well below the 10 mrad (0.10 mGy) dose design objective in Appendix I to 10 CFR Part 50.
- The calculated maximum beta air dose at the site boundary from noble gas discharges was 1.78×10^{-2} mrad (1.78×10^{-4} mGy) for IP1 and IP2 and 1.57×10^{-4} mrad

($1.57x10^{-6}$mGy), well below the 20 mrad (0.20 mGy) dose design objective in Appendix I to 10 CFR Part 50.

- The calculated maximum organ dose to an offsite member of the general public from gaseous iodine, tritium, and particulate effluents was $1.19x10^{-2}$ mrem ($1.19x10^{-4}$ mSv) to the child thyroid for IP1 and IP2 and $1.07x10^{-3}$ mrem ($1.07x10^{-5}$ mSv) to the child liver for IP3, well below the 15 mrem (0.15 mSv) dose design objective in Appendix I to 10 CFR Part 50.
- The calculated maximum total whole-body dose to an offsite member of the general public from the site's combined ground water and storm drain pathways is $1.78x10^{-3}$ mrem ($1.78x10^{-5}$ mSv).
- The calculated maximum organ (adult bone) dose to an offsite member of the general public from the site's combined ground water and storm drain pathways is $7.21x10^{-3}$ mrem ($7.21x10^{-5}$ mSv).
- The calculated maximum total body dose to an off-site member of the public from all radioactive emissions (radioactive gaseous and liquid effluents, direct radiation shine, and new liquid effluent release pathway) from the IP2 and IP3 site was 7.07 mrem ($7.07\ x10^{-2}$ mSv), well below the 25 mrem (0.25 mSv) limit in EPA's 40 CFR Part 190.

The NRC staff reviewed the 2006 Radioactive Effluent Release Report and found that the 2006 radiological data are consistent, with reasonable variation as the result of operating conditions and outages, with the 5-year historical radiological effluent releases and resultant doses. These results, including those from the new issue concerning a new liquid effluent release pathway, confirm that IP2 and IP3 is operating in compliance with Federal radiation protection standards contained in Appendix I to 10 CFR Part 50, 10 CFR Part 20, and 40 CFR Part 190. As noted in Section 2.1.4 of this SEIS, the applicant does not anticipate any significant changes to the radioactive effluent releases or exposure pathways from IP2 and IP3 operations during the license renewal term, and, therefore, the NRC staff expects that impacts to the environment are not likely to change.

Entergy has indicated that it may replace IP2 and IP3 reactor vessel heads and control rod drive mechanisms during the period of extended operation. Such an action is not expected to change the applicant's ability to maintain radiological doses to members of the public well within regulatory limits. This is based on the absence of any projected significant increases in the amount of radioactive liquid, gaseous, or solid waste as a result of the replacements, as discussed in Section 2.1.4 of this SEIS. Thus, the staff concludes that similar small doses to members of the public and small impacts to the environment are expected during the period of extended operations.

2.2.8 Socioeconomic Factors

This section describes current socioeconomic factors that have the potential to be directly or indirectly affected by changes in IP2 and IP3 operations. IP2 and IP3 and the communities that support them can be described as a dynamic socioeconomic system. The communities provide the people, goods, and services required by IP2 and IP3 operations. IP2 and IP3 operations, in

turn, create the demand and pay for the people, goods, and services in the form of wages, salaries, and benefits for jobs and dollar expenditures for goods and services. The measure of the communities' ability to support the demands of IP2 and IP3 depends on their ability to respond to changing environmental, social, economic, and demographic conditions.

The socioeconomics region of influence (ROI) is defined by the areas where IP2 and IP3 employees and their families reside, spend their income, and use their benefits, thereby affecting the economic conditions of the region. The IP2 and IP3 ROI consists of a four-county area (Dutchess, Orange, Putnam, and Westchester Counties) where approximately 84 percent of IP2 and IP3 employees reside. The following sections describe the housing, public services, offsite land use, visual aesthetics and noise, population demography, and the economy in the ROI surrounding IP2 and IP3.

Entergy employs a permanent workforce of approximately 1255 employees (Entergy 2007a). Approximately 90 percent live in Dutchess, Orange, Putnam, Rockland, Ulster, and Westchester Counties, New York, and Bergen County, New Jersey (Table 2-7). The remaining 10 percent of the workforce is divided among 36 counties in Connecticut, Pennsylvania, New Jersey, New York, and elsewhere with numbers ranging from 1 to 15 employees per county. Given the residential locations of IP2 and IP3 employees, the most significant impacts of plant operations are likely to occur in Dutchess, Orange, Putnam, and Westchester Counties. The focus of the socioeconomic impact analysis in this draft SEIS is therefore on the impacts of IP2 and IP3 on these four counties.

Refueling outages at IP2 and IP3 occur at 24-month intervals for each unit, which results in an outage each year for one or the other units. During refueling outages, site employment increases by 950 workers for approximately 30 days (Entergy 2007a). During outages, most of these workers are likely to reside in the four-county ROI.

Table 2-7. IP2 and IP3 Employee Residence by County in 2006

County	Number of IP Energy Center Personnel	Percentage of Total
Bergen, NJ	17	1.4
Dutchess, NY	528	42.1
Orange, NY	243	19.4
Putnam, NY	78	6.2
Rockland, NY	28	2.2
Ulster, NY	31	2.5
Westchester, NY	206	16.4
Other	124	9.9
Total	1255	100

Source: Entergy 2007a

2.2.8.1 Housing

Table 2-8 lists the total number of occupied housing units, vacancy rates, and median value in the ROI. According to the 2000 Census, there were over 613,000 housing units in the ROI, of

which approximately 584,000 were occupied. The median value of owner-occupied units ranged from $141,500 in Orange County to $285,800 in Westchester County. The vacancy rate was the lowest in Westchester County (3.5 percent) and highest in Putnam County (6.6 percent).

In 2006, the estimated total number of housing units in Westchester County grew by more than 6000 units to 355,581, and the total number of occupied units declined by 4000 units to 333,114. As a result, the number of available vacant housing units increased by more than 10,200 units to 22,467, or 6.3 percent of the available units. In addition, the estimated number of available housing units also increased in Dutchess, Orange, and Putnam Counties (USCB 2008a).

Table 2-8. Housing in Dutchess, Orange, Putnam and Westchester Counties, New York

	Dutchess	Orange	Putnam	Westchester	ROI
			2000		
Total	106,103	122,754	35,030	349,445	613,332
Occupied housing units	99,536	114,788	32,703	337,142	584,169
Vacant units	6,567	7,966	2,327	12,303	29,163
Vacancy rate (percent)	6.2	6.5	6.6	3.5	4.8
Median value (dollars)	150,800	141,500	205,500	285,800	195,900
			2006*		
Total	111,507	132,983	36,471	355,581	636,542
Occupied housing units	104,289	121,887	33,544	333,114	592,834
Vacant units	7,218	11,096	2,927	22,467	43,708
Vacancy rate (percent)	6.5	8.3	8.0	6.3	6.9
Median value (dollars)	334,200	319,300	407,800	581,600	410,725

* Estimated
Source: USCB 2008a; 2006 American Community Survey

2.2.8.2 Public Services

This section presents a discussion of public services including water supply, education, and transportation.

Water Supply

IP2 and IP3 do not utilize a public water system for plant circulating and service water purposes, but instead rely on surface water from the Hudson River. Potable water and process water are supplied to the site by the Village of Buchanan water supply system. Based on water bills, IP2 and IP3 utilize approximately 2.3 million ft^3 or 17.4 million gal per month (65,000 m^3 or 8.7 million L per month) of potable water (VBNY 2006). There are no restrictions on the supply of potable water from the Village of Buchanan. The Village of Buchanan obtains its water from two sources, the City of Peekskill Public Water System and the Montrose Improvement District. While the demand on the City of Peekskill Public Water System currently appears to be near the system design capacity, the contract with the Montrose Improvement District (now consolidated with the Northern Westchester Joint Water Works) appears to NRC staff to be capable of providing an adequate supply of potable water based on treatment capacity upgrades.

Public water supply systems in the vicinity of IP2 and IP3 include community and noncommunity (including nontransient noncommunity and transient noncommunity) systems. Community water systems within a 10-mi (16-km) radius of IP2 and IP3 include Westchester, Putnam, Orange, and Rockland County systems. Each of these county systems uses both ground water and surface water sources (EPA 2006b). Although outside the 10-mi (16-km) radius, public water supply systems in Dutchess County were included because Dutchess County provides residence to the largest percentage of the site's permanent full-time employees (42 percent). Approximately 57 percent of the Dutchess County community water systems, including the Poughkeepsie water supply system, obtain water from surface water sources that include the Hudson River (EPA 2006b).

The Village of Buchanan purchases water from the City of Peekskill Public Water System and the Montrose Improvement District. The City of Peekskill has two sources of water, both of which are surface waters. The City of Peekskill's year-round major water source originates in the Town of Putnam Valley (Putnam County). The City of Peekskill's second source of water is an emergency source from a neighboring community, via the Catskill Aqueduct. Water is pumped to the Camp Field Reservoir in the City of Peekskill, where it is then filtered and treated (PWD 2005).

The Town of Cortlandt purchases 80 percent of its water supply from the Montrose Improvement District, which treats raw water purchased from the New York City Catskill Aqueduct. The town purchases 10 percent from the City of Peekskill, which filters and treats raw water pumped from the Peekskill Hollow Brook to the city's Camp Field Reservoir, and 10 percent from the Town of Yorktown, which purchases water filtered and treated by the Westchester County-owned Amawalk treatment plant (CCWD no date).

The Cortlandt Consolidated Water District (CCWD) has joined with the Yorktown and Montrose Improvement District in a new corporation known as the Northern Westchester Joint Water Works (NWJWW). The NWJWW has assumed ownership of the Amawalk treatment plant, which has been upgraded to 7-mgd (26,000-m^3/day) capacity. A new NWJWW 7-mgd (26,000-m^3/day) plant (Catskill water treatment plant) has been in operation since 2000 (CCWD no date).

Westchester Joint Water Works (WJWW) serves the municipalities of the Village/Town of Mamaroneck, Town/Village of Harrison, portions of the City of New Rochelle, and the City of Rye. WJWW, which has a capacity of 14.2 mgd (53,800 m^3/day) and an average daily demand of 13.1 mgd (49,600 m^3/d), obtains its water from the Catskill and Delaware watersheds of the New York City water system, which includes the Delaware Aqueduct, Rye Lake (Delaware watershed), and the Kensico reservoir (WJWW 2006).

A majority of Rockland County uses ground water to supply numerous small public water systems, most of which are supplied by a single well (RWS 2006). The large public water systems of Rockland County include United Water New York (UWNY), Nyack Village Public Water System, and Suffern Village Public Water System (RWS 2006). UWNY provides water to approximately 267,000 residents from 53 ground water wells drilled throughout the county, Lake DeForest, and the Letchworth reservoirs (UWNY 2006). The UWNY peak demand in 2006 was estimated at 47.5 mgd (180,000 m^3/day) and its peak supply at approximately 48.5 mgd (184,000 m^3/day) (RCDH 2006).

The Poughkeepsie Water Treatment Facility, which is owned and operated by the City and Town of Poughkeepsie, provides drinking water in Dutchess County to the City of Poughkeepsie, Town of Poughkeepsie, and Village of Wappingers Falls. The plant is located along and draws water from the Hudson River. The plant was built in 1962 and is currently rated at a maximum capacity of 16 mgd (61,000 m^3/day). Average demand is reported to be approximately 8 mgd (31,000 m^3/day) (PTWD 2005).

The Village of Ossining Water System in Westchester County is supplied from two surface water sources, the Indian Brook Reservoir, located near Fowler Avenue and Reservoir Road, and the Croton Reservoir, which is part of the New York City Water System. The average blend of water is approximately 63 percent from the Croton Reservoir and 37 percent from the Indian Brook Reservoir. The system obtains its water from the Croton watershed in Putnam and Westchester Counties and serves approximately 30,000 people. The Village of Ossining Water System services an average daily demand of approximately 3.7 mgd (14,000 m^3/day) (VOWS 2005).

Many public water supply systems supply only small segments of the population. For example, Orange County has approximately 150 public water systems, but no major public water systems in the county were identified within 10 mi of IP2 and IP3. Ground water is the primary source of both community and noncommunity water supply systems and serves 60 to 85 percent of the population in the area (Entergy 2007a; RCDH 2006). Large areas of Westchester, Putnam, Orange, Rockland, and Dutchess Counties are not served by community water supplies. Private water supplies in these areas draw primarily from ground water sources. The ground water quality in New York is generally good, but contamination can and does occur locally.

The Village of Croton-on-Hudson public water system is supplied by a ground water well system located downstream from the New Croton Dam and spillway. Ground water is pumped from the well system directly into the distribution system. The system has a total storage capacity of 2.3 mgd (8700 m^3/day) and supplies approximately 7600 people an average of 1.1 mgd (4200 m^3/day) (VCOH 2005).

Table 2-9 lists the major public water supply systems within the vicinity of IP2 and IP3.

Table 2-9. Major Public Water Supply Systems in 2005 (mgd)

Water Supplier [a]	Water Source [a]	Average Daily Production [b]	Design Capacity [b]	Population Served [a]
Northern Westchester Joint Water Works [c]	SW	6.9	14.0	0
Peekskill, NY	SW	3.9	4.0	22,400
Croton-on-Hudson, NY	GW	1.1	2.3	7,100
Westchester Joint Water Works	SW	13.1	14.2	55,200
Ossining, NY	SW	3.7	6.0	30,000
Poughkeepsie, NY	SW	8.9	16.0	28,000
United Water New York	GW & SW	47.5	48.5	270,000
Village of Suffern	GW	2.0	4.0	12,000
Village of Nyack	SW	1.8	3.0	14,700

GW = Ground water; SW = surface water; N/A = Not Applicable or No Information Available
[a] EPA 2008b
[b] Average daily production and design capacity. Information from 2005 Annual Drinking Water Quality Report for each public water system.
[c] Includes the CCWD, Yorktown Improvement District, and the Montrose Improvement District (CCWD 2006).

An estimated 85,000 residents north of Kensico Dam in Westchester County use ground water as their primary water source. Exceptions are residents using surface water or aqueduct sources in Mt. Kisco, parts of the Town of Yorktown, much of the Town of Cortlandt, and most municipalities directly adjoining the Hudson River (WCDP 2003). Approximately 15 percent of the residents of the Town of Cortlandt are estimated to use ground water supplies (WCDP 2003, Table 2).

<u>Education</u>

IP2 and IP3 are located in the Hendrick Hudson Central School District, Westchester County, which had an enrollment of approximately 2800 students in 2003. Including the Hendrick Hudson Central School District, Westchester County has 40 school districts with a total enrollment of approximately 147,000 students. In contrast, Dutchess, Orange, and Putnam Counties have 16, 17, and 6 school districts with a total enrollment of approximately 46,000, 66,000, and 17,000 students, respectively (WCDP 2005).

<u>Transportation</u>

Several major highway routes serve as transportation corridors along either side of the Hudson River Valley. Westchester County and Putnam County are located on the eastern side of the Hudson River. The primary highways in Westchester County include Interstate 684, US 9, US 6, and US 202, as well as the Taconic State and Saw Mill River Parkways (see Figures 2–1 and 2-2). US 9 runs north and south along the Hudson River Valley through both Westchester and Putnam Counties. Further east, the Taconic State Parkway also runs north and south

through both counties. The Taconic State Parkway and the Saw Mill River Parkway connect near Hawthorne, New York, southeast of the site. Interstate 684 runs north and south along the eastern side of Westchester County and connects to Interstate 84 in Putnam County. US 6 runs east and west through the southern end of Putnam County and the northern portion of Westchester County. US 202 runs east and west across northern Westchester County. The Saw Mill River Parkway extends northeast and southwest between US 9 at Riverdale, New York, and Interstate 684. Additional highways within the two counties include State Routes 117, 120, 129, 100, 139, and 301.

The nearest highway serving the site area is US 9. Using local roads from US 9, the site can be accessed from Broadway. A summary of current New York State Department of Transportation estimates for average annual daily traffic counts on US 9 north and south of the site is presented in Table 2-10.

The Palisades Interstate Parkway is the largest highway system in Rockland County, running north and south through the county, and connecting with US 6 and US 9W in southeastern Orange County (see Figure 2–2). US 9W runs north and south along the Hudson River and connects with Interstate 87 to the south at the Village of Nyack, New York. Interstate 87 allows travel north and south through Orange County but then loops toward the east across Rockland County, crosses the Hudson, and intersects US 9, the Saw Mill River Parkway, and the Taconic State Parkway in Westchester County. US 202 runs northeast and southwest through Rockland County till it meets US 9W and then crosses the Hudson River and runs easterly and intersects the Taconic State Parkway. Route 17 (future Interstate 86) runs northwest and southeast across Orange County to where it intersects Interstate 87, and turns south until it intersects Route 3 near New York City. Interstate 84 runs east and west through Orange County, crosses the Hudson River, and travels down Dutchess County and into Putnam County were it meets Interstate 684.

Dutchess County is located approximately 13 mi (21 km) north of the site, on the east side of the Hudson River. The major roads in this county are Interstate 84, US 44, US 9, Route 199 (Taconic State Parkway), and Route 22. Interstate 84 and US 44 run east and west in the southern and central portions of the county, respectively. Route 199 (Taconic State Parkway), Route 22, and US 9 run north and south in the central, eastern, and western portions of the county, respectively.

Table 2-10. Average Annual Daily Traffic Counts on US 9 Near IP2 and IP3, 2004[a]

Roadway and Location	Annual Average Daily Traffic
US 9—from Montrose crossing to Route 9A overlap [b]	50,500
US 9—from Peekskill city line to Montrose crossing	11,800[c]
US 9—from Montrose crossing to Old Post Road crossing	5,950[c]

Source: NYSDOT 2005

[a] Traffic volume during the average 24-hour day during 2004.

[b] Readings taken at a continuous count station (accounts for seasonal and daily variation.

[c] NYSDOT projection from the latest year for which data were available.

2.2.8.3 Offsite Land Use

This section describes land use conditions in Dutchess, Orange, Putnam, and Westchester Counties in New York, because the majority of the IP2 and IP3 workforce lives in these counties. In addition to payment-in-lieu-of-taxes (PILOT) and property tax payments to Westchester County, the surrounding counties receive property tax payments from the 1255 people employed by the site.

Dutchess County

Dutchess County is distinctly different from its neighboring counties in that it contains a combination of urban and rural settings rather than metropolitan areas. Currently, Dutchess County is conserving open spaces such as farms while increasing the number of housing units available in order to create a mix of urban areas and farmland (Dutchess County Department of Planning and Development 2006).

Dutchess County occupies roughly 802 sq mi (2080 sq km) or approximately 513,000 acres (208,000 ha) (USCB 2008b). The largest category of land use in Dutchess County is agriculture. Evenly distributed throughout the county, land used for agriculture makes up 21.3 percent (112,339 acres (45,462 ha)) of the county's area (USDA 2002a). Major agricultural land uses consist of cropland (52.75 percent), woodland (23.32 percent), pasture (11.12 percent), and other uses (12.81 percent) (USDA 2002a). Residential land areas cover approximately 7.1 percent of Dutchess County, with approximately 1.4 percent being devoted to commercial, industrial, and transportation uses (Entergy 2007a).

Dutchess County is planning to create developments in central locations by developing mass transit systems and waterways. Retail areas are planned to be centralized and within convenient walking distance from these transient terminals. Developments outside the primary growth areas are designed to blend into the natural landscape. In this way, Dutchess County hopes to maintain its open spaces and farming culture (PDCTC 2006; Dutchess County Department of Planning and Development 2006).

Orange County

Three interstates intersect within Orange County. A byproduct of the county's interstate road access is a clustering of industry and commercial development along these highway corridors. Recently, most new development has occurred in the southeastern corner of the county as a result of the access to major transportation corridors. The largest land development in the southeastern part of the county is the U.S. Military Academy at West Point (see Figure 2-2) (Orange County Department of Planning 2003).

Orange County occupies roughly 816 sq mi (2110 sq km) or approximately 522,000 acres (211,000 ha) (USCB 2008b). Approximately 107,977 acres (43,697 ha) are used for agricultural purposes, with major agricultural land uses consisting of cropland (65.53 percent), woodland (16.50 percent), pasture (8.99 percent), and other uses (8.98 percent) (USDA 2002b). Residential land areas cover approximately 7.5 percent of Orange County, with approximately 1.7 percent devoted to commercial, industrial, and transportation uses (Entergy 2007a).

Orange County's Comprehensive Development Plan continues to reflect the importance of transportation interchanges, crossroads, and corridors (Orange County Department of Planning 2003). The dynamic real estate market and the loss of open spaces has been a challenge for Orange County. The county, along with civic organizations, has been inventorying current open spaces as part of defining and recommending future open space needs. Orange County also plans to initiate a redevelopment program to assist with historical improvements to the cities and villages within Orange County. With the increasing growth of Orange County, nontraditional zoning strategies are expected to help maintain historical and open spaces throughout the county (Orange County Department of Planning 2003).

Putnam County

Putnam County occupies roughly 231 sq mi (598 sq km) or approximately 148,000 acres (59,900 ha) (USCB 2008b) and is one of the fastest growing counties in New York (Putnam County Division of Planning and Development 2003). Approximately 6720 acres (2720 ha) (4.3 percent) are in agricultural use, with major agricultural land uses consisting of woodland (59.87 percent), cropland (26.49 percent), and other uses (13.65 percent) (USDA 2002c). Hilly topography has prevented or slowed development in the more rugged parts of the county. Additionally, there are many wetlands throughout the county. The most significant wetland in the county is the Great Swamp, which is a 4200-acre (1700-ha) wetland. Agricultural land use, undeveloped land, and forest land within the county have been decreasing. Residential land use occurs on large lot subdivisions or in rural areas. Industrial and commercial development can be found around the villages and along the major transportation corridors (Putnam County Division of Planning and Development 2003). Residential land use accounts for approximately 6.9 percent of the county's land, while only 1.1 percent is used for commercial, industrial, or transportation purposes (Entergy 2007a).

Putnam County attempts to integrate development into the natural environment, which includes enhancing, when possible, views of the Hudson River (Putnam County Division of Planning and Development 2003). The county and municipalities are working together by changing the zoning ordinances and subdivision regulations to preserve strategic historic structures and protect open spaces, while providing affordable housing and development throughout the county (Putnam County Division of Planning and Development 2003).

Westchester County

Westchester County occupies roughly 433 sq mi (1121 sq km) or approximately 277,000 acres (112,000 ha) (USCB 2008b). According to the 2002 U.S. Department of Agriculture (USDA) Census of Agriculture, 129 farms were located in Westchester County, which is a 10 percent increase since 1997 (USDA 2002d). Land acreage associated with farms increased 14 percent during this period with total acreage increasing from 8681 acres (3513 ha) to over 9917 acres (4013 ha). The average size of farms also increased 4 percent, from 74 to 77 acres (30 to 31 ha) from 1997 to 2002. Of the approximately 9917 acres (4013 ha) in agricultural land use in 2002, the major agricultural land uses consisted of woodland (48.84 percent), cropland (24.83 percent), pasture (12.81 percent), and other uses (13.53 percent) (USDA 2002d).

Residential land areas cover approximately 30.1 percent of Westchester County, with approximately 3.1 percent devoted to commercial, industrial, and transportation uses (Entergy 2007a). The long-range plan for the physical development of Westchester County concentrates on three distinct physical characteristics—centers, corridors, and open space (Westchester County Department of Planning 2000).

IP2 and IP3 are located in Westchester County in the Village of Buchanan, within the Town of Cortlandt. IP2 and IP3 provide tax revenues and other payments to both the Town of Cortlandt and the Village of Buchanan. The Town of Cortlandt encompasses 34.5 sq mi (89.4 sq km) or 22,080 acres (8935 ha) (TOCNY 2006). Land use is predominately residential zoning with ½-acre to 2-acre plots further protecting environmentally sensitive areas and open spaces (TOCNY 2004). The town's growth was intentionally slowed over the past several decades, allowing the town's leaders to plan its development. Significant commercial development has taken place along major transportation corridors, as well as at new community facilities within the area. From 1992 to 2004, the Town of Cortlandt has increased open space by 65 percent from 2729 acres (1104 ha) to 4502 acres (1822 ha) (TOCNY 2004). The town also has made an effort to increase public access to the Hudson River waterfront and encourage historic preservation (TOCNY 2004)

The Village of Buchanan, located within the Town of Cortlandt, encompasses 1.4 sq mi (3.6 sq km) or 896 acres (363 ha) (VBNY 1998). Land use in the village has changed very little over the last 20 to 30 years. The Village of Buchanan recently began restoring older buildings to beautify the village square. The Village of Buchanan has zoning ordinances, subdivision ordinances, and a development review board (Entergy 2007a).

2.2.8.4 Visual Aesthetics and Noise

IP2 and IP3 can be seen from the Hudson River but are shielded from the land side by surrounding high ground and vegetation. With the exception of Broadway, the site is also shielded from view from the Village of Buchanan. The superheater stack for IP1 (334 ft (102 m) tall), the IP2 and IP3 turbine buildings (each 134 ft (41.8 m) tall), and reactor containment structures (each 250 ft (76 m) tall) dominate the local landscape and can be seen from the Hudson River.

Noise from IP2 and IP3 is detectable off site, and the Village of Buchanan has a sound ordinance (Chapter 211-23 of the Village Zoning Code) that limits allowable sound levels at the property line of the sound generating facility. The combined frequencies of the sound standard equate to an overall level of 48 decibels (dB(A)). An ambient noise level monitoring program was conducted in the vicinity of IP2 and IP3 between September 2001 and January 2002, which

showed that IP2 and IP3 meet the Village of Buchanan's sound ordinance (Enercon Services 2003).

2.2.8.5 Demography

According to the 2000 census, approximately 1,113,089 people lived within 20 mi (32 km) of IP2 and IP3, which equates to a population density of 886 persons per sq mi (332 persons per sq km) (Entergy 2007a). This density translates to the least sparse Category 4 (greater than or equal to 120 persons per square mile within 20 mi). Approximately 16,791,654 people live within 50 mi (80 km) of IP2 and IP3 (Entergy 2007a). This equates to a population density of 2138 persons per sq mi (825 persons per sq km). Applying the proximity measures from NUREG-1437, "Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants" (GEIS), IP2 and IP3 are classified as proximity Category 4 (greater than or equal to 190 persons per square mile within 50 mi (80 km)). Therefore, according to the sparseness and proximity matrix presented in the GEIS, IP2 and IP3 ranks of sparseness Category 4 and proximity Category 4 indicate that IP2 and IP3 are located in a high-population area.

Table 2-11 shows population projections and growth rates from 1970 to 2050 in Dutchess, Orange, Putnam, and Westchester Counties. The population growth rate in Westchester County for the period of 1990 to 2000 was the lowest of the four counties at 5.6 percent. County populations are expected to continue to grow in all four counties in the next decades although Westchester County's population is expected to increase at a lower rate. Dutchess, Orange, and Putnam County populations are projected to continue to grow at a rapid rate through 2050.

The 2000 and 2006 (estimate) demographic profiles of the four-county ROI population are presented in Table 2-12 and Table 2-13. Minority individuals (both race and ethnicity) constitute 28.8 percent of the total four-county population. The minority population was composed largely of Hispanic or Latino and Black or African-American residents.

According to the U.S. Census Bureau's 2006 American Community Survey, minority populations in the four-county region were estimated to have increased by nearly 90,000 persons and made up 32.7 percent of the total four-county population in 2006 (see Table 2-13). The largest increases in minority populations were estimated to occur in Hispanic or Latino and Asian populations. The Black or African-American population increased by approximately 5 percent from 2000 to 2006 but remained unchanged as a percentage of the total four-county population.

Table 2-11. Population and Percent Growth in Dutchess, Orange, Putnam, and Westchester Counties, New York, from 1970 to 2000 and Projected for 2010 and 2050

	Dutchess		Orange		Putnam		Westchester	
Year	Population	Percent Growth[a]	Population	Percent Growth[a]	Population	Percent Growth[a]	Population	Percent Growth[a]
1970	222,295	—	221,657	—	56,696	—	894,104	—
1980	245,055	10.2	259,603	17.1	77,193	36.2	866,599	-3.1
1990	259,462	5.9	307,647	18.5	83,941	8.7	874,866	1.0
2000	280,150	8.0	341,367	11.0	95,745	14.1	923,459	5.6
2006	***295,146***	***5.4***	***376,392***	***10.3***	***100,603***	***5.1***	***949,355***	***2.8***
2010	328,000	17.1	408,900	19.8	110,000	14.9	974,200	5.5
2020	362,900	10.6	467,000	14.2	120,300	9.4	985,800	1.2
2030	431,500	18.9	532,400	14.0	134,300	11.6	1,011,900	2.6
2040	460,450	6.7	584,005	9.7	146,439	9.0	1,054,968	4.3
2050	503,133	9.3	641,518	9.8	158,966	8.6	1,088,609	3.2

— = No data available.

(a) Percent growth rate is calculated over the previous decade.

Sources: Population data for 1970 through 2000 (USCB 2008c); population data for 2006 (estimated) 2006 American Community Survey; population projections for 2010–2030 by New York Metropolitan Transportation Council, September 2004; population projections for 2040 and 2050 (calculated)

Table 2-12. Demographic Profile of the Population in the IP2 and IP3 Four-County ROI in 2000

	Dutchess	Orange	Putnam	Westchester	Region of Influence
Total Population	280,150	341,367	95,745	923,459	1,640,721
Race (percent of total population, not Hispanic or Latino)					
White	80.3	77.6	89.8	64.1	71.2
Black or African-American	8.9	7.5	1.5	13.6	10.8
American Indian and Alaska Native	0.2	0.2	0.1	0.1	0.1
Asian	2.5	1.5	1.2	4.4	3.3
Native Hawaiian and Other Pacific Islander	0.0	0.0	0.0	0.0	0.0
Some other race	0.2	0.1	0.1	0.3	0.3
Two or more races	1.5	1.4	1.0	1.8	1.6
Ethnicity					
Hispanic or Latino	18,060	39,738	5,976	144,124	207,898
Percent of total population	6.4	11.6	6.2	15.6	12.7
Minority Population (including Hispanic or Latino ethnicity)					
Total minority population	55,237	76,607	9,772	331,683	473,299
Percent minority	19.7	22.4	10.2	35.9	28.8

Source: USCB 2008c

Table 2-13. Demographic Profile of the Population in the IP2 and IP3 Four-County ROI in 2006 (Estimate)

	Dutchess	Orange	Putnam	Westchester	Region of Influence
Total Population	295,146	376,392	100,603	949,355	1,721,496
Race (percent of total population, not Hispanic or Latino)					
White	77.2	71.1	85.0	60.8	67.3
Black or African-American	7.8	8.7	2.0	13.5	10.8
American Indian and Alaska Native	0.1	0.3	0.0	0.1	0.1
Asian	3.4	2.5	2.2	5.5	4.3
Native Hawaiian and Other Pacific Islander	0.1	0.0	0.0	0.0	0.0
Some other race	0.2	0.3	0.1	0.5	0.4
Two or more races	2.6	1.7	1.0	1.0	1.5
Ethnicity					
Hispanic or Latino	24,879	57,980	9,692	175,990	268,541
Percent of total population	8.4	15.4	9.6	18.5	15.6
Minority Population (including Hispanic or Latino ethnicity)					
Total minority population	67,160	108,604	15,068	372,414	563,246
Percent minority	22.8	28.9	15.0	39.2	32.7

Source: USCB 2008c

Transient Population

Within 50 mi (80 km) of IP2 and IP3, colleges and recreational opportunities attract daily and seasonal visitors who create demand for temporary housing and services. In 2007, there were approximately 655,000 students attending colleges and universities within 50 mi (80 km) of IP2 and IP3 (IES 2008).

In 2000 in Westchester County, 0.8 percent of all housing units were considered temporary housing for seasonal, recreational, or occasional use. By comparison, seasonal housing accounted for 2.3 percent, 1.8 percent, 4.0 percent, and 3.1 percent of total housing units in Dutchess, Orange, and Putnam Counties, and New York as a whole, respectively (USCB 2008c). Table 2-14 provides information on seasonal housing located within 50 mi (80 km) of IP2 and IP3.

1 **Table 2-14. Seasonal Housing within 50 mi (80 km) of the IP2 and IP3**

County [a]	Housing units	Vacant housing units: For seasonal, recreational, or occasional use	Percent	
New York	**7,679,307**	**235,043**	**3.1**	
Bronx	490,659	962	0.2	
Dutchess	106,103	2,410	2.3	
Kings	930,866	2,616	0.3	
Nassau	458,151	3,086	0.7	
New York	798,144	19,481	2.4	
Orange	122,754	2,215	1.8	
Putnam	35,030	1,417	4.0	
Queens	817,250	4,574	0.6	
Richmond	163,993	524	0.3	
Rockland	94,973	380	0.4	
Suffolk	522,323	38,350	7.3	
Sullivan	44,730	13,309	29.8	
Ulster	77,656	5,238	6.7	
Westchester	349,445	2,711	0.8	
County Subtotal	5,012,077	97,273	4.1	(avg)
Connecticut	**1,385,975**	**23,379**	**1.7**	
Fairfield	339,466	3795	1.1	
Litchfield	79,267	4579	5.8	
New Haven	340,732	3,245	1.0	
County Subtotal	759,465	11619	2.6	(avg)
New Jersey	**3,310,275**	**109,075**	**3.3**	
Bergen	339,820	1266	0.4	
Essex	301,011	660	0.2	
Hudson	240,618	674	0.3	
Middlesex	273,637	905	0.3	
Morris	174,379	1237	0.7	
Passaic	170,048	849	0.5	
Somerset	112,023	456	0.4	
Sussex	56,528	3575	6.3	
Union	192,945	475	0.2	
Warren	41,157	361	0.9	
County Subtotal	1,902,166	10,458	1.0	(avg)
Pennsylvania	**5,249,750**	**148,230**	**2.8**	
Pike	34,681	15350	44.3	
County Subtotal	34,681	15,350	44.3	(avg)
County Total	**7,708,389**	**134,700**	**4.3**	(avg)

Source: USCB 2008c
[a] Counties within 50 mi of IP2 and IP3 with at least one block group located within the 50-mi radius
avg = percent average for counties within the IP2 and IP3 50-mi radius and excludes state percentage

Migrant Farm Workers

Migrant farm workers are individuals whose employment requires travel to harvest agricultural crops. These workers may or may not have a permanent residence. Some migrant workers may follow the harvesting of crops, particularly fruit, throughout the northeastern U.S. rural areas. Others may be permanent residents near IP2 and IP3 who travel from farm to farm harvesting crops.

Migrant workers may be members of minority or low-income populations. Because they travel and can spend significant time in an area without being actual residents, migrant workers may be unavailable for counting by census takers. If uncounted, these workers would be underrepresented in U.S. Census Bureau (USCB) minority and low-income population counts.

Information on migrant farm and temporary labor was collected in the 2002 Census of Agriculture. Table 2-15 provides information on migrant farm workers and temporary farm labor (fewer than 150 days) within 50 mi (80 km) of IP2 and IP3. According to the 2002 Census of Agriculture, approximately 9100 farm workers were hired to work for fewer than 150 days and were employed on 1800 farms within 50 mi (80 km) of the IP2 and IP3. The county with the largest number of temporary farm workers (1951 workers on 193 farms) was Suffolk County in New York.

In the 2002 Census of Agriculture, farm operators were asked for the first time whether any hired migrant workers, defined as a farm worker whose employment required travel that prevented the migrant worker from returning to his or her permanent place of residence the same day. A total of 360 farms in the 50-mi (80-km) radius of IP2 and IP3 reported hiring migrant workers. Suffolk County in New York reported the most farms (110) with hired migrant workers, followed by Orange and Ulster Counties in New York with 69 and 55 farms, respectively. Dutchess, Putnam, and Westchester Counties host relatively small numbers of migrant workers compared to those counties.

According to 2002 Census of Agriculture estimates, 275 temporary farm laborers (those working fewer than 150 days per year) were employed on 34 farms in Westchester County, and 435, 1583, and 127 temporary farm workers were employed on 132, 244, and 22 farms, respectively, in Dutchess, Orange, and Putnam Counties (USDA 2002e).

Table 2-15. Migrant Farm Worker and Temporary Farm Labor within 50 mi (80 km) of IP2 and IP3

County [a]	Number of farm workers working fewer than 150 days	Number of farms hiring workers for fewer than 150 days	Number of farms reporting migrant farm labor	Number of farms with hired farm labor
New York				
Bronx	0	0	0	0
Dutchess	435	132	18	194
Kings	0	0	0	0
Nassau	91	24	4	31
New York	0	0	0	4
Orange	1583	244	69	349
Putnam	127	22	0	27
Queens	–	1	0	1
Richmond	–	1	0	3
Rockland	69	19	0	21
Suffolk	1951	193	110	313
Sullivan	595	100	1	124
Ulster	550	102	55	163
Westchester	275	34	3	68
Subtotal	**5676**	**872**	**260**	**1298**
Connecticut				
Fairfield	377	108	1	114
Litchfield	459	174	9	198
New Haven	713	88	25	102
Subtotal	**1549**	**370**	**35**	**414**
New Jersey				
Bergen	103	32	3	40
Essex	–	3	1	4
Hudson	0	0	0	0
Middlesex	334	71	15	92
Morris	432	69	12	83
Passaic	66	15	4	17
Somerset	160	100	8	114
Sussex	200	158	4	217
Union	–	7	1	8
Warren	549	131	17	178
Subtotal	**1844**	**586**	**65**	**753**

Table 2-15 (continued)

County [a]	Number of farm workers working fewer than 150 days	Number of farms hiring workers for fewer than 150 days	Number of farms reporting migrant farm labor	Number of farms with hired farm labor
Pennsylvania				
Pike	–	8	0	10
Subtotal	**–**	**8**	**0**	**10**
Total	**9069**	**1836**	**360**	**2475**

Source: USDA 2002e, "Census of Agriculture," County Data, Table 7. Hired Farm Labor—Workers and Payroll: 2002

[a] Counties within 50 mi of IP2 and IP3 with at least one block group located within the 50-mi radius

2.2.8.6 Economy

This section contains a discussion of the economy, including employment and income, unemployment, and taxes.

<u>Employment and Income</u>

Between 2000 and 2006, the civilian labor force in Westchester County increased 3.8 percent from 452,417 to 469,558. The civilian labor force in Dutchess, Orange, and Putnam Counties also grew by 11.9, 16.4, and 9.4 percent, respectively (USCB 2008c).

In 2002, health care and social assistance represented the largest sector of employment in the four-county region followed closely by retail, manufacturing, and the accommodation and food service industry. The health care and social assistance sector employed the most people in Westchester County followed by retail trade and professional, scientific, and technical services sectors. A list of some of the major employers in Westchester County in 2006 is provided in Table 2-16. As shown in the table, the largest employer in Westchester County in 2006 was IBM Corporation with 7475 employees.

Income information for the IP2 and IP3 ROI is presented in Table 2-17. In 1999, the date of the last economic census, the four counties each had median household incomes far above the New York State average. Per capita income, with the exception of Orange County, was also above the New York State average. In 1999, only 8.8 percent of the population in Westchester County was living below the official poverty level, while in Dutchess, Orange, and Putnam Counties, 7.5, 10.5, and 4.4 percent of the respective populations were living below the poverty level. The percentage of families living below the poverty level was about the same for Dutchess, Orange, and Westchester Counties. Putnam County had the smallest percentage of families living below the poverty level (USCB 2008c).

1 **Table 2-16. Major Employers in Westchester County in 2006**

Firm	Number of Employees
IBM Corporation	7475
County of Westchester	5881
Yonkers Public Schools	4049
Westchester Medical Center	3367
United States Postal Service District Office	3007
Verizon Communications	2733
Sound Shore Health System of Westchester	2515
City of Yonkers	2418
Riverside Health Care (St. John's Riverside Hospital)	2418
PepsiCo Incorporated	2372
White Plains Hospital Center	1923
New York State Department of Correctional Services	1735
Pace University	1620
MTA Metro-North Railroad	1617
Entergy Nuclear Northeast	1500
Morgan Stanley	1475
The Bank of New York Company	1450
Mount Vernon City School District	1450
Con Edison	1400
City School District of New Rochelle	1352
Phelps Memorial Hospital Center	1347
White Plains Public Schools	1285

Source: The Journal News 2006

2 **Table 2-17. Income Information for the IP2 and IP3 ROI**

	Dutchess	Orange	Putnam	Westchester	New York
Median household income 1999 (dollars)	53,086	52,058	72,279	63,582	43,393
Per capita income 1999 (dollars)	23,940	21,597	30,127	36,726	23,389
Percent of families living below the poverty level (2000)	5.0	7.6	2.7	6.4	11.5
Percent of individuals living below the poverty level (2000)	7.5	10.5	4.4	8.8	14.6

Source: USCB 2008c

Unemployment

In 2006, the annual unemployment averages in Westchester and Dutchess, Orange, and Putnam Counties were 5.3, 5.5, 6.2, and 4.8 percent, respectively, which were lower than the annual unemployment average of 6.5 percent for the State of New York (USCB 2008c).

Taxes

IP2 and IP3 are assessed annual property taxes by the Town of Cortlandt, the Village of Buchanan, and the Hendrick Hudson Central School District. PILOT payments, property taxes, and other taxes from the site are paid directly to the Town of Cortlandt, the Village of Buchanan, and the Hendrick Hudson Central School District (see Table 2-18). The payments to the Town of Cortlandt are distributed to the Town of Cortlandt, Westchester County, the Verplanck Fire District, the Hendrick Hudson Central School District, and Lakeland Central Schools.

PILOT payments, property taxes, and other taxes paid by Entergy account for a significant portion of revenues for these government agencies. The remainder is divided between the Village of Buchanan, Westchester County, the Town of Cortlandt, and the Verplanck Fire District.

The Village of Buchanan is the principal local jurisdiction that receives direct revenue from the site. In fiscal year 2006, PILOT payments, property taxes, and other taxes from the site contributed about 40 percent of the Village of Buchanan's total revenue of $5.07 million, which is used for police, fire, health, transportation, recreation, and other community services for over 2100 residents (NYSOSC 2007). Additionally in fiscal year 2006, PILOT payments, property taxes, and other taxes from the site contributed over 27 percent of the total revenue collected for the Hendrick Hudson Central School District.

Entergy also pays approximately $1 million dollars per year to New York State Energy Research and Development Authority (NYSERDA) for lease of the discharge canal structure and underlying land (NYSERDA 2007).

From 2003 through 2006, the Town of Cortlandt had between $31.6 and $34.5 million annually in total revenues (NYSOSC 2008). Between 2003 and 2006, IP2 and IP3 PILOT and property tax payments represented 11 to 16 percent of the Town's total revenues (see Table 2-18).

From 2003 through 2006, the Hendrick Hudson Central School District had between $51 and $57 million annually in total revenues (NYSOSC 2008). Between 2003 and 2006, IP2 and IP3 PILOT payments represented 27 to 38 percent of the school district's total revenues (see Table 2-18).

From 2003 to 2006, the Village of Buchanan had between $5 and $5.7 million annually in total revenues (NYSOSC 2008). Between 2003 and 2006, IP2 and IP3 PILOT and property tax payments represented between 39 and 43 percent of the Village's total revenues (see Table 2-18).

Table 2-18. IP2 and IP3 PILOT and Property Tax Paid and Percentage of the Total Revenue of the Town of Cortlandt, Hendrick Hudson Central School District, and Village of Buchanan, 2003 to 2006

Entity	Year	Total Revenue (millions of dollars)	PILOT and Property Tax Paid (millions of dollars)	Percent of Total Revenue
Town of Cortlandt	2003	31.6	5.0	16
	2004	31.9	4.7	15
	2005	34.5	3.8	11
	2006	33.8	3.7	11
Hendrick Hudson Central School District	2003	51.1	19.6	38
	2004	52.8	18.9	36
	2005	56.9	16.9	30
	2006	55.9	15.3	27
Village of Buchanan	2003	5.7	2.3	40
	2004	5.0	2.2	43
	2005	5.1	2.0	39
	2006	5.1	2.0	40

Source: NYSOSC 2008; ENN 2007c

2.2.9 Historic and Archeological Resources

This section presents a brief summary of the region's cultural background and a description of known historic and archaeological resources at the IP2 and IP3 site and its immediate vicinity. The information presented was collected from the New York State Historic Preservation Office (NYSHPO), and the applicant's environmental report (Entergy 2007a).

2.2.9.1 Cultural Background

Prehistory

The basic prehistoric cultural sequence and chronology for New York State is presented in Table 2-19 below and the text that follows. This cultural sequence was generated primarily for western and southern New York, and its applicability to the unusual estuarine environments of the lower Hudson and southeastern New York is uncertain. Given the lack of excavated data specific to the lower Hudson River Valley, the NRC staff used this generalized sequence (Ritchie 1980).

Table 2-19. Cultural Sequence and Chronology

Cultural Period	Time Period
Paleo-Indian Period	9000–7000 B.C.
Archaic Period	7000–1000 B.C.
Woodland Period	1000 B.C.–A.D. 1524
European Contact	A.D. 1524–1608

Paleo-Indian Period

Archeological evidence suggests that Paleo-Indian people were hunter-gatherers who primarily hunted large mammals using projectiles tipped with distinctively flaked "fluted" stone points. These small, widely dispersed bands ranged over large geographic areas supplementing food taken from large mammal hunts by collecting edible wild plant foods, fishing, and hunting smaller game (Ritchie 1980).

Humans entered upstate New York and the Hudson River Valley for the first time around 10,000–9,000 B.C. Ritchie (1980) reports isolated finds of fluted points characteristic of the Clovis tradition in the Albany area. Data on Paleo-Indian fluted points indicate only one example each in Westchester, Rockland, and Orange Counties. Levine's more extensive publication (1989) regarding Paleo-Indian fluted points from surface collections in the Upper Hudson River Valley is similarly vague regarding the nature of findspots and their environmental settings. Most appear to have been collected from agricultural plow zones and indicate a temporary occupation, such as a hunting camp.

Excavated sites are consistently small and indicative of extremely short-term utilization. Of particular interest to the lower Hudson is the Port Mobil site, located above the Arthur Kill on Staten Island. Though badly disturbed, the location of the site indicates a strong estuarine orientation, and the lithic materials recovered at the site derive from both eastern New York and eastern Pennsylvanian sources (Ritchie 1994).

Archaic Period

Generalized hunter-gatherers exploiting large game and a wide variety of fauna, including small mammals and birds, and fish, characterize the Archaic period. The Early and Middle Archaic Periods had long been interpreted as representing a low point in human occupation in the Northeast, but as with the Paleo-Indian period, surface collections have begun to fill in the gap (Levine 1989). Part of the explanation for the increasing density of human occupation of upper New York State may involve the gradual transition from relatively resource-poor coniferous forests to hardwood forests during the course of the period (Salwen 1975). Gradually rising sea levels would have shortened the descent to the Hudson River banks and flooded any number of Early Archaic sites.

Brennan noted that Archaic hunting and foraging was centered on two pools or bays, the Tappan Zee, stretching from just north of Yonkers to the Croton River, and Haverstraw Bay, from the Croton River to Bear Mountain. He disagreed, however, with the notion that any of the sites represented long-term, much less permanent, settlements and specialized subsistence. Instead, he suggested that Archaic exploitation of the lower Hudson was only seasonal, as part of a generalized subsistence strategy (Brennan 1977).

Woodland Period

The Woodland Period in New York State saw the establishment of horticulture and the development of larger social units, including matriarchal and matrilocal clans, sedentary villages, and tribes. Pottery is gradually introduced, and a much wider variety of material culture comes into use. While minor climate fluctuations took place during this period, the overall environment was very similar to that of today.

Early Woodland sites are similar to those of the Late Archaic Period. They are typically small sites, with projectile points, scrapers, and bone tools providing evidence of hunting, fishing, and limited cultivation (Funk 1976). Pottery is found on an increasing number of sites, typically stamped and impressed cooking pots tempered with crushed shell. The wide variety of pottery types found at individual sites, however, points to low levels of interaction between groups. Other new features of the early Woodland Period are burials with elaborate grave goods, including flints and bone tools, shell and copper beads, and stone pendants (Ritchie 1980).

By the Middle and Late Woodland Periods, the size and complexity of sites increased tremendously. The key to later developments was the introduction of horticulture and the cultivation of maize (*Zea mays*), beans (*Phaseolus vulgaris*), and squash (*Cucurbita pepo*). Processing of these crops was facilitated by the use of cooking pots and storage pits. Villages were occupied year-round by the end of the period and often comprised multiple longhouses positioned on defensible hills and fortified with walls or palisades.

European Contact, 1524–1608

The Contact Period in the lower Hudson Valley began in 1524, when the Spanish explorer Giovanni de Verrazzano reached New York Harbor in his ship, the *Dauphin*. After anchoring near Staten Island, he attempted to go ashore in a small boat but was forced to return to his ship because of a sudden storm. Verrazzano then departed quickly and continued up the East Coast. The Spanish continued to exploit the area between the Chesapeake and the Gulf of Maine, primarily as slavers, while French fishermen appear to have frequented the Grand Banks in the 16th century.

Historic Period

The Colonial Period, 1608–1776

The English explorer Henry Hudson undertook two unsuccessful Arctic explorations in search of the Northwest Passage to the Orient in 1608. With the support of the Dutch East Indies Company, Hudson's famous voyage in the *Half Moon* took place in 1609, whereupon he discovered instead the river that now bears his name. Almost immediately thereafter, Dutch traders in great numbers began flooding into the area, primarily in search of furs. In 1614, the New Netherlands Company was formed and given a charter by the Dutch to exploit the areas between the Connecticut, Mohawk, and Hudson Rivers. In 1614, the Dutch established Fort Nassau on the west bank of the Hudson River at what is now Albany.

The island known as Manhattan was, famously, purchased from the Manhattes in 1626, and other areas such as Staten Island, Hoboken, and Nyack were purchased in the succeeding decades (Francis 1997; Kraft 1991). Dutch, Walloon, Huguenot, and even small numbers of Jews began to arrive as refugees and settlers in New Amsterdam, but by 1630, the population was still only around 300. In 1664 an English fleet sailed into the harbor at New Amsterdam,

and after some negotiation, the Dutch capitulated. The English seized the entire colony of New Amsterdam and renamed the area New York and New Jersey.

The Revolutionary War, 1776–1783

New York and, more specifically, Westchester County were the site of many significant events during the American Revolution. The social and economic structure of the State was still dominated by large landowners, and discontent had already emerged among tenant farmers during the 1750s and 1760s. British troops landed on Staten Island in July 1776 and advanced northward, pressing colonial forces under the command of George Washington to make a strategic retreat north into Westchester County (Griffin 1946). With a large British force advancing, the bulk of American forces in Westchester retreated across the Hudson to New Jersey (Griffin 1946; Countryman 2001). Westchester remained on the front lines until the end of the war. The American defense line stretched from Mamaroneck to Peekskill, with British forces arrayed across southern Westchester County, creating a "neutral ground" in between, across which violence raged. The British gradually captured the bulk of Westchester County by 1779 but were unable to press their advantage further (Griffin 1946; Countryman 2001).

The Americans slowly pushed the British back from the Hudson Highlands and then Westchester County. In July 1779, General Anthony Wayne and his Corps of Light Infantry conducted a successful assault against a British encampment at Stony Point. The modern Stony Point Battlefield in Rockland County is across the Hudson River from the IP2 and IP3 site.

19th Century Development

The economy of Westchester County remained overwhelmingly agricultural during the first half of the 19th century, driving a number of infrastructure improvements. The Croton Turnpike, for example, was organized in 1807 to carry the enormous cattle traffic en route to New York City from Westchester County. Though shipbuilding was a major industry on both the Hudson and Long Island Sound sides of Westchester, regular sloop traffic to Manhattan did not begin until the later 18th century. After 1807, the steamboat revolution, engineered by Robert Livingston and Robert Fulton, opened a new era on the Hudson River.

The landscape of New York State and Westchester County was profoundly transformed by land speculation, which opened virtually the entirety of the State for farming, and more gradually by the spread of industry. Copper was mined near Sing-Sing and iron near Port Chester and Irvington, and iron working was established in Peekskill. During the latter part of the 19th century, the area just north of the IP2 and IP3 site was surface-mined, and a small lime kiln and blast furnace were operated within or adjacent to the footprint of the current facility (Enercon, 2006). By the end of the 19th century, industrialization was widespread in Westchester County.

20th Century Development

Land remained the dominant theme for the 20th century in Westchester County, but in a far different sense than during the 19th. The preceding century had seen the landscape transformed through the end of the manorial system and the spread of freehold farming, then by industrialization and transportation networks, and finally by deliberate preservation as New York City's water source. Though the surrounding counties had always been secondary to New York City in terms of population, productivity, and wealth, the 20th century gradually saw decisive political and economic subordination.

2.2.9.2 Historic and Archeological Resources at the IP2 & IP3 Site

Previously Recorded Resources

A Phase 1A Survey (literature review and sensitivity assessment) was conducted in 2006 by Entergy (Enercon, 2006). This survey was primarily a literature review and included only an informal walkover of a portion of the plant site. Areas of potential aboriginal and historical interest were noted; however, no sites were recorded as part of this effort. No systematic pedestrian or subsurface cultural resources surveys have been conducted at the IP2 and IP3 site.

NYSHPO houses the State's archeological site files and information on historic resources such as buildings and houses, including available information concerning the National or State Register eligibility status of these resources. The NRC cultural resources team visited NYSHPO and conducted a records search for archeological sites located within or near the IP2 and IP3 property. The results of this search are detailed below.

There are no previously recorded archeological sites within the IP2 & IP3 property. A search for sites within a 1-mi (1.6-km) radius of the plant also revealed no previously recorded sites. The nearest recorded site (A-119-02-0003) is located southwest of the plant, at Verplanck's Point. Site A-119-02-003 is the site of the Revolutionary War era Fort Lafayette. The New York State Historic Trust site inventory form indicates that there is no longer any visible, above ground evidence of the fort; however, the inventory form documents artifacts from the fort site (including cannonballs and uniform buttons) found in the collections of local residents in the mid-1970s. The nearest previously recorded prehistoric archaeological site is the "Peekskill Shell Heap" (NYSM 6910). This site is a shell and artifact midden deposit located northeast of the IP2 and IP3 site in the City of Peekskill.

A review of the NYSHPO files was conducted to identify aboveground historic resources within 5 mi (8 km) of the plant. In Westchester County, 29 resources are listed on the National Register of Historic Places (NRHP) within the 5-mi (8-km) radius. Additionally, there are 16 NRHP-listed resources in Rockland County, 19 in Orange County, and 22 in Putnam County within 5 mi (8 km). The nearest NRHP-listed historic resource to the IP2 and IP3 facilities is the Standard House in the City of Peekskill, approximately 2 mi (3.2 km) to the northeast. The Standard House is a three-story Italianate structure built in 1855 and originally used as a boarding house and tavern.

IP1 began operation in August 1962 and was shut down in October 1974 and placed in SAFSTOR with intent for decommissioning at a later date. The plant was one of three "demonstration plants" that began operation in the early 1960s and is representative of the earliest era of commercial reactors to operate in the United States. To date, no formal significance or eligibility evaluation has been conducted for IP1.

Results of Walkover Survey

The NRC staff performed an informal walkover survey of the IP2 and IP3 property during the environmental site audit, including portions of the power block area and portions of the former Lent's Cove Park (wooded area north of the power block area). During this walkover, it was observed that the power block area has been extensively disturbed and graded. The NRC staff walked a meandering path through the wooded area north of the plant and along a portion of the shoreline of Lent's Cove.

The NRC cultural resources team observed evidence of prehistoric use of this area in two locations along the walkover route. The NRC staff observed two pieces of chert debitage near a stream in the western portion of the wooded area, and a Woodland Period, Meadowood Phase, projectile point was observed near the shoreline along Lent's Cove. Historic Period use of this area was also observed in the form of an apparent stone house foundation and scattered historic era trash piles.

Evidence of mining (Enercon 2006) was confirmed in the western portion of the wooded area. Manmade holes of varying size and piles of spoil material were observed by the NRC staff along the route of the walkover in this portion of the property.

The NRC staff observed a concrete stairway and retaining wall (remnants of an early 20th century park) south of the main power block area. These appear to be the only remaining features of the former Indian Point Park, a popular recreation area from 1923 to 1956 (Enercon 2006).

Potential Archeological Resources

As the result of disturbances associated with site preparation and construction, the main generating station areas at IP2 and IP3 have little or no potential for archeological resources. There is potential for archeological resources to be present in the wooded area north of the main generating station areas, and the historic period mining features in this area represent a potentially significant resource. The portion of the property south and east of the power block area, which contains a variety of ancillary plant facilities, has been disturbed by construction activities over the course of the plant's history. It is possible, however, that portions of that area not disturbed by construction activities may contain intact subsurface archeological deposits. Additionally, the concrete stairway and retaining wall from the former Indian Point Park would require evaluation, should any construction activity be planned for that area of the facility.

2.2.10 Related Federal Project Activities and Consultations

During the preparation of the IP2 and IP3 ER, Entergy did not identify any known or reasonably foreseeable Federal projects or other activities that could contribute to the cumulative environmental impacts of license renewal at the site (Entergy 2006a).

The NRC staff further reviewed the possibility that activities of other Federal agencies might affect the renewal of the operating licenses for IP2 and IP3. The presence of any such activity could result in cumulative environmental impacts and the possible need for a Federal agency to become a cooperating agency in the preparation of the draft SEIS.

The NRC staff identified several current Federal projects occurring near IP2 and IP3, which the staff will discuss in the following paragraphs. The NRC staff has determined that none of these Federal projects would result in impacts to the IP2 and IP3 license renewal review that would make it desirable for another Federal agency to become a cooperating agency in the preparation of this draft SEIS.

The NRC is required under Section 102(c) of NEPA to consult with and obtain the comments of any Federal agency that has jurisdiction by law or special expertise with respect to any environmental impact involved. Federal agency comment correspondence is included in Appendix E.

New York/New Jersey/Philadelphia Airspace Redesign

The Federal Aviation Administration (FAA) is proposing to redesign the airspace in the New York/New Jersey/Philadelphia (NY/NJ/PHL) Metropolitan Area. This redesign was conceived as a system for more efficiently directing Instrument Flight Rule aircraft to and from five major airports in the NY/NJ/PHL Metropolitan Area, including John F. Kennedy International Airport and LaGuardia Airport in New York, Newark Liberty International Airport and Teterboro Airport in New Jersey, and Philadelphia International Airport in Pennsylvania. All of these airports are south of the IP2 and IP3 facility with the closest being the Teterboro Airport which is about 30 mi away. The redesign project also included 16 satellite airports in the study area. Of these satellite airports, the White Plains/Westchester County Airport, located about 24 mi south-southeast of the IP2 and IP3 facility, and Stewart International Airport, located about 25 mi north, are the closest to the facility.

FAA, in cooperation with DOT, prepared an EIS to evaluate the environmental effects of the NY/NJ/PHL Metropolitan Area Airspace Redesign in accordance with NEPA (DOT/FAA 2007). The proposed action for this EIS is to redesign the airspace in the NY/NJ/PHL metropolitan area. This involves developing new routes and procedures to take advantage of improved aircraft performance and emerging air traffic control technologies. The final EIS identified that potential significant impacts exist in the categories Noise/Compatible Land Use and Socioeconomic Impacts/Environmental Justice (DOT/FAA 2007). The greatest potential impact of the proposed action and preferred alternative is changes in the noise levels in the airspace redesign area.

The EIS provides detailed descriptions of the proposed noise mitigation procedures identified for the preferred alternative mitigation package. The EIS studied regions of the Appalachian Trail which lie north of the IP2 and IP3 facility. The trail crosses the Hudson River about 4 mi north of the facility near Bear Mountain. In this area, the EIS mitigated preferred alternative for 2011 would result in an average of 512.4 daily air jet operations in the region (DOT/FAA 2007). The no action alternative for 2011 air traffic would result in an average of 268.1 daily air jet operations (DOT/FAA 2007). The mitigated preferred alternative would, therefore, result in a more than 90-percent increase in air traffic in the region immediately north and northwest of the facility. The formal Record of Decision (ROD) for the airspace redesign study which supports the FAA's mitigated preferred alternative was issued in September 2007 (FAA 2007).

Hudson River PCBs Site

The EPA Hudson River PCBs Site encompasses a nearly 200-mi stretch of the Hudson River in eastern New York State from Hudson Falls, New York, to the Battery in New York City and includes communities in 14 New York counties and 2 counties in New Jersey (EPA 2008c). The EPA ROD for the Hudson River PCBs Superfund Site addresses the risks to people and ecological receptors associated with PCBs in the in-place sediments of the Upper Hudson River. The February 2002 ROD calls for targeted environmental dredging and removal of approximately 2.65 million cubic yards of PCB-contaminated sediment from a 40-mi stretch of the Upper Hudson. In the ROD, EPA selected a plan that addresses the risks to people and the environment associated with PCBs in the sediments of the Upper Hudson River. The actions in the Upper Hudson will lower the risks to people, fish, and wildlife in the Lower Hudson (EPA 2008c).

On January 25, 2008, EPA completed the final step in the approval process for the design of Phase 1 of the Hudson River PCBs Site dredging program (EPA 2008c). Phase 1 encompasses the construction of facilities necessary to process and transport sediments to be dredged from the river, as well as the first year of the dredging program and the habitat replacement and reconstruction program for those areas dredged during Phase 1. Phase 2 will consist of dredging the first three sections of the Upper Hudson River (north of the Federal Dam at Troy, New York) (EPA 2008d).

U.S. Army Corps of Engineers Hudson River Federal Navigation Project

The U.S. Army Corps of Engineers (USACE), New York District, prepared an EIS addressing the effects of the Hudson River Federal Navigation Project in 1983. Environmental assessments updating the EIS were prepared by the USACE New York District for various maintenance dredging projects since the mid-1980s. USACE determined that the maintenance dredging for the Hudson River Federal Navigation Project, with placement of dredged material on the federally owned upland placement site on Houghtaling Island, has no significant adverse environmental impacts on water quality, marine resources, fish, wildlife, recreation, aesthetics, and flood protection (USACE 2006).

Coastal Zone Management Act

In the United States, coastal areas are managed through the Coastal Zone Management Act of 1972 (CZMA). The Act, administered by the NOAA Office of Ocean and Coastal Resource Management, provides for management of the nation's coastal resources, including the Great Lakes, and balances economic development with environmental conservation. The Federal Consistency Regulations implemented by NOAA are contained in 15 CFR Part 930.

This law authorizes individual states to develop plans that incorporate the strategies and policies they will employ to manage development and use of coastal land and water areas. Each plan must be approved by NOAA. One of the components of an approved plan is “enforceable polices,” by which a state exerts control over coastal uses and resources.

The New York Coastal Management Program was approved by NOAA in 1982. The lead agency is the Division of Coastal Resources within the Department of State. The lead agency implements and supervises all the various Coastal Zone Management programs in the state. New York's coastal zone includes coastal counties on Long Island as well as Westchester County, the boroughs of New York City, counties along the Hudson River up the Federal Dam at Troy, and counties along the Great Lakes (NOAA 2007b). Federal Consistency requires “federal actions, occurring inside a state’s coastal zone, that have a reasonable potential to affect the coastal resources or uses of that state’s coastal zone, to be consistent with that state’s enforceable coastal policies, to the maximum extent practicable.”

IP2 and IP3 are located in Westchester County, within the State’s Coastal Zone, specifically in the Peekskill South region of the Hudson River (NYSDOS undated). The IP2 and IP3 site is adjacent to a Significant Coastal Fish and Wildlife Habitat (Haverstraw Bay), and south of the Hudson Highlands Scenic Area of Statewide Significance (NYSDOS undated). Based on IP2 and IP3’s location within the State’s Coastal Zone, license renewal of IP2 and IP3 will require a State coastal consistency certification.

2.3 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation."

10 CFR Part 50. Code of Federal Regulations, Title 10, Energy, Part 50, "Domestic Licensing of Production and Utilization Facilities."

10 CFR Part 51. Code of Federal Regulations, Title 10, Energy, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."

10 CFR Part 100. Code of Federal Regulations, Title 10, Energy, Part 100, "Reactor Site Criteria."

40 CFR Part 190. Code of Federal Regulations, Title 40, Protection of Environment, Part 190, "Environmental Radiation Protection Requirements for Normal Operations of Activities in the Uranium Fuel Cycle."

40 CFR Part 261. Code of Federal Regulations, Title 40, Protection of Environment, Part 261, "Identification and Listing of Hazardous Waste."

40 CFR Part 264. Code of Federal Regulations, Title 40, Protection of Environment, Part 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities."

40 CFR Part 273. Code of Federal Regulations, Title 40, Protection of Environment, Part 273, "Standards for Universal Waste Management."

32 FR 4001. U.S. Department of the Interior. "Native Fish and Wildlife: Endangered Species." March 11, 1967.

41 FR 41914. U.S. Fish and Wildlife Service. "Endangered and Threatened Wildlife and Plants: Determination of Critical Habitat for American Crocodile, California Condor, Indiana Bat, and Florida Manatee." September 24, 1976.

69 FR 39395. U.S. Fish and Wildlife Service. "Endangered and Threatened Wildlife and Plants; 90-Day Finding on a Petition to List the New England Cottontail as Threatened or Endangered." June 30, 2004.

71 FR 61022. National Marine Fisheries Services. "Endangered and Threatened Species; Revision of Species of Concern List, Candidate Species Definition, and Candidate Species List." October 17, 2006.

72 FR 37346. U.S. Fish and Wildlife Service. "Endangered and Threatened Wildlife and Plants: Removing the Bald Eagle in the Lower 48 States from the List of Endangered and Threatened Wildlife." Final rule. July 9, 2007.

72 FR 69033. U.S. Fish and Wildlife Service. "Review of Native Species That Are Candidates or Proposed for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions." Proposed Rule. December 12, 2007.

6 New York Codes, Rules, and Regulations (NYCRR) Subpart B. Title 6 of the Official Compilation of New York Codes, Rules and Regulations, Subpart B, "Solid Waste."

16 U.S.C. Section 668aa(c). "Endangered Species Preservation Act." October 15.

16 U.S.C. Section 1531 to 1544. "Endangered Species Act of 1973" (16 U.S.C. 1531–1544, 87 Stat. 884), as amended. Public Law 93-205, approved December 28, 1973.

16 U.S.C. Section 5151 to 5158. "Atlantic Striped Bass Conservation Act" (16 U.S.C. 5151–1544, 98 Stat. 3187). Public Law 98-613, approved 1984.

Abood, K.A., T.L. Englert, S.G. Metzger, C.V. Beckers, Jr., T.J. Groninger, and S. Mallavaram. 2006. "Current and Evolving Physical and Chemical Conditions in the Hudson River Estuary." American Fisheries Society Symposium 51, pp. 39–61.

Achman, D.R., B.J. Brownawell, and L. Zhang. 1996. "Exchange of Polychlorinated Biphenyls Between Sediment and Water in the Hudson River Estuary." Estuaries 19:4, pp. 950–965.

ASA (ASA Analysis and Communication). 2007. 2005 Year Class Report for the Hudson River Estuary Monitoring Program. Prepared on behalf of Dynergy Roseton LLC, Entergy Nuclear Indian Point 2 LLC, Entergy Nuclear Indian Point 3 LLC, and Mirant Bowline LLC. January 2007. ADAMS No. ML073331067.

Ashizawa, D., and J.J. Cole. 1994. "Long-Term Temperature Trends of the Hudson River: A Study of the Historical Data." Estuaries 17:18, pp. 166–171.

ASSRT (Atlantic Sturgeon Status Review Team). 2007. "Status Review of Atlantic Sturgeon (Acipenser oxyrinchus oxyrinchus)." Report to National Marine Fisheries Service, Northeast Regional Office. February 23, 2007. 174 pp. Accessed at http://www.nmfs.noaa.gov/pr/pdfs/statusreviews/atlanticsturgeon2007.pdf on December 7, 2007.

Atlantic States Marine Fisheries Commission (ASMFC). 1998. "American Shad Stock Assessment: Peer Review Report." March 1998. Washington, DC. Accessed at http://www.asmfc.org/speciesDocuments/shad/stockassmtreports/shadstockassmtreport.PDF on January 21, 2008.

Atlantic States Marine Fisheries Commission (ASMFC). 2004. "Status of the Blue Crab (Callinectes sapidus) on the Atlantic Coast." Special Report No. 80.

Atlantic States Marine Fisheries Commission (ASMFC). 2006a. "2006 Stock Assessment Report for Atlantic Menhaden." Atlantic Menhaden Technical Committee. September 26, 2006. Accessed at http://www.asmfc.org/speciesDocuments/menhaden/reports/stockAssessments/2006StockAssessmentReport.pdf?bcsi_scan_513F405096A035F7=0&bcsi_scan_filename=2006StockAssessmentReport.pdf on February 5, 2008.

Atlantic States Marine Fisheries Commission (ASMFC). 2006b. "Species profile: Atlantic striped bass, the challenges of managing a restored stock." Accessed at http://www.asmfc.org/speciesDocuments/stripedBass/speciesprofile.pdf on December 10, 2007. ADAMS No. ML083360698.

Atlantic States Marine Fisheries Commission (ASMFC). "2006 Weakfish Stock Assessment Report." December 2006. Accessed at http://www.asmfc.org/speciesDocuments/weakfish/stockassessmentreports/2006WeakfishStock

Assessment.pdf?bcsi_scan_B666A1DE717DB577=0&bcsi_scan_filename=2006WeakfishStock Assessment.pdf on February 13, 2008.

Atlantic States Marine Fisheries Commission (ASMFC). 2007a. “American Shad Stock Assessment Report for Peer Review.” Stock Assessment Report No. 07-01 (Supplement) of the Atlantic States Marine Fisheries Commission. August 16, 2007. Accessed at http://www.asmfc.org/speciesDocuments/shad/stockassmtreports/2007ShadStockAssmtReport VolumeI.pdf on January 21, 2008.

Atlantic States Marine Fisheries Commission (ASMFC). 2007b. “Species Profile: Weakfish—The Challenge of Managing a Stock Decline When Fishing is Not the Cause.” ASMFC Fisheries Focus, Vol. 16, Issue 4: May/June 2007. Accessed at http://www.asmfc.org/speciesDocuments/weakfish/weakfishProfile.pdf on February 17, 2008.

Atlantic States Marine Fisheries Commission (ASMFC). 2007c. “Species Profile: Atlantic Sturgeon, Ancient Species’ Slow Road to Recovery.” Accessed at http://www.asmfc.org/speciesDocuments/sturgeon/sturgeonProfile.pdf on December 6, 2007.

Bain, M.B., N. Haley, D.L. Peterson, K.K. Arend, K.E. Mills, and P.J. Sullivan. 2007. “Recovery of a U.S. Endangered Fish.” PLoS ONE 2(1): e168. Department of Natural Resources, Cornell University, Ithaca, New York. Accessed at http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0000168#s3 on December 11, 2007.

Barnthouse, L.W., and W. Van Winkle. 1988. “Analysis of Impingement Impacts on Hudson River Fish Populations.” American Fisheries Society Monograph 4, pp. 182–190.

Berggren, T.J., and J.T. Lieberman. 1978. “Relative Contribution of Hudson, Chesapeake, and Roanoke Striped Bass, Morone saxatilis, Stocks to the Atlantic Coast Fishery.” U.S. National Marine Fisheries Service Fishery Bulletin 76, pp. 335–345.

Bigelow, H.B., and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. Fishery Bulletin 74, Fishery Bulletin of the Fish and Wildlife Service, Volume 53, Contribution No. 592, Woods Hole Oceanographic Institution. U.S. Government Printing Office. Accessed at http://www.gma.org/fogm on January 21, 2008.

Blumberg, A.F., and F.L. Hellweger. 2006. “Hydrodynamics of the Hudson River Estuary.” American Fisheries Society Symposium 51, pp. 9–28.

Boreman, J., and C.P. Goodyear. 1988. “Estimates of Entrainment Mortality for Striped Bass and Other Fish Species Inhabiting the Hudson River Estuary.” American Fisheries Society Monograph 4, pp. 152–160.

Brennan, L.A. 1977. “The Lower Hudson: The Archaic.” In Amerinds and their Paleoenvironments in Northeastern North America. pp. 411–430. Edited by Walter S. Newman and Bert Salwen. New York Academy of Sciences, NY.

Britton, N.L., and A. Brown. 1913. An Illustrated Flora of the Northern United States, Canada and the British Possessions. Volume II. Second edition, revised and enlarged. Charles Scribner’s Sons, New York.

Brosnan, T.M., and M.L. O’Shea. 1996. “Long-term Improvements in Water Quality Due to Sewage Abatement in the Lower Hudson River.” Estuaries 19:4, pp. 890–900.

Buckley, J.L. 1989. "Species Profiles: Life Histories and Environment; Requirements of Coastal Fishes and Invertebrates (North Atlantic)—Rainbow Smelt." U.S. Fish and Wildlife Service Biological Report 82(11.106), U.S. Army Corps of Engineers, TR EL-82-4. 11 pp. Accessed at http://www.nwrc.usgs.gov/wdb/pub/species_profiles/82_11-106.pdf on March 13, 2008.

Caraco, N.F., J.J. Cole, P.A. Raymond, D.L. Strayer, M.L. Pace, S.E.G. Findlay, and D.T. Fisher. 1997. "Zebra Mussel Invasion in a Large, Turbid River: Phytoplankton Response to Increased Grazing." Ecology 78, pp. 588–602.

Caraco, N.F., J.J. Cole. S.E.G. Findlay, D.T. Fischer, G.G. Lampman, M.L. Pace, and D.L. Strayer. 2000. "Dissolved Oxygen Declines in the Hudson River Associated with the Invasion of the Zebra Mussel (Dreissena polymorpha)." Environmental Science and Technology 34, pp. 1204–1210.

Caraco, N.F., and J.J. Cole. 2006. "Hydrologic Control of External Carbon Loads and Primary Production in the Tidal Freshwater Hudson." American Fisheries Society Symposium 51, pp. 63–74.

Center for Plant Conservation (CPC). 2008. "National Collection of Endangered Plants—Plant Profiles." Accessed at http://www.centerforplantconservation.org/ASP/CPC_NCList_Alpha.asp on March 12, 2008. ADAMS No. ML083390228.

Chesapeake Bay Program. 2006. "White Perch." Accessed at http://www.chesapeakebay.net/white_perch.htm on January 11, 2008. ADAMS No. ML083390252.

CHGEC (Central Hudson Gas and Electric Corporation). 1999. "Draft Environmental Impact Statement for State Pollutant Discharge Elimination System Permits for Bowline Point, Indian Point 2 and 3, and Roseton Steam Electric Generating Stations." Consolidated Edison Company New York, Inc. New York Power Authority and Southern Energy New York. December 1999. ADAMS Accession No. ML083400128.

Christensen, S.W., and T.L. Englert. 1988. "Historical Development of Entrainment Models for Hudson River Striped Bass." American Fisheries Society Monograph 4, 133–142.

Collette, B.B., and G. Klein-MacPhee (eds.). 2002. Bigelow and Schroeder's Fishes of the Gulf of Maine (3rd Ed.). 748 pp. Smithsonian Institute Press, Herndon, VA.

Conant, R., and J.T. Collins. 1998. A Field Guide to Reptiles and Amphibians, Eastern and Central North America. Third edition, expanded. Houghton Mifflin Co., Boston.

Cortlandt Consolidated Water District (CCWD). 2006. "Annual Water Supply Statement," p. 1. Accessed at www.townofcortlandt.com on July 15, 2006. ADAMS No. ML083390256.

Countryman, E. 2001. "From Revolution to Statehood (1776–1825)." In The Empire State: A History of New York, p. 237. Edited by Milton M. Klein. Cornell University Press, Ithaca, NY.

Dadswell, M.J., B.D. Taubert, T.S. Squiers, D. Marchette, and J. Buckley. 1984. "Synopsis of Biological Data on Shortnose Sturgeon, Acipenser brevirostrum LeSueur 1818". NOAA Technical Report NMFS-14, FAO Fisheries Synopsis No. 140, 45 pp. Accessed at http://www.nmfs.noaa.gov/pr/pdfs/species/shortnosesturgeon_biological_data.pdf on December 11, 2007.

Daniels, R.A., K.E. Limburg, R.E. Schmidt, D.L. Strayer, and R.C. Chambers. 2005. "Changes in Fish Assemblages in the Tidal Hudson River, New York." American Fisheries Society Symposium 45: pp. 471–503. Accessed at http://www.ecostudies.org/reprints/daniels_et_al_2005.pdf on March 13, 2008.

Deason, E.E. 1982. "Mnemiopsis leidyi (Ctenophora) in Narragansett Bay, 1975–1979: Abundance, Size, Composition, and Estimation of Grazing." Estuarine, Coastal and Shelf Science 15(2), pp. 121–134.

Department of Transportation (DOT)/Federal Aviation Administration (FAA). 2007. Final Environmental Impact Statement, New York/New Jersey/Philadelphia Metropolitan Area Airspace Redesign. July 2007.

Derrick, P.A., and V.S. Kennedy. 1997. "Prey Selection by the Hogchoker, Trinectes maculates (Pisces: Soleidae), Along Summer Salinity Gradients in Chesapeake Bay, USA." Marine Biology 129(4), pp. 699–711.

Dew, C.B., and J.H. Hecht. 1994. "Hatching, Estuarine Transport, and Distribution of Larval and Early Juvenile Atlantic Tomcod, Microgadus tomcod, in the Hudson River." Estuaries, Vol. 17, No. 2, pp. 472–488. Accessed at http://estuariesandcoasts.org/cdrom/ESTU1994_17_2_472_488.pdf on December 11, 2007. (Agencywide Documents Access and Management System (ADAMS) Accession No. ML073460164)

Dovel, W.L., J.A. Mihursky, and A.J. McErlean. 1969. "Life History Aspects of the Hogchoker, Trinectes maculatus, in the Patuxent River Estuary, Maryland." Cheasapeake Science 10(2), pp. 104–119. Accessed at http://estuariesandcoasts.org/cdrom/CPSC1969_10_2_104_119.pdf on February 18, 2008.

Dunn, J.L., and J. Alderfer (eds.). 2006. National Geographic Field Guide to the Birds of North America. Fifth Edition. National Geographic, Washington, DC.

Dunning, D.J., Q.E. Ross, M.T. Mattson, and D.G. Heimbuch. 2006a. "Distribution and Abundance of Bay Anchovy Eggs and Larvae in the Hudson River and Nearby Waterways." American Fisheries Society Symposium 51, pp. 215–226.

Dunning, D.J., J.R. Waldman, Q.E. Ross, and M.T. Mattson. 2006b. "Dispersal of Age-2+ Striped Bass Out of the Hudson River." American Fisheries Society Symposium 51, pp. 287–294.

Dutchess County Department of Planning and Development—Greenway Connections Report. 2006. Dutchess County New York. Accessed at http://www.co.dutchess.ny.us/EnvironmentLandPres/ELPgreenwayguide.htm on June 30, 2006.

Enercon Services, Inc. (Enercon). 2003. "Economic and Environmental Impacts Associated with Conversion of Indian Point Units 2 and 3 to a Closed-Loop Condenser Cooling Water Configuration."

Enercon Services, Inc. (Enercon). 2006. "Phase 1A Literature Review and Archaeological Sensitivity Assessment of the Indian Point Site, Westchester County, New York." Tulsa, OK.

Entergy Nuclear Northeast (ENN). 2007a. "Indian Point 2, Offsite Dose Calculation Manual (ODCM), Part II—Calculation Methodology." Revision 11, Table 2-9.

Entergy Nuclear Northeast (ENN). 2007b. "Indian Point Site Audit Information Needs" (Letter from Fred R. Dacimo, Indian Point Energy Center to the U.S. Nuclear Regulatory Commission). Buchanan, NY. November 14, 2007. (ADAMS Accession No. ML073330590)

Entergy Nuclear Northeast (ENN). 2007c. "Supplement to License Renewal Application (LRA) Environmental Report References." November 14, 2007. (ADAMS Accession No. ML073330590)

Entergy Nuclear Operations Inc. (Entergy). 2003a. "Indian Point Units 1 and 2—Annual Effluent and Waste Disposal Report." Docket Numbers 50-3 and 50-247, Buchanan, NY. (ADAMS Accession No. ML031220099)

Entergy Nuclear Operations Inc. (Entergy). 2003b. "Indian Point Unit 3—Annual Radioactive Effluent Release Report." Docket Number 50-286, Buchanan, NY. (ADAMS Accession No. ML031220024)

Entergy Nuclear Operations Inc. (Entergy). 2004. "Indian Point Units 1, 2, and 3—2003 Annual Effluent and Waste Disposal Report." Docket Numbers 50-3, 50-247, and 50-286, Buchanan, NY. (ADAMS Accession No. ML041250522)

Entergy Nuclear Operations Inc. (Entergy). 2005a. "Indian Point Units 1, 2, and 3—2004 Radioactive Effluent Release Report." Docket Numbers 50-3, 50-247, and 50-286, Buchanan, NY. (ADAMS Accession No. ML051180211)

Entergy Nuclear Operations, Inc. (Entergy). 2005b. "Indian Point Energy Center, Indian Point 3, Updated Final Safety Analysis Report," Revision 01.

Entergy Nuclear Operations, Inc. (Entergy). 2006a. "Indian Point 2 UFSAR," Revision 20.

Entergy Nuclear Operations Inc. (Entergy). 2006b. "Indian Point Units 1, 2, and 3—2005 Annual Radioactive Effluent Release Report." Docket Numbers 50-3, 50-247, and 50-286, Buchanan, NY. (ADAMS Accession No. ML061240373)

Entergy Nuclear Operations, Inc. (Entergy). 2006c. "Abundance and Stock Characteristics of the Atlantic Tomcod Spawning Population in the Hudson River, Winter 2003–2004." Prepared by Normandeau Associates, Inc., Document R-19900.000. December 2006. ADAMS No. ML073511572.

Entergy Nuclear Operations Inc. (Entergy). 2006d. "Indian Point, Units 1, 2 and 3—Annual Radiological Environmental Operating Report for 2005." Docket Numbers 50-3, 50-247, and 50 286, Buchanan, NY. (ADAMS Accession No. ML061290085)

Entergy Nuclear Operations, Inc. (Entergy). 2007a. "Applicant's Environmental Report, Operating License Renewal Stage." (Appendix E of "Indian Point, Units 2 & 3, License Renewal Application.") April 23, 2007. (ADAMS Accession No. ML071210530)

Entergy Nuclear Operations, Inc. (Entergy). 2007b. "Indian Point, Units 2 & 3, License Renewal Application." April 23, 2007. (ADAMS Accession No. ML071210512)

Entergy Nuclear Operations Inc. (Entergy). 2007c. "Indian Point Units 1, 2, and 3—2006 Annual Radioactive Effluent Release Report." Docket Numbers 50-3, 50-247, and 50-286, Buchanan, NY. (ADAMS Accession No. ML071230305)

Entergy Nuclear Operations Inc. (Entergy). 2007d. "Indian Point, Units 1, 2, and 3—Annual Radiological Environmental Operating Report for 2006." Docket Numbers 50-3, 50-247, and 50 286, Buchanan, NY. (ADAMS Accession No. ML071420088)

Entergy Nuclear Operations Inc. (Entergy). 2008. "Dry Cask Storage Information Sheet" (http://www.entergy-nuclear.com/content/Resource_Library/dry_cask/ Dry_Cask_Storage_info_sheet.pdf). Accessed at http://www.entergy-nuclear.com/resource_library/IPEC.aspx on June 26, 2008. ADAMS No. ML083390262.

Environmental Protection Agency (EPA). 2004. "Total Maximum Daily Loads, Listed Water Information, Cycle: 2004. Hudson River, Lower Hudson River." Accessed at http://oaspub.epa.gov/tmdl/enviro.control?p_list_id=NY-1301-0002&p_cycle=2004 on February 23, 2008.

Environmental Protection Agency (EPA). 2006a. "Green Book." Accessed at http://www.epa.gov/air/oaqps/greenbk/ancl.html on August 10, 2007. ADAMS No.ML083390099

Environmental Protection Agency (EPA). 2006b. "Safe Drinking Water Information System (SDWIS) Database." Accessed at http://oaspub.epa.gov on January 24, 2006. ADAMS No. ML083390264.

Environmental Protection Agency (EPA). 2007a. "Level III Ecoregions of the Conterminous United States." Western Ecology Division. Accessed at http://www.epa.gov/wed/pages/ecoregions/level_iii.htm on March 11, 2008. ADAMS No. ML083390482

Environmental Protection Agency (EPA). 2007b. "Nanotechnology White Paper." EPA 100/B-07/001, February 2007. Science Policy Council, Washington, D.C. Accessed at http://www.epa.gov/osa/pdfs/nanotech/epa-nanotechnology-whitepaper-0207.pdf?bcsi_scan_A3171404B2C9D30E=0&bcsi_scan_filename=epa-nanotechnology-whitepaper-0207.pdf on December 2, 2008.

Environmental Protection Agency (EPA). 2008a. "Hudson River PCB Superfund Site, Dredge Area 2 Delineation Fact Sheet, 2008." Accessed at http://www.epa.gov/hudson/factsheet_2nd_phaselow.pdf on February 4, 2008. ADAMS No. ML083360712.

Environmental Protection Agency (EPA). 2008b. "Local Drinking Water Information, Pennsylvania Drinking Water, Envirofacts Data on Pennsylvania, County Search—Allegheny and Beaver Counties—January 18, 2008." Accessed at http://oaspub.epa.gov/enviro/sdw_form_v2.create_page?state_abbr=PA in April 2008. ADAMS No. ML083390266.

Environmental Protection Agency (EPA). 2008c. "Hudson River PCBs" Web page. Accessed at http://www.epa.gov/hudson on March 5, 2008. ADAMS No. ML083390040.

Euston, E.T., S.A. Haney, K.A. Hattala, and A.W. Kahnle. 2006. "Overview of the Hudson River Recreational Fisheries, with an Emphasis on Striped Bass." American Fisheries Society Symposium 51, pp. 295–315.

Everly, A.W., and J. Boreman. 1999. "Habitat Use and Requirements of Important Fish Species Inhabiting the Hudson River Estuary." National Oceanic and Atmospheric Administration, Technical Memorandum NMFS-NE-121. Accessed at

http://www.nefsc.noaa.gov/nefsc/publications/tm/tm121/ on November 29, 2007. (ADAMS Accession No. ML073460167)

Fabrizio, M.C. 1987. "Contribution of Chesapeake Bay and Hudson River Stocks of Striped Bass to Rhode Island Coastal Waters as Estimated by Isoelectric Focusing of Eye Lens Proteins." Transactions of the American Fisheries Society 116, pp. 588–593.

Facey, D.E., and M.J. Van Den Avyle. 1986. "Species Profile: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (South Atlantic)—American Shad." U.S. Fish and Wildlife Service Biol. Rep. 82 (11.76). U.S. Army Corps of Engineers, TR EL-82-4. Accessed at http://conserveonline.org/workspaces/atlantic.diadromous.migratory.fish/alosa.sapidissima/Shad%20profile.pdf on December 18, 2007.

Fay, C.W., R.J. Neves, and G.B. Pardue. 1983. "Species Profile: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic)—Alewife/Blueback Herring." U.S. Fish and Wildlife Service Biol. Rep. 82 (11.45). U.S. Army Corps of Engineers, TR EL-82-4. Accessed at http://www.nwrc.usgs.gov/wdb/pub/species_profiles/82_11-009.pdf on November 29, 2007. (ADAMS Accession No. ML073460154)

Federal Aviation Administration (FAA). 2007. Press Release: "FAA Issues Final Decision on Airspace Redesign." September 5, 2007. Accessed at http://news.thomasnet.com/companystory/535311 on March 5, 2008. ADAMS No. ML083390269.

Findlay, S., D. Strayer, M. Bain, and W.C. Nieder. 2006. "Ecology of Hudson River Submerged Aquatic Vegetation." Final Report to the New York State Department of Environmental Conservation. Accessed at http://www.nysl.nysed.gov/scandoclinks/ocm82162378.htm on February 21, 2008.

Fish and Wildlife Service (FWS). 2001. "Bog Turtle (Clemmys muhlenbergii), Northern Population, Recovery Plan." Hadley, Massachusetts. 103 pp. Accessed at http://ecos.fws.gov/docs/recovery_plan/010515.pdf on March 4, 2008.

Fish and Wildlife Service (FWS). 2002. "Threatened and Endangered Species: Indiana Bat (Myotis sodalis)." Accessed at http://www.fws.gov/midwest/Endangered/ on March 4, 2008. ADAMS No. ML083390273.

Fish and Wildlife Service (FWS). 2004. "Plant Invaders of Mid-Atlantic Natural Areas: Aquatic Plants." U.S. Fish and Wildlife Service Bayscapes Conservation Landscaping Program. October 7, 2004. Accessed at http://www.nps.gov/plants/alien/pubs/midatlantic/trna.htm on February 23, 2008. ADAMS No. ML083390277.

Fish and Wildlife Service (FWS). 2007a. "Indiana Bat (Myotis sodalis) Draft Recovery Plan: First Revision." Fort Snelling, Minnesota. 258 pp. Accessed at http://www.fws.gov/midwest/Endangered/mammals/documents/inba_fnldrftrecpln_apr07.pdf on March 4, 2008.

Fish and Wildlife Service (FWS). 2007b. "Species Assessment and Listing Priority Assignment Form, Scientific Name: Sylvilagus transitionalis, Common Name: New England Cottontail."