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Protecting People and the Environment

NUREG-1437
Supplement 46
Volume 1

Generic Environmental Impact Statement for License Renewal of Nuclear Plants

Supplement 46

Regarding Seabrook Station

Final Report

Office of Nuclear Reactor Regulation

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ABSTRACT

This final supplemental environmental impact statement (SEIS) has been prepared in response to an application submitted by NextEra Energy Seabrook, LLC (NextEra) to renew the operating license for Seabrook Station (Seabrook) for an additional 20 years.

This final SEIS includes the analysis that evaluates the environmental impacts of the proposed action and alternatives to the proposed action. Alternatives considered include replacement power from new natural-gas-fired combined-cycle generation; new nuclear generation; a combination alternative that includes some natural-gas-fired capacity, and a wind-power component; and the no-action alternative of not renewing the license.

The NRC's preliminary recommendation is that the adverse environmental impacts of license renewal for Seabrook are not great enough to deny the option of license renewal for energy-planning decision makers. This recommendation is based on the following:

- analysis and findings in the generic environmental impact statement (GEIS);
- the Environmental Report (ER) submitted by NextEra;
- consultation with Federal, state, and local agencies;
- the NRC staff's own independent review, as documented in the 2011 draft SEIS and the 2013 supplement to the draft SEIS;
- the NRC staff's consideration of public comments received during the scoping process; and
- consideration of public comments received on the draft supplemental environmental impact statement and the 2013 supplement to the draft SEIS.

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BACKGROUND

By letter dated May 25, 2010, NextEra Energy Seabrook, LLC (NextEra) submitted an application to the U.S. Nuclear Regulatory Commission (NRC) to issue a renewed operating license for Seabrook Station (Seabrook) for an additional 20-year period.

Pursuant to Title 10, Part 51.20(b)(2) of the *Code of Federal Regulations* (10 CFR 51.20(b)(2)), the renewal of a power reactor operating license requires preparation of an environmental impact statement (EIS) or a supplement to an existing EIS. In addition, 10 CFR 51.95(c) states that the NRC shall prepare an EIS, which is a supplement to the Commission's NUREG-1437, *Generic Environmental Impact Statement (GEIS) for License Renewal of Nuclear Plants*.

The GEIS was originally published in 1996 and amended in 1999. Subsequently, on June 20, 2013, the NRC published a final rule (78 FR 37282) revising 10 CFR Part 51, "Environmental protection regulations for domestic licensing and related regulatory functions." The final rule updates the potential environmental impacts associated with the renewal of an operating license for a nuclear power reactor for an additional 20 years. The 2013 revised GEIS, which updates the 1996 GEIS, provides the technical basis for the final rule. The revised GEIS specifically supports the revised list of National Environmental Policy Act (NEPA) issues and associated environmental impact findings for license renewal contained in Table B–1 in Appendix B to Subpart A of the revised 10 CFR Part 51. The 2013 rule revised the previous rule to consolidate similar Category 1 and 2 issues; changed some Category 2 issues into Category 1 issues; and added new Category 1 and 2 issues.

The 2013 rule became effective July 22, 2013, after publication in the *Federal Register*. Compliance by license renewal applicants is not required until June 20, 2014 (i.e., license renewal applications submitted later than 1 year after publication must be compliant with the new rule). Nevertheless, under NEPA, the NRC must now consider and analyze—in its license renewal Supplemental Environmental Impact Statement (SEIS)—the potential significant impacts described by the revised rule's new Category 2 issues and, to the extent there is any new and significant information, the potential significant impacts described by the revised rule's new Category 1 issues.

Hereafter in this SEIS, general references to the GEIS, without stipulation, are inclusive of the 1996 and 1999 GEIS. Information and findings specific to the June 2013, final rule and GEIS, are clearly identified.

In addition, on September 19, 2014, the NRC published a revised rule at 10 CFR 51.23 (Continued Storage Rule) and associated Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel. The NRC staff has also separately addressed in this SEIS, under the uranium fuel cycle, the impacts from the Continued Storage Rule.

Upon acceptance of NextEra's application, the NRC staff began the environmental review process described in 10 CFR Part 51 by publishing a Notice of Intent to prepare a supplemental EIS (SEIS) and conduct scoping. In preparation of this SEIS for Seabrook, the NRC staff performed the following:

- conducted public scoping meetings on August 19, 2010, in Hampton, NH;
- conducted a site audit at the plant in October 2010;
- reviewed NextEra's environmental report (ER) and compared it to the GEIS;

- consulted with other agencies;
- conducted a review of the issues following the guidance set forth in NUREG-1555, "Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal"; and
- considered public comments received during the scoping process and on the draft SEIS and the supplement to the draft SEIS.

PROPOSED FEDERAL ACTION

NextEra initiated the proposed Federal action—issuing a renewed power reactor operating license—by submitting an application for license renewal of Seabrook, for which the existing license (NPF-86) will continue in effect until March 15, 2030, or until the issuance of renewed license. The NRC's Federal action is the decision whether to issue a renewed license authorizing operation for an additional 20 years beyond that authorized by the existing licenses.

PURPOSE AND NEED FOR THE PROPOSED FEDERAL ACTION

The purpose and need for the proposed action (issuance of a renewed license) is to provide an option that allows for baseload power generation capability beyond the term of the current nuclear power plant operating license to meet future system generating needs. Such needs may be determined by other energy-planning decision makers, such as state, utility, and, where authorized, Federal agencies (other than NRC). This definition of purpose and need reflects the NRC's recognition that, unless there are findings in the safety review required by the Atomic Energy Act or findings in the National Environmental Policy Act (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 as to whether a particular nuclear power plant should continue to operate.

If the renewed license is issued, the appropriate energy-planning decision makers, along with NextEra, will ultimately decide if the plant will continue to operate based on factors such as the need for power. If the operating license is not renewed, then the facility must be shut down on or before the expiration date of the current operating license.

ENVIRONMENTAL IMPACTS OF LICENSE RENEWAL

The SEIS evaluates the potential environmental impacts of the proposed action. The environmental impacts from the proposed action are designated as SMALL, MODERATE, or LARGE. As set forth in the GEIS, Category 1 issues are those that meet all of the following criteria:

- The environmental impacts associated with the issue are 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.
- 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.
- Mitigation of adverse impacts associated with the issue is 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.

> **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 Category 1 issues, no additional site-specific analysis is required in this SEIS unless new and significant information is identified. Chapter 4 of this report presents the process for identifying new and significant information. Site-specific issues (Category 2) are those that do not meet one or more of the criterion for Category 1 issues; therefore, an additional site-specific review for these non-generic issues is required, and the results are documented in the SEIS.

The environmental review of the Seabrook license renewal application was performed using the criteria from the 1996 and 1999 GEIS. Neither NextEra nor NRC identified information that is both new and significant related to Category 1 issues that would call into question the conclusions in the GEIS. This conclusion is supported by the NRC's review of the applicant's ER and other documentation relevant to the applicant's activities, the public scoping process and substantive comments raised, and the findings from the environmental site audit conducted by the NRC staff.

The NRC staff also reviewed information relating to the new issues identified in the 2013 GEIS, specifically, geology and soils; radionuclides released to the groundwater; effects on terrestrial resources (non-cooling system intake); exposure of terrestrial organisms to radionuclides; exposure of aquatic organisms to radionuclides; human health impacts from chemicals; physical occupational hazards; environmental justice; and cumulative impacts. These issues are documented in Chapter 4 of this SEIS.

The NRC staff has reviewed NextEra's established process for identifying and evaluating the significance of any new and significant information (including the consideration and analysis of new issues associated with the recently approved revision to 10 CFR Part 51) on the environmental impacts of license renewal of Seabrook. Neither NextEra nor NRC identified information that is both new and significant related to Category 1 issues that would call into question the conclusions in the GEIS. This conclusion is supported by NRC's review of the applicant's ER, other documentation relevant to the applicant's activities, the public scoping process and substantive comments raised, consultations with Federal and state agencies, and the findings from the environmental site audit conducted by NRC staff. Further, the NRC staff did not identify any new issues applicable to Seabrook that have a significant environmental impact. The NRC staff, therefore, relies upon the conclusions of the GEIS for all Category 1 issues applicable to Seabrook.

Table ES–1 summarizes the Category 2 issues relevant to Seabrook, as well as the NRC staff's findings related to those issues. If the NRC staff determined that there were no Category 2

issues applicable for a particular resource area, the findings of the GEIS, as documented in Appendix B to Subpart A of 10 CFR Part 51, are incorporated for that resource area.

Table ES–1. Summary of NRC Conclusions Relating to Site-Specific Impact of License Renewal

Resource Area	Relevant Category 2 Issues	Impacts
Land Use	None	SMALL
Air Quality	None	SMALL
Surface Water Resources	None	SMALL
Groundwater Resources	Radionuclides released to groundwater [a]	SMALL
Aquatic Resources	Impingement Entrainment Heat shock	SMALL to LARGE
Terrestrial Resources	Effects on terrestrial resources (non-cooling system impacts)[a]	SMALL
Protected Species and Habitats	Threatened or endangered species	SMALL to LARGE
Human Health	Electromagnetic fields—acute effects (electric shock)	SMALL
Socioeconomics	Housing impacts Public services (public utilities) Offsite land use Public services (transportation) Historic and archaeological resources	SMALL
Cumulative Impacts	Aquatic resources All other resource areas	MODERATE to LARGE SMALL

[a] These issues are new Category 2 issues identified in the 2013 GEIS and Rule (78 FR 37282). U.S. Nuclear Regulatory Commission. "Revisions to Environmental Review for Renewal of Nuclear Power Plant Operating Licenses." June 2013.

With respect to environmental justice, the NRC staff has determined that there would be no disproportionately high and adverse impacts to these populations from the continued operation of Seabrook during the license renewal period. Additionally, the NRC staff has determined that no disproportionately high and adverse human health impacts would be expected in special pathway receptor populations in the region as a result of subsistence consumption of water, local food, fish, and wildlife.

NextEra reported in its ER that it is aware of one potentially new issue related to its license renewal application—elevated concentrations of tritium were documented on the Seabrook site due to a previous leak from the cask loading area/transfer canal adjacent to the spent fuel pool. Overall groundwater monitoring suggests that offsite migration of tritium is not occurring, because NextEra detected no tritium in marsh sentinel wells. As discussed in Section 4.10 of this SEIS, the NRC staff agrees with NextEra's position that there are no significant impacts associated with tritium in the groundwater at Seabrook.

SEVERE ACCIDENT MITIGATION ALTERNATIVES

Since NextEra had not previously considered alternatives to reduce the likelihood or potential consequences of a variety of highly uncommon, but potentially serious, accidents at Seabrook, NRC regulation 10 CFR 51.53(c)(3)(ii)(L) requires that NextEra evaluate Severe Accident Mitigation Alternatives (SAMAs) in the course of the license renewal review. SAMAs are potential ways to reduce the risk or potential impacts of uncommon, but potentially severe, accidents, and may include changes to plant components, systems, procedures, and training.

The NRC staff reviewed the ER's evaluation of potential SAMAs. As stated by the applicant, the four potentially cost-beneficial SAMAs are not aging-related. The staff reviewed the identified potentially cost-beneficial SAMAs and agrees that the mitigative alternatives do not involve aging management of passive, long-lived systems, structures, or components during the period of extended operation. Therefore, they need not be implemented as part of the license renewal pursuant to 10 CFR Part 54.

ALTERNATIVES

The NRC staff considered the environmental impacts associated with alternatives to license renewal. These alternatives include other methods of power generation and not renewing the Seabrook operating license (the no-action alternative). Replacement power options considered were new natural-gas-fired combined-cycle generation; new nuclear generation; and a combination alternative that includes a some natural-gas-fired capacity and a wind-power component. The NRC staff initially considered a number of additional alternatives for analysis as alternatives to license renewal of Seabrook; these were later dismissed due to technical, resource availability, or commercial limitations that currently exist and that the NRC staff believes are likely to continue to exist when the existing Seabrook license expires. The no-action alternative by the NRC staff, and the effects it would have, were also considered.

Where possible, the NRC staff evaluated potential environmental impacts for these alternatives located both at the Seabrook site and at some other unspecified alternate location. Energy conservation and energy efficiency; solar power; wood waste; hydroelectric power; ocean wave and current energy; geothermal power; municipal solid waste; biomass; oil-fired power; fuel cells; new coal-fired generation; purchased power; and wind power were also considered. The NRC staff evaluated each alternative using the same impact areas that were used in evaluating impacts from license renewal.

RECOMMENDATION

The NRC's recommendation is that the adverse environmental impacts of license renewal for Seabrook are not great enough to deny the option of license renewal for energy-planning decision makers. This recommendation is based on the following:

- the analyses and findings in the GEIS, as published in 1996 and as revised in 1999 and 2013;
- the ER submitted by NextEra;
- the staff's consultation with Federal, state, and local agencies;
- NRC staff's independent environmental review;
- the staff's consideration of public comments received during the scoping process; and

- the staff's consideration of public comments received on the draft SEIS and the supplement to the draft SEIS.

ABBREVIATIONS AND ACRONYMS

°C	degree(s) Celsius
°F	degree(s) Fahrenheit
$\mu g/m^3$	microgram(s) per cubic meter
AADT	average annual daily traffic
ac	acre(s)
AC	alternating current
ACAA	American Coal Ash Association
ACC	averted cleanup and contamination costs
ACHP	Advisory Council on Historic Preservation
ACRS	Advisory Committee on Reactor Safeguards
ADAMS	Agencywide Documents Access and Management System
AEA	Atomic Energy Authority
AEC	Atomic Energy Commission
ALARA	as low as is reasonably achievable
ANL	Argonne National Laboratory
ANOSIM	analysis of similarities
ANOVA	analysis of variance
AOC	averted offsite property damage cost
AOE	averted offsite occupational exposure
AOSC	averted onsite costs
AOV	air-operated valve
APE	averted public exposure
AQCR	Air Quality Control Region
ARD	Air Resources Division
ASLB	Atomic Safety and Licensing Board Panel
ASME	American Society of Mechanical Engineers
ATWS	anticipated transient without scram
AWEA	The American Wind Energy Association
BACI	before-after control-impact
BAU	business as usual
BLM	Bureau of Land Management
BOEM	Bureau of Ocean Energy Management

BOEMRE	Bureau of Ocean Energy Management, Regulation and Enforcement
BTA	best technology available
Btu	British thermal unit(s)
CAA	Clean Air Act, as amended through 1990
CAES	compressed air energy storage
CAIR	Clean Air Interstate Rule
CAR	Code of Administrative Rules
CCP	coal combustion product
CCR	coal combustion residue
CCS	carbon capture and storage
CCW	component cooling water
CDF	core damage frequency
CDM	clean development mechanism
CEI	compliance evaluation inspection
C_{eq}	carbon equivalent(s)
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CET	containment event tree
CEUS	central and eastern United States
CEVA	containment enclosure ventilation area
CFR	*Code of Federal Regulations*
cfs	cubic foot/feet per second
CH_4	methane
CIV	containment isolation valve
CL	confidence limit
CLB	current licensing basis
cm	centimeter(s)
CMR	Code of Massachusetts Regulations
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent(s)
COE	cost of enhancement
COL	combined license

CPUE	catch per unit effort
CR	control rod
CRI	control rod insertion
CS	cooling system
CSC	Coastal Services Center
CSP	concentrating solar power
CV	coefficient of variation
CWA	Clean Water Act
CWS	circulating water system
dBA	decibels adjusted
DBA	design-basis accident
DBT	design-basis threat
DC	direct current
DFW	Division of Fisheries and Wildlife
DG	diesel generator
DGP	Dewatering General Permit
DNI	direct normal isolation
DOE	U.S. Department of Energy
DR	demand response
DSEIS	draft supplemental environmental impact statement
DSIRE	Database of State Incentives for Renewables and Efficiency
DSM	demand-side management
DWEC	Deepwater Wind Energy Center
EAC	Electricity Advisory Committee
ECCS	emergency core cooling system
ECGA	East Coast Greenway Alliance
EDG	emergency diesel generator
EERE	Office of Energy Efficiency and Renewable Energy
EFH	essential fish habitat
EFW	emergency feedwater
EI	exposure index
EIA	Energy Information Administration
EIS	environmental impact statement
ELF-EMF	extremely low frequency-electromagnetic field
EMF	electromagnetic field

EMP	electromagnetic pulse
EMS	emergency management system
ENHA	Essex National Heritage Area
EO	Executive Order
EOF	Emergency Operations Facility
EOP	emergency operating procedure
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act of 1986
EPR	U.S. Evolutionary Power Reactor
EPRI	Electric Power Research Institute
EPZ	emergency planning zone
ER	Environmental Report
ERC	Energy Recovery Council
ESA	Endangered Species Act
ETE	evacuation time estimate
F&O	facts and observations
FEIS	Final Environmental Impact Statement
FERC	Federal Energy Regulatory Commission
FIVE	fire-induced vulnerability evaluation
FLM	Federal Land Manager
FOTC/NEC	Friends of the Coast/New England Coalition
FPL	Florida Power and Light
FPL-NED	Florida Power and Light-New England Division
FPLE	Florida Power and Light Energy Seabrook, LLC
fps	foot/feet per second
FR	*Federal Register*
FSEIS	Final Supplemental Environmental Impact Statement
ft	foot/feet
ft^2	square foot/feet
ft^3	cubic foot/feet
FWS	U.S. Fish and Wildlife Service
g	gram(s)
g/m^2	gram(s) per square meter
gal	gallon(s)
GEA	Geothermal Energy Association

GEIS	generic environmental impact statement
GHG	greenhouse gas
GL	Generic Letter
gpd	gallon(s) per day
gpm	gallon(s) per minute
GWh	gigawatt hour(s)
GWP	global warming potential
ha	hectare(s)
HAP	hazardous air pollutant
HCLPF	high confidence low probability of failure
HELB	high-energy line break
HEP	human error probability
HFO	high winds, tornadoes, external floods, and other
HPI	high-pressure injection
hr	hour
HRA	human reliability analysis
HUD	Housing and Urban Development
HVAC	heating, ventilation, and air conditioning
IAEA	International Atomic Energy Agency
IES	Institute of Educational Services
IGCC	integrated gasification combined cycle
ILRT	integrated leak rate test
in.	inch(es)
INEEL	Idaho National Engineering and Environmental Laboratory
IPCC	Intergovernmental Panel on Climate Change
IPE	individual plant examination
IPEEE	individual plant examination of external events
ISEPA	Iowa Stored Energy Plant Agency
ISFSI	independent spent fuel storage installation
ISLOCA	interfacing system loss-of-coolant accident
ISO	independent system operator
ISO-NE	New England's Independent System Operator
kg	kilogram(s)
KLD	KLD Associates
km	kilometer(s)

km^2	square kilometer(s)
kV	kilovolt(s)
kWh	kilowatt-hour(s)
L	liter(s)
lb	pound(s)
Ldn	day-night sound intensity level
LERF	large early release frequency
LHSI	low-head safety injection
LLNL	Lawrence Livermore National Laboratory
LOCA	loss-of-coolant accident
LOOP	loss of offsite power
LOS	level(s) of service
LOSP	loss of system pressure
LRA	license renewal application
m	meter(s)
m/s	meter(s) per second
m^2	square meter(s)
m^3	cubic meter(s)
mA	milliampere(s)
MAAP	Modular Accident Analysis Program
MACCS2	MELCOR Accident Consequence Code System 2
MACR	maximum averted cost risk
MD	motor-driven
MDFG	Massachusetts Department of Fish and Game
MDFW	Massachusetts Division of Fisheries and Wildlife
MDS	multi-dimensional scaling
MELCOR	Methods for Estimation of Leakages and Consequences of Releases
MFGD	Massachusetts Fish and Game Department
MFW	main feedwater
mgd	million gallons per day
mg/m^3	milligram(s) per cubic meter
mGy	million gallons per year
MHC	Massachusetts Historical Commission
mi	mile(s)

mi^2	square mile(s)
mm	millimeter(s)
MMI	modified Mercalli intensity
MMPA	Marine Mammal Protection Act
MMS	minerals management services
MMT	million metric tons
MOV	motor-operated valve
MPCS	main plant computer system
mph	mile(s) per hour
mrad	milliradian(s)
mrem	millirem
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSL	mean sea level
MSSV	main steam safety valve
mSv	millisievert
MSW	municipal solid waste
MT	metric ton(s)
MTBE	methyl tert-butyl ether
MTHM	metric tonne(s) of heavy metal
MW	megawatt(s)
MWd/MTU	megawatt-day(s) per metric ton uranium
MWe	megawatt(s)-electric
MWh	megawatt-hour(s)
MWt	megawatt(s)-thermal
N_2O	nitrous oxide
NAAQS	national ambient air quality standards
NAESC	North Atlantic Energy Service Corporation
NAI	Normandeau Associates, Inc.
NARAC	National Atmospheric Release Advisory Center
NAS	National Academy of Sciences
NCDC	National Climatic Data Center
NCES	National Center for Education Statistics
NECIA	Northeast Climate Impacts Assessment
NEI	Nuclear Energy Institute
NEPA	National Environmental Policy Act

NERC	North American Electric Reliability Corporation
NESC	National Electrical Safety Code
NESN	New England Seismic Network
NETL	National Energy Technology Laboratory
NextEra	NextEra Energy Seabrook, LLC
NF_3	nitrogen trifluoride
NGCC	natural gas-fired combined cycle
NHDES	New Hampshire Department of Environmental Services
NHDHR	New Hampshire Division of Historical Resources
NHDOJ	New Hampshire Department of Justice
NHDOT	New Hampshire Department of Transportation
NHDRED	New Hampshire Department of Resources and Economic Development
NHELMIB	New Hampshire Economic and Labor Market Information Bureau
NHFGD	New Hampshire Fish and Game Department
NHNHB	New Hampshire Natural Heritage Bureau
NHOEP	New Hampshire Office of Energy and Planning
NHPA	National Historic Preservation Act of 1966, as amended
NHSCO	New Hampshire State Climate Office
NHY	New Hampshire Yankee
NIEHS	National Institute of Environmental Health Sciences
NIMS	National Incident Management System
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NO_x	nitrogen oxide(s)
NO_2	nitrogen dioxide
NPCC	Northwest Power and Conservation Council
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRC	Nuclear Regulatory Commission
NRCS	Natural Resources Conservation Service
NREL	National Renewal Energy Laboratory
NRF	National Recovery Framework
NRHP	National Register of Historic Places
NRR	Office of Nuclear Reactor Regulation

NSR	new source review
NTTF	Near Term Task Force
NU	Northeast Utilities Service Company
NUREG	NRC technical report designation (Nuclear Regulatory Commission)
NWCC	National Wind Coordinating Committee
NWF	National Wildlife Federation
NYDEC	New York Department of Environmental Conservation
O_3	ozone
OCS	outer continental shelf
ODCM	offsite dose calculation manual
OPSB	Ohio Power Siting Board
PAB	primary auxiliary building
PAH	polycyclic aromatic hydrocarbon
Pb	lead
PCC	primary component cooling
PCCW	primary component cooling water
pCi/L	picocurie(s) per liter
PDS	plant damage state
PGA	peak ground acceleration
PM	particulate matter
PM_{10}	particulates with diameters less than 10 microns
$PM_{2.5}$	particulates with diameters less than 2.5 microns
PNNL	Pacific Northwest National Laboratory
PORV	power-operated relief valve
POST	Parliamentary Office of Science and Technology
ppb	part(s) per billion
PPD	Presidential Policy Directive
ppm	part(s) per million
ppt	part(s) per thousand
PRA	probabilistic risk assessment
PSD	prevention of significant deterioration
psia	per square inch absolute
PSNH	Public Service Company of New Hampshire

PV	photovoltaic
PWR	pressurized water reactor
RAI	request for additional information
RC	release category
RCP	reactor coolant pump
RCRA	Resource Conservation and Recovery Act of 1976, as amended
RCS	reactor coolant system
REMP	Radiological Environmental Monitoring Program
RGGI	Regional Greenhouse Gas Initiative
RHR	residual heat removal
ROI	region of influence
ROP	Reactor Oversight Process
ROW	right of way
RPC	replacement power costs
RPS	renewable portfolio standards
RRW	risk reduction worth
RSA	revised statutes annotated
RSCS	Radiation Safety and Control Services, Inc.
RSP	remote shutdown panel
RWST	reactor water storage tank
SAAQS	State Ambient Air Quality Standards
SAMA	severe accident mitigation alternative
SAMG	severe accident mitigation guideline
SAPL	Seacoast Anti-Pollution League
SAR	Safety Analysis Report
SBO	station blackout
SBOMS	Station Blackout Mitigation Strategies
SCR	selective catalytic reduction
SDWIS	Safe Drinking Water Information System
Seabrook	Seabrook Station
SEIS	supplemental environmental impact statement
SEPS	supplemental electrical power system
SER	safety evaluation report
SF_6	sulfur hexafluoride
SFP	spent fuel pool

SG	steam generator
SGTR	steam generator tube rupture
SHPO	State Historic Preservation Officer
SI	safety injection
SLOCA	small break LOCA
SNL	Sandia National Laboratory
SO_2	sulfur dioxide
SO_x	sulfur oxide(s)
SQG	small quantity generator
SR	State Route
SRP	standard review plan
STG	steam turbine generator
SUFP	start up feed pump
Sv	sievert
SW	service water
SWGR	switchgear
SWPPP	Stormwater Pollution Prevention Plan
SWS	service water system
TAC	Technical Assignment Control
TDAFW	turbine-driven auxiliary feedwater
TDEFW	turbine-driven emergency feedwater
TE	temperature element
TIBL	thermal internal boundary layer
TMDL	Total Maximum Daily Load
TRO	total residual oxidant
U.S.C.	United States Code
UCS	Union of Concerned Scientists
UFSAR	updated final safety analysis report
US	U.S. Route
USACE	U.S. Army Corps of Engineers
USCB	U.S. Census Bureau
USDA	U.S. Department of Agriculture
USDE	U.S. Department of Education
USDOD	U.S. Department of Defense

USGCRP	U.S. Global Change Research Program
USGS	U.S. Geological Survey
VOC	volatile organic compound
W/m^2	watts per square meter
WCR	Waste Confidence rule
WEC	wave energy conversion
WOE	weight-of-evidence
WOG	Westinghouse Owner's Group
WPCP	water pollution control plant
WTS	water treatment system
YOY	young-of-the-year
yr	year

1.0 PURPOSE AND NEED FOR ACTION

Under the U.S. Nuclear Regulatory Commission's (NRC's) environmental protection regulations in Title 10, Part 51, of the *Code of Federal Regulations* (10 CFR Part 51), "Environmental protection regulations for domestic licensing and related regulatory functions," which implement the National Environmental Policy Act (NEPA) (42 U.S.C. 4321 et seq.), renewal of a nuclear power plant operating license requires the preparation of an environmental impact statement.

The Atomic Energy Act of 1954 (42 U.S.C. 2011 et seq.) originally specified that licenses for commercial power reactors be granted for up to 40 years with an option to renew. The 40-year licensing period was based on economic and antitrust considerations rather than on technical limitations of the nuclear facility.

The decision to seek a license renewal rests entirely with nuclear power facility owners and, typically, is based on the facility's economic viability and the investment necessary to continue to meet NRC safety and environmental requirements. The NRC makes the decision to grant or deny license renewal based on whether the applicant has demonstrated that the environmental and safety requirements in the agency's regulations can be met during the period of extended operation.

1.1 Proposed Federal Action

NextEra Energy Seabrook, LLC (NextEra) initiated the proposed Federal action by submitting an application for license renewal for Seabrook Station (Seabrook), for which the existing license, NPF-86, expires on March 15, 2030. The NRC's Federal action is the decision whether to renew the license for an additional 20 years.

1.2 Purpose and Need for the Proposed Federal Action

The purpose and need for the proposed action (issuance of a renewed license) is to provide an option that allows for baseload power generation capability beyond the term of the current nuclear power plant operating license to meet future system generating needs. Such needs may be determined by other energy-planning decision makers, such as State, utility, and, where authorized, Federal agencies (other than NRC). This definition of purpose and need reflects the NRC's recognition that, unless there are findings in the safety review required by the Atomic Energy Act or findings in the NEPA environmental analysis that would lead the NRC to reject a license renewal application (LRA), the NRC does not have a role in the energy-planning decisions of whether a particular nuclear power plant should continue to operate.

If the renewed license is issued, the appropriate energy-planning decision makers, along with NextEra, will ultimately decide if the plant will continue to operate based on factors such as the need for power. If the operating license is not renewed, then the facility must be shut down on or before the expiration date of the current operating license, March 15, 2030.

1.3 Major Environmental Review Milestones

NextEra submitted an Environmental Report (ER) (NextEra 2010a) as part of its LRA (NextEra 2010) in May 2010. After reviewing the application and the ER for sufficiency, the NRC staff published a Notice of Acceptance and Opportunity for Hearing in the *Federal Register* (75 FR 42462) on July 21, 2010. The NRC published another notice in the *Federal Register*,

also on July 21, 2010, on its intent to conduct scoping, thereby beginning the 60-day scoping period.

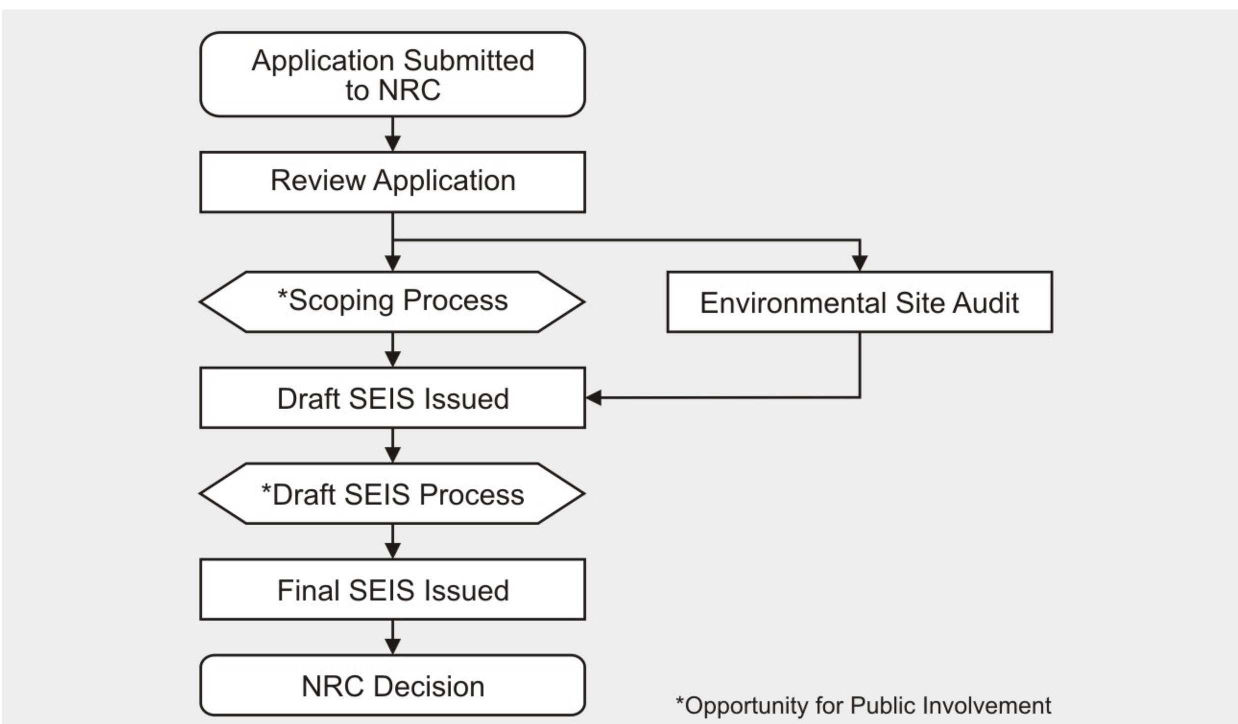
The agency held two public scoping meetings on August 19, 2010, in Hampton, NH. The NRC report entitled, "Environmental Impact Statement Scoping Process Summary Report for Seabrook Station," dated March 2011, presents the comments received during the scoping process (NRC 2011). Appendix A to this Supplemental Environmental Impact Statement (SEIS) presents the comments considered to be within the scope of the environmental license renewal review and the associated NRC responses.

To independently verify information provided in the ER, the NRC staff conducted a site audit at Seabrook in October 2010. During the site audit, NRC staff met with plant personnel; reviewed specific documentation; toured the facility; and met with interested Federal, State, and local agencies. The NRC report entitled, "Summary of Site Audit Related to the Review of the License Renewal Application for Seabrook Station, Unit 1 (Technical Assignment Control (TAC) No. ME3959)," dated November 10, 2010, summarizes the site audit and the attendees (NRC 2011b).

Figure 1–1 shows the major milestones in the review of the SEIS. Upon completion of the scoping period and site audit, the NRC staff compiled its finding in a draft SEIS. This document was made available for public comment for 75 days. During this time, the NRC staff hosted public meetings and collected public comments. Based on the information gathered, the NRC staff amended the draft SEIS findings as necessary and then published this final SEIS.

Figure 1–1. Environmental Review Process

The process provides opportunities for public involvement.



Subsequent to the issuance of the draft SEIS in 2011, NextEra notified the NRC of significant changes that were made to the severe accident mitigation alternatives (SAMA) analysis related

to the Seabrook LRA (NextEra 2012). Specifically, NextEra identified many changes to its SAMA analysis, based on various plant and probabilistic risk assessment (PRA) model changes, that were sufficiently different from what was published in the NRC staff's August 2011 draft SEIS to warrant the issuance of this supplement. In response, the NRC staff prepared a supplement to the draft SEIS in accordance with 10 CFR 51.72(a)(2) and (b), which addressed preparation of a supplement to an environmental impact statement for proposed actions that have not been taken, under the following conditions:

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

This final SEIS incorporates the draft SEIS, the comments submitted on the draft SEIS, the supplement to the draft SEIS, and the comments submitted on the supplement.

The NRC has established a license renewal process that can be completed in a reasonable period of time with clear requirements to assure safe plant operation for up to an additional 20 years of plant life. The safety review is conducted simultaneously with the environmental review. The NRC staff documents the findings of the safety review in a safety evaluation report (SER). The NRC considers the findings in both the SEIS and the SER in its decision to either grant or deny the issuance of a renewed license.

1.4 Generic Environmental Impact Statement

The NRC performed a generic assessment of the environmental impacts associated with license renewal to improve the efficiency of the license renewal process. The *Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants* (GEIS), NUREG-1437, documents the results of the NRC staff's systematic approach to evaluate the environmental consequences of renewing the licenses of individual nuclear power plants and operating them for an additional 20 years (NRC 1996, 1999). NRC staff analyzed in detail and resolved those environmental issues that could be resolved generically in the GEIS. The GEIS was originally issued in 1996, an Addendum 1 to the GEIS was issued in 1999, and a revision to the GEIS was issued in 2013.

On June 20, 2013, the NRC published a final rule (78 FR 37282) revising 10 CFR Part 51, "Environmental protection regulations for domestic licensing and related regulatory functions." The final rule updates the potential environmental impacts associated with the renewal of an operating license for a nuclear power reactor for an additional 20 years. The 2013 revised GEIS, which updates the 1996 GEIS, provides the technical basis for the final rule. The revised GEIS specifically supports the revised list of National Environmental Policy Act (NEPA) issues and associated environmental impact findings for license renewal contained in Table B–1 in Appendix B to Subpart A of the revised 10 CFR Part 51. The 2013 rule revised the previous rule to consolidate similar Category 1 and 2 issues; changed some Category 2 issues into Category 1 issues; and added new Category 1 and 2 issues.

The 2013 rule became effective July 22, 2013, after publication in the *Federal Register*. Compliance by license renewal applicants is not required until June 20, 2014 (i.e., license renewal applications submitted later than 1 year after publication must be compliant with the new rule). Nevertheless, under NEPA, the NRC must now consider and analyze—in its license renewal Supplemental Environmental Impact Statement (SEIS)—the potential significant impacts described by the revised rule's new Category 2 issues and, to the extent there is any

new and significant information, the potential significant impacts described by the revised rule's new Category 1 issues.

Hereafter in this SEIS, general references to the GEIS, without stipulation, are inclusive of the 1996 and 1999 GEIS. Information and findings specific to the June 2013, final rule and GEIS, are clearly identified.

The GEIS establishes separate environmental impact issues for the NRC staff to independently verify. Of these issues, the NRC staff determined that some generic issues are generic to all plants (Category 1). Other issues do not lend themselves to generic consideration (Category 2 or uncategorized). The staff evaluated these issues on a site-specific basis in the SEIS. Appendix B to Subpart A of 10 CFR 51 provides a summary of the staff findings in the GEIS.

In addition, on August 26, 2014, the Commission approved a revised rule at 10 CFR 51.23 (Continued Storage Rule) and associated Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel (NUREG-2157, NRC 2014). Subsequently, on September 19, 2014, the NRC published the revised rule (79 FR 56238) in the *Federal Register* along with NUREG-2157 (79 FR 56263). The NRC staff has addressed the impacts from the Continued Storage Rule in Chapter 6.1, The Uranium Fuel Cycle, of this SEIS.

For each potential environmental issue, the GEIS does the following:

- describes the activity that affects the environment,
- identifies the population or resource that is affected,
- assesses the nature and magnitude of the impact on the affected population or resource,
- characterizes the significance of the effect for both beneficial and adverse effects,
- determines if the results of the analysis apply to all plants, and
- considers if 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) terminology for "significant." The NRC established three levels of significance for potential impacts—SMALL, MODERATE, and LARGE—as defined below.

> **Significance** indicates the importance of likely environmental impacts and is determined by considering two variables: **context** and **intensity**.
>
> **Context** is the geographic, biophysical, and social context in which the effects will occur.
>
> **Intensity** refers to the severity of the impact, in whatever context it occurs.

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.

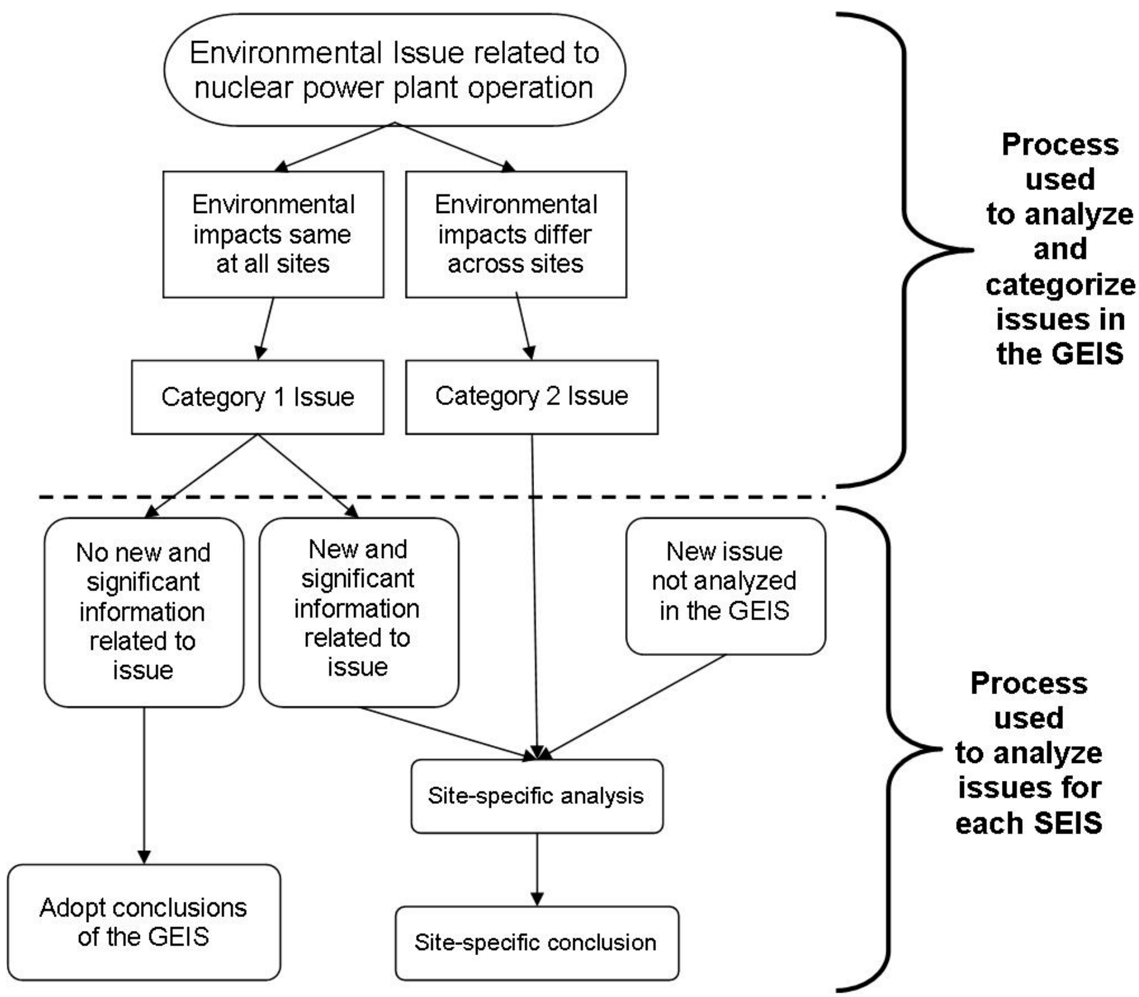
LARGE—Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

The GEIS 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 (Figure 1–2). Issues are assigned a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1 issues are those that meet the following criteria:

- 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.
- A single significance level (i.e., SMALL, MODERATE, or LARGE) has been assigned to the impacts (except for collective off-site radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal).
- 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.

Figure 1–2. Environmental Issues Evaluated During License Renewal

In the GEIS, 92 issues were evaluated.
A site-specific analysis is required for 23 of those 92 issues.



For generic issues (Category 1), no additional site-specific analysis is required in the SEIS unless new and significant information is identified. Chapter 4 of this report presents the process for identifying new and significant information. Site-specific issues (Category 2) are those that do not meet one or more of the criteria of Category 1 issues; therefore, additional

site-specific review for these issues in required. The SEIS presents the results of those site-specific reviews.

On June 20, 2013, the NRC published a final rule (NRC 2013a) revising its environmental protection regulation, 10 CFR Part 51, "Environmental protection regulations for domestic licensing and related regulatory functions."

Specifically, the final rule updates the potential environmental impacts associated with the renewal of an operating license for a nuclear power reactor for an additional 20 years. A revised GEIS (NRC 2013b), which updates the 1996 GEIS, provides the technical basis for the final rule. The revised GEIS specifically supports the revised list of NEPA issues and associated environmental impact findings for license renewal contained in Table B-1 in Appendix B to Subpart A of the revised 10 CFR Part 51. The revised GEIS and final rule reflect lessons learned and knowledge gained during previous license renewal environmental reviews. In addition, public comments received on the draft revised GEIS and rule and during previous license renewal environmental reviews were re-examined to validate existing environmental issues and identify new ones.

The final rule identifies 78 environmental impact issues, of which 17 will require plant-specific analysis. The final rule consolidates similar Category 1 and 2 issues, changes some Category 2 issues into Category 1 issues, and consolidates some of those issues with existing Category 1 issues. The final rule also adds new Category 1 and 2 issues. The new Category 1 issues include geology and soils, exposure of terrestrial organisms to radionuclides, exposure of aquatic organisms to radionuclides, human health impact from chemicals, and physical occupational hazards. Radionuclides released to groundwater, effects on terrestrial resources (non-cooling system impacts), minority and low-income populations (i.e., environmental justice), and cumulative impacts were added as new Category 2 issues.

The final rule became effective 30 days after publication in the *Federal Register*. Compliance by license renewal applicants is not required until 1 year from the date of publication (i.e., license renewal ERs submitted later than 1 year after publication must be compliant with the new rule). Nevertheless, under NEPA, the NRC must now consider and analyze, in its license renewal SEISs, the potential significant impacts described by the final rule's new Category 2 issues and, to the extent there is any new and significant information, the potential significant impacts described by the final rule's new Category 1 issues.

1.5 Supplemental Environmental Impact Statement

This SEIS presents an analysis that considers the environmental effects of the continued operation of Seabrook, alternatives to license renewal, and mitigation measures for minimizing adverse environmental impacts. Chapter 8 contains analysis and comparison of the potential environmental impacts from alternatives, and Chapter 9 presents the recommendation to the Commission as to whether or not the environmental impacts of license renewal are so great to deny the option of license renewal for energy-planning decision makers.

In the preparation of this SEIS for Seabrook, the NRC staff conducted the following activities:

- reviewed the information provided in the NextEra ER;
- consulted with other Federal, State, and local agencies;
- conducted an independent review of the issues during the site audit; and
- considered the public comments received during the scoping process.

New information can be identified from many sources, including the applicant, the NRC, other agencies, or public comments. If a new issue is revealed, it is first analyzed to determine if it is within the scope of the license renewal evaluation. If it is not addressed in the GEIS, the NRC staff determines its significance and documents its analysis in the SEIS.

> **New and significant information** either identifies a significant environmental issue that was not covered in the GEIS or was not considered in the analysis in the GEIS and leads to an impact finding that is different from the finding presented in the GEIS.

NextEra submitted its Environmental Report (ER) under NRC's 1996 rule governing license renewal environmental reviews (61 FR 28467, June 5, 1996, as amended), as codified in NRC's environmental protection regulation, 10 CFR Part 51. The 1996 GEIS (NRC 1996) and Addendum 1 to the GEIS (NRC 1999) provided the technical basis for the list of NEPA issues and associated environmental impact findings for license renewal contained in Table B-1 in Appendix B to Subpart A of 10 CFR Part 51. For Seabrook, the NRC staff initiated its environmental review in accordance with the 1996 rule and GEIS (NRC 1996, 1999) and documented its findings in Chapter 4 of this SEIS.

As described in Section 1.4, the NRC published a final rule (78 FR 37282, June 20, 2013) revising 10 CFR Part 51, including the list of NEPA issues and findings in Table B-1 of 10 CFR Part 51. Under NEPA, the NRC must now consider and analyze in this SEIS the potential significant impacts described by the final rule's new Category 2 issues and, to the extent there is any new and significant information, the potential significant impacts described by the final rule's new Category 1 issues. The new Category 1 issues include geology and soils, exposure of terrestrial organisms to radionuclides, exposure of aquatic organisms to radionuclides, human health impact from chemicals, and physical occupational hazards. Radionuclides released to groundwater, effects on terrestrial resources (non-cooling system impacts), minority and low-income populations (i.e., environmental justice), and cumulative impacts were added as new Category 2 issues. These new issues are also analyzed in Chapter 4 of this SEIS. Hereafter in this SEIS, general references to the "GEIS," without stipulation, are inclusive of the 1996 and 1999 GEIS (NRC 1996, 1999). Information and findings specific to the June 2013 final rule (78 FR 37282) (NRC 2013a) or the June 2013 GEIS (NRC 2013b) or both are appropriately referenced as such.

1.6 Cooperating Agencies

During the scoping process, no Federal, State, or local agencies were identified as cooperating agencies in the preparation of this SEIS.

1.7 Consultations

The Endangered Species Act of 1973, as amended; the Magnuson-Stevens Fisheries Conservation and Management Act of 1996, as amended; and the National Historic Preservation Act of 1966 require that Federal agencies consult with applicable State and Federal agencies and groups before taking action that may affect endangered species, fisheries, or historic and archaeological resources, respectively. Below are the agencies and groups with whom the NRC consulted; Appendix D to this report includes copies of consultation documents.

- Advisory Council on Historic Preservation (ACHP);
- Massachusetts Historical Commission;

- National Marine Fisheries Service (NMFS), Northeast Regional Office, Gloucester, MA;
- New Hampshire Department of Environmental Services (NHDES);
- New Hampshire Division of Historical Resources (NHDHR);
- New Hampshire Natural Heritage Bureau (NHNHB);
- New Hampshire Fish & Game Department (NHFGD); and
- U.S. Fish and Wildlife Service (FWS), Northeast Regional Office, Hadley, MA.

1.8 Correspondence

During the course of the environmental review, the NRC staff contacted the following Federal, State, regional, local, and tribal agencies. Appendix E to this report contains a chronological list of all documents sent and received during the environmental review.

- Abenaki Nation of Missisquoi;
- Abenaki Nation of New Hampshire;
- ACHP;
- Bureau of Indian Affairs, Eastern Regional Office, Nashville, TN;
- Cowasuck Band of Pennacook-Abenaki People;
- Massachusetts Division of Fisheries and Wildlife;
- Massachusetts Historical Commission;
- NMFS, Northeast Regional Office, Gloucester, MA;
- NHDES;
- NHDHR;
- New Hampshire Natural Heritage Bureau;
- FWS, Northeast Regional Office, Hadley, MA; and
- Wampanoag Tribe of Gay Head-Aquinnah.

A list of persons who received a copy of the draft SEIS and the supplement to the draft SEIS is provided in Chapter 11.

1.9 Status of Compliance

NextEra is responsible for complying with all NRC regulations and other applicable Federal, State, and local requirements. Appendix H to the GEIS describes some of the major Federal statutes. Table 1–1 lists the permits and licenses issued by Federal, State, and local authorities for activities at Seabrook.

Table 1–1. Licenses and Permits

Existing environmental authorizations for Seabrook operations.

Permit	Number	Dates	Responsible Agency
Operating License	NPF-86	Issued: 3/15/1990 Expires: 3/15/2030	NRC
National Pollutant Discharge Elimination System (NPDES) Permit	NH0020338	Issued: 4/1/2002 Expired: 4/1/2007 Renewal application submitted: 9/25/2006	EPA, in timely renewal
NPDES Storm Water Multi-Sector General Permit for Industrial Activities	Notice of Intent Number NHR05A729	Issued: 9/29/2008 Expires: 9/29/2013	EPA
Hazardous Materials Certificate of Registration	061112 008 003UW	Issued: 6/12/2012 Expires: 6/30/2015	U.S. Department of Transportation
Permit to Discharge	SEA1003	Issued: 5/30/2014 Expires: 5/29/2014	Town of Seabrook
Title V General Permit	GSP-EG-0398	Issued: 1/31/2014 Expires: 4/30/2015	NHDES, Air Resources Division
Title V Operating Permit	TV-0017	Issued: 7/25/2013 Expires: 7/31/2018	NHDES, Air Resources Division
Hazardous Waste Limited Permit	DES-HW-LP-2014-06	Issued: 5/8/2014 Expires: 5/8/2019	NHDES, Waste Management Division
Aboveground Storage Tank Registration	Facility ID#930908A	Issued: 12/24/2007 Expires: N/A	NHDES, Waste Management Division
Permit to Display Finfish and Invertebrates	MFD 1402	Issued: 1/1/2014 Expires: 12/31/2015	NHFGD
Registration to Transport Radioactive Material	FP-S-113014	Issued: 10/22/2012 Expires: 11/30/2014	Virginia Department of Emergency Management
License to Deliver Radioactive Material	T-NH001-L14	Issued: 1/14/2014 Expires: 12/31/2014	Tennessee Department of Environment & Conservation
Permit to Deliver Radioactive Material	0111000045	Issued: 3/38/2014 Expires: 4/30/2015	Utah Department of Environmental Quality

1.10 References

NextEra Energy Seabrook, LLC (NextEra), 2010, “License Renewal Application, Seabrook Station,” May 25, 2010, Agencywide Documents Access and Management System (ADAMS) Accession No. ML101590099.

NextEra, 2010a, “License Renewal Application, Seabrook Station,” Appendix E, “Applicant’s Environmental Report, Operating License Renewal Stage,” May 25, 2010, ADAMS Accession Nos. ML101590092 and ML101590089.

NextEra, 2011, Letter from P. Freeman, Site Vice President, NextEra, to NRC Document Control Desk, “Subject: Seabrook Station Environmental Permit Renewals,” February 18, 2011, ADAMS Accession No. ML110550161.

NextEra, 2012, Letter from Paul O. Freeman, NextEra, to U.S. NRC Document Control Desk. Subject: "Seabrook Station, Supplement 2 to Severe Accident Mitigation Alternatives Analysis, NextEra Energy Seabrook License Renewal Application," Seabrook, NH, March 19, 2012, ADAMS Accession No. ML12080A137.

U.S. Nuclear Regulatory Commission (NRC), 1996, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, NUREG-1437, Volumes 1 and 2, May 31, 1996, ADAMS Accession Nos. ML040690705 and ML040690738.

NRC, 1999, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, NUREG-1437, Volume 1, Addendum 1, Section 6.3, "Transportation," Table 9.1, "Summary of Findings on NEPA Issues for License Renewal of Nuclear Power Plants, Final Report," August 31, 1999, ADAMS Accession No. ML040690720.

NRC, 2010a, "NextEra Energy Seabrook; Notice of Intent to Prepare an Environmental Impact Statement and Conduct the Scoping Process for Seabrook Station, Unit 1," *Federal Register*, Vol. 75, No. 138, pp. 42168–42170, July 20, 2010.

NRC, 2010b, "Summary of the Site Audit Related to the Review of the License Renewal Application for Seabrook Station, Unit 1, (TAC No. ME 3959)," November 10, 2010, ADAMS Accession No. ML 102950271.

NRC, 2011, "Issuance of Environmental Scoping Summary Report Associated with the Staff's Review of the Application by NextEra Energy Seabrook, LLC for Renewal of the Operating License for Seabrook Station (TAC Number ME3959)," March 1, 2011, ADAMS Accession No. ML110100113.

NRC, 2013a, "Revisions to Environmental Review for Renewal of Nuclear Power Plant Operating Licenses," *Federal Register*, Vol. 78, No. 119, pp. 37282-37324, June 20, 2013.

NRC, 2013b, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, Washington, DC: Office of Nuclear Reactor Regulation, NUREG-1437, Revision 1, Volumes 1, 2, and 3, June 2013, ADAMS Accession Nos. ML13106A241, ML13106A242, and ML13106A244.

2.0 AFFECTED ENVIRONMENT

Seabrook Station (Seabrook) is located in the Town of Seabrook, Rockingham County, NH, 2 miles (mi) (3.2 kilometers (km)) west of the Atlantic Ocean. Seabrook is approximately 2 mi (3.2 km) north of the Massachusetts state line, 15 mi (24 km) south of the Maine state line, and 10 mi (16 km) south of Portsmouth, NH. There are two metropolitan areas within 50 mi (80 km) of the site: Manchester, NH (31 mi (50 km) west-northwest) and Boston, MA (41 mi (66 km) south-southwest). Figure 2–1 and Figure 2–2 present the 6-mi (10-km) and 50-mi (80-km) vicinity maps, respectively.

Because existing conditions are partially the result of past construction and operation at the plant, the impacts of these past and ongoing actions, and how they have shaped the environment, are presented in this chapter. Section 2.1 describes the facility and its operation; Section 2.2 discusses the affected environment; and Section 2.3 describes related Federal and State activities near the site.

2.1 Facility Description

The Seabrook site spans 889 acres (ac) (360 hectare (ha)) on a peninsula bordered by Browns River, Hunts Island Creek, and estuarine marshlands. Seabrook is divided into two lots. Lot 1 is owned by the joint owners of Seabrook and encompasses approximately 109 ac (44 ha). This is where most of the operating facility is located and is mostly developed. Site structures include the Unit 1 containment building, primary auxiliary building (PAB), fuel storage building, waste processing building, control and diesel generator building, turbine building, administration and service building, ocean intake and discharge structures, circulating water pump house, and service water pump house (NextEra 2010a). The original construction plans called for two identical units at Seabrook; however, construction on Unit 2 was halted prior to completion. The remaining Unit 2 buildings are now used primarily for storage.

Lot 2 is owned by NextEra Energy Seabrook, LLC (NextEra) and is approximately 780 ac (316 ha) and is also the exclusion area. Lot 2 is mainly an open tidal marsh area with fabricated linear drainage ditches and tidal creeks. This area is made available for wildlife resources (NextEra 2010a). Figure 2–3 provides a general layout of Seabrook.

2.1.1 Reactor and Containment Systems

Seabrook Unit 1 is a nuclear-powered steam electric generating facility that began commercial operation on August 19, 1990. Though NextEra initially planned for two units at Seabrook, NextEra cancelled construction of Unit 2 in 1984. NextEra has no plans to complete Unit 2 in the future. Seabrook Unit 1 is powered by a Westinghouse pressurized water reactor (PWR). Westinghouse Electric Company supplied the nuclear steam supply system, and General Electric Company supplied the turbine generator. The nuclear steam supply system at Seabrook is a four-loop PWR. The reactor core heats up water, which is then pumped to four U-tube heat exchangers—known as steam generators (SGs)—where the heat boils the water on the shell-side into steam. After drying, the steam travels to the turbines. The steam yields its energy to turn the turbines, which connect to the electrical generator.

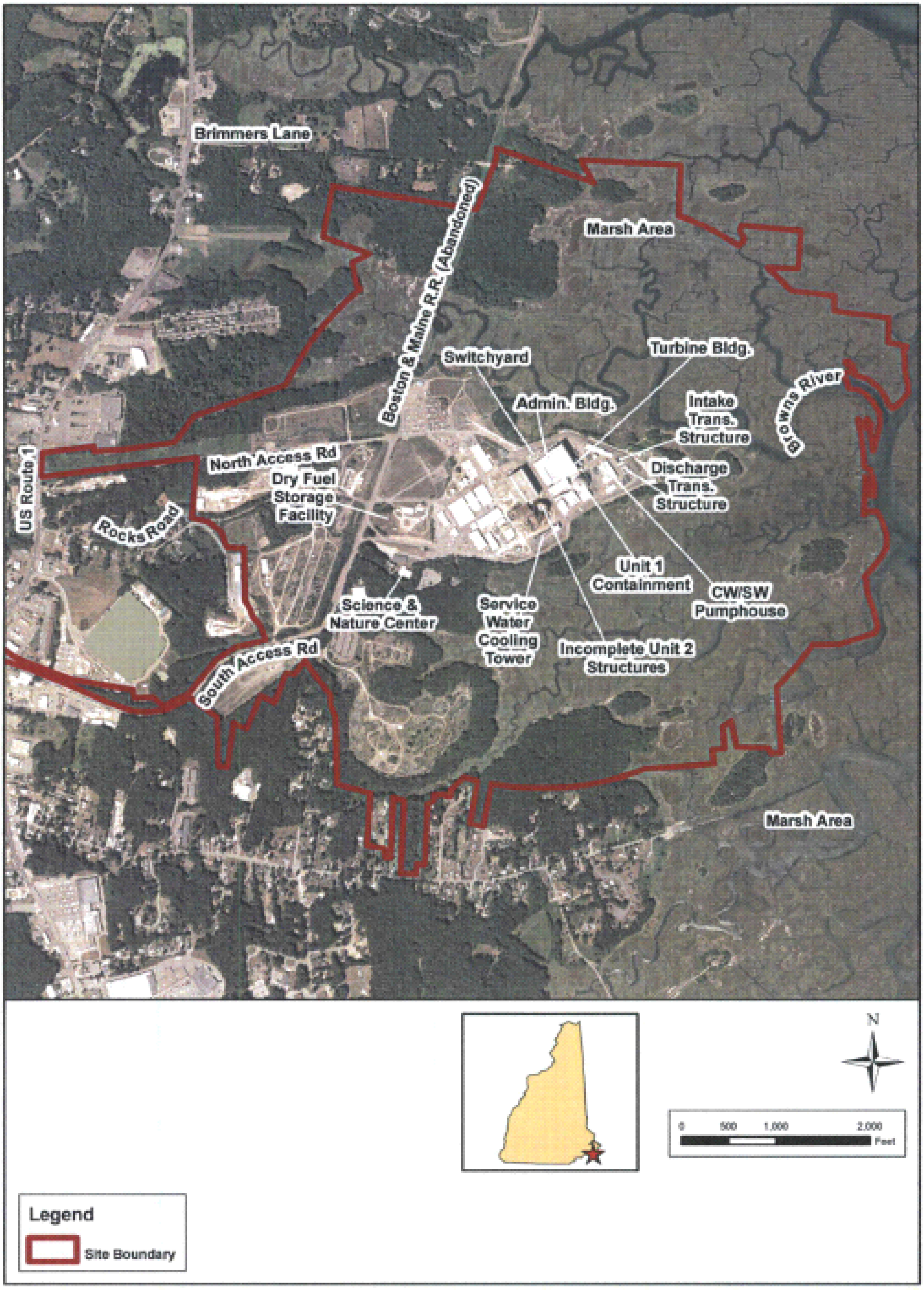
Figure 2–1. Location of Seabrook, 6-mi (10-km) Region

Source: (NextEra, 2010a)

Figure 2–2. Location of Seabrook, 50-mi (80-km) Region

Source: NextEra, 2010a)

Figure 2–3. Seabrook Site Boundary And Facility Layout



Source: (NextEra, 2010a)

The reactor, SGs, and related systems are enclosed in a double containment, which is comprised of a containment structure and a containment enclosure. The double containment is designed to prevent uncontrolled emissions of radioactivity to the environment. The containment structure is a reinforced concrete cylinder with a slab base and hemispherical dome. A carbon steel liner is attached to the inside face of the concrete shell of the

containment structure and ensures a high degree of leak tightness. In addition, the 3.6-foot (ft) (1.1-meter (m)) thick concrete walls serve as a radiation shield for both normal and accident conditions (NextEra 2010a). The containment structure is surrounded by the containment enclosure which is a reinforced concrete, cylindrical containment enclosure, that is designed to entrap, filter, and then discharge any leakage from the containment structure to the atmosphere through charcoal filters (NextEra 2010).

Seabrook fuel for the reactor core consists of low-enriched (less than 5 percent by weight) uranium-235. Fuel design is such that individual rod average burnup (burnup averaged over the length of the fuel rod) will not exceed 62,000 megawatt days (MWd) per metric ton uranium (MTU). Unit 1 originally produced a reactor core power of 3,411 megawatts-thermal (MWt). The reactor core power was increased in 2005 to 3,587 MWt and then again in 2006 to the plant's current output of 3,648 MWt. The original design net electrical capacity was 1,198 megawatts-electric (MWe), which was increased to 1,221 MWe in 2005 and then to 1,245 MWe in 2006 (NextEra 2010a).

2.1.2 Radioactive Waste Management

The radioactive waste systems collect, treat, and dispose of radioactive and potentially radioactive wastes that are byproducts of Seabrook operations. The byproducts are activation products resulting from the irradiation of reactor water and impurities within the reactor water (principally metallic corrosion products) and fission products, resulting from defective fuel cladding or uranium contamination within the reactor coolant system. Operating procedures for the radioactive waste system ensure that radioactive wastes are safely processed and discharged from Seabrook. The systems are designed and operated to assure that the quantities of radioactive materials released from Seabrook are as low as is reasonably achievable (ALARA) and within the dose standards set forth in Title 10, Part 20 of the *Code of Federal Regulations* (10 CFR Part 20), "Standards for protection against radiation," and 10 CFR Part 50, "Domestic licensing of production and utilization facilities." The Seabrook Offsite Dose Calculation Manual (ODCM) contains the methods and parameters used to calculate offsite doses resulting from radioactive effluents. These methods are used to ensure that radioactive material discharged from Seabrook meets regulatory dose standards.

Radioactive wastes resulting from Seabrook operations are classified as liquid, gaseous, and solid. Radioactive wastes generated by Seabrook operations are collected and processed to meet applicable requirements. The design and operational objectives of the radioactive waste management systems are to limit the release of radioactive effluents from Seabrook during normal operation and anticipated operational occurrences (NextEra 2010a).

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 18 months. Spent nuclear fuel from the reactor is stored onsite in a spent fuel pool (SFP) and a dry fuel storage facility. The dry fuel storage facility is licensed in accordance with 10 CFR Part 72 (NextEra 2010a).

Storage of radioactive materials is regulated by the U.S. Nuclear Regulatory Commission (NRC) under the Atomic Energy Act of 1954, as amended, and storage of hazardous wastes is regulated by the U.S. Environmental Protection Agency (EPA) under the Resource Conservation and Recovery Act of 1976 (RCRA).

Systems used at Seabrook to process liquid, gaseous, and solid radioactive wastes are described in the following sections.

2.1.2.1 Radioactive Liquid Waste System

The Seabrook liquid waste system collects, segregates, stores, and disposes of radioactive liquid waste. This system is designed to reduce radioactive materials in liquid effluents to levels that are ALARA and reduce the volume of waste through recycling. The system collects and transports non-corrosive, radioactive, or potentially radioactive liquid wastes from equipment and floor drains to be processed using a combination of filtration and demineralization (NextEra 2010a).

All liquid radwaste process systems end in either a sample or distillate tank. Liquid wastes are processed on a batch basis so that each treated batch can be sampled. Depending on the sample results, the waste is either reprocessed or returned to the condensate storage tanks for reuse in Seabrook. Once the liquid waste is processed, it is evaluated to meet discharge limit requirements and then released to the Atlantic Ocean via the station's NPDES-permitted discharge transition structure. Radioactive effluent releases require positive operator action, are continuously monitored, and can be automatically terminated in the event of a high radiation alarm or a power failure.

Any solid wastes generated as a byproduct of the liquid waste processing system are packaged for offsite shipment. Evaporators were installed for use in the liquid waste processing system but then were never used. (NextEra 2010a)

2.1.2.2 Radioactive Gaseous Waste System

Gaseous waste management systems process and control the release of gaseous radioactive effluents to the atmosphere. The purpose of the radioactive gaseous waste system is to collect and process radioactive and potentially radioactive waste gas. This system also limits the release of gaseous activity so that personnel exposure and activity releases, in restricted and unrestricted areas, are ALARA. The radioactive gaseous waste system is used to reduce radioactive materials in gaseous effluents before discharge to meet the dose limits in 10 CFR Part 20 and the dose design objectives in Appendix I to 10 CFR Part 50. Offgases from the main condenser are the major source of gaseous radioactive waste. Other radioactive gas sources collected by the system include leakage from steam piping and equipment in the reactor building, turbine generator building, and radwaste building.

Before release into the environment through the PAB normal ventilation cleanup exhaust unit, the gas is passed through charcoal and particulate filtration media. Seabrook discharges gaseous waste in accordance with the procedures and methods described in the ODCM so that exposure to persons offsite are ALARA and do not exceed limits specified in 10 CFR Part 20 and Appendix I to 10 CFR Part 50.

2.1.2.3 Radioactive Solid Waste Processing Systems

Seabrook's solid waste management system is designed to safely collect, process, package, store, and prepare radioactive wet and dry solid waste materials generated by plant operations for shipment to an offsite waste processor for disposal at a licensed burial facility. The system is designed to process waste while maintaining occupational exposure at ALARA. To ensure compliance with applicable regulations in 10 CFR Parts 20, 61, and 71, characterization, classification, processing, waste storage, handling, and transportation of solid wastes are controlled by the Process Control Program.

Due to differences in radioactivity or contamination levels of the many wastes, various methods are employed for processing and packaging. The disposition of a particular item of waste is determined by its radiation level, type, presence of hazardous material, and the availability of disposal space. The wet solid wastes system transfers resins from sluice tanks to liners to then

be packaged for offsite shipment. Solid dry active wastes—such as contaminated paper, plastic, wood, metals, and spent resin—may be processed by compaction in either boxes or cargo containers. During compaction, the airflow in the vicinity of the compactor is directed by the compactor exhaust fan through a high-efficiency particulate filter before it is discharged. Large or highly radioactive components and equipment, that have been contaminated during reactor operation and that are not amenable to compaction, are handled either by qualified plant personnel or by outside contractors specializing in radioactive materials handling, and the components and equipment are packaged in shipping containers for transportation offsite. Solid radioactive wastes are packaged and shipped from Seabrook in containers that meet the requirements established by the U.S. Department of Transportation and by the NRC.

Seabrook also generates small quantities of low-level mixed waste—waste that exhibits hazardous characteristics and contains low levels of radioactivity. The plant generates approximately 1 gallon (gal) per year of mixed waste as a byproduct of oil and grease analyses. Seabrook is classified as a Federal Small Quantity Generator (SQG) of Hazardous Waste and is not permitted for mixed waste storage; the mixed waste is collected and sent to a licensed facility for processing and disposal within 90 days. Some unique plant maintenance events, such as SG cleaning, can generate a larger amount of mixed waste. During the 2009 refueling outage, for example, 40 tons of mixed waste was generated during chemical cleaning of the SGs, a process that may be performed in future outages. Any additional mixed waste resulting from this process will be collected and sent to a licensed processor within 90 days.

Class A waste is collected, sorted, packaged, and shipped offsite to the Clive, UT, disposal facility—a licensed radioactive waste landfill—for further processing. Seabrook currently ships Class B and C waste to Studsvik, a waste processing facility in Erwin, TN. Studsvik processes this waste and then, through a State of Tennessee-licensed attribution model, is allowed to take title of Seabrook's wastes. After processing and taking title of the wastes, Studsvik then sends the material to Waste Control Specialists in Andrews County, TX, for long-term storage and disposal. Seabrook has an existing contract with Studsvik to process its Class B and C waste in this manner; however, should this contract expire, Seabrook would potentially need to store its Class B and C waste onsite.

Onsite, NextEra estimates that it has sufficient capacity to store Class B and C waste in its waste processing building for approximately 7 years. If NextEra were unable to find a replacement processing and disposal facility for Studsvik, 7 years of onsite storage capacity would provide a sufficient buffer, allowing enough time to design, site, and install a Class B and C waste storage facility onsite. If such a facility were required in the future, it would need to meet any relevant State and Federal licensing requirements, and the potential environmental impacts of the construction and operation of the facility would be evaluated at that time.

NextEra currently has contracts in place for processing and disposal of its Class A, B, and C wastes—and because it has a sufficient amount of storage onsite—Seabrook would be able to safely handle and store its radioactive waste during the term of license renewal.

2.1.3 Nonradiological Waste Management

Seabrook generates nonradioactive wastes as part of routine plant maintenance, cleaning activities, and plant operations. RCRA waste regulations governing the disposal of solid and hazardous waste are contained in 40 CFR Parts 239–299. In addition, 40 CFR Parts 239–259 contain regulations for solid (nonhazardous) waste, and 40 CFR Parts 260–279 contain regulations for hazardous waste. RCRA Subtitle C establishes a system for controlling hazardous waste from "cradle to grave," and RCRA Subtitle D encourages States to develop comprehensive plans to manage nonhazardous solid waste and mandates minimum

technological standards for municipal solid waste landfills. New Hampshire State RCRA regulations are administered by the New Hampshire Department of Environmental Services (NHDES) and address the identification, generation, minimization, transportation, and final treatment, storage, or disposal of hazardous and nonhazardous waste.

2.1.3.1 Nonradioactive Waste Streams

Seabrook generates solid waste, defined by the RCRA, as part of routine plant maintenance, cleaning activities, and plant operations. New Hampshire is part of EPA Region 1 and its Solid Waste Program. In 1991, the EPA authorized NHDES to administer portions of the RCRA Program in the State of New Hampshire that are incorporated into Env-Wm 100-1100 of the New Hampshire Code of Administrative Rules.

The EPA classifies certain nonradioactive wastes as hazardous based on characteristics including ignitability, corrosivity, reactivity, or toxicity (hazardous wastes are listed in 40 CFR Part 261). State-level regulators may add wastes to the EPA's list of hazardous wastes. RCRA supplies standards for the treatment, storage, and disposal of hazardous waste for hazardous waste generators (regulations are available in 40 CFR Part 262).

The EPA recognizes the following main types of the hazardous waste generators (40 CFR 260.10) based on the quantity of the hazardous waste produced:

- large quantity generators that generate 2,200 pounds (lb) (1,000 kilograms (kg)) per month or more of hazardous waste, more than 2.2 lb (1 kg) per month of acutely hazardous waste, or more than 220 lb (100 kg) per month of acute spill residue or soil;
- SQGs that generate more than 220 lb (100 kg) but less than 2,200 lb (1,000 kg) of hazardous waste per month; and
- conditionally exempt small quantity generators that generate 220 lb (100 kg) or less per month of hazardous waste, 2.2 lb (1 kg) or less per month of acutely hazardous waste, or less than 220 lb (100 kg) per month of acute spill residue or soil.

Under NHDES Hazardous Waste rules, Seabrook is classified as a Full Quantity Generator of hazardous waste in that it generates greater than 100 kg (220 lb) of hazardous waste in any single calendar month. Under Federal regulations, Seabrook is an SQG of hazardous waste, which is greater than 100 kg but less than 1,000 kg in any month. Seabrook's hazardous wastes include waste paint, waste solvents, expired laboratory chemicals, and microfilm processing waste (NextEra 2010a).

The EPA classifies several hazardous wastes as universal wastes; these include batteries, pesticides, mercury-containing items, and fluorescent lamps. NHDES has incorporated the EPA's regulations (40 CFR Part 273) regarding universal wastes in New Hampshire Code of Administrative Rules Env-Hw 1101. Universal wastes produced by Seabrook are disposed of or recycled in accordance with NHDES regulations.

Conditions and limitations for wastewater discharge by Seabrook are specified in National Pollutant Discharge Elimination System (NPDES) Permit No. NH0020338. Radioactive liquid waste is addressed in Section 2.1.2 of this supplemental environmental impact statement (SEIS). Section 2.2.4 gives more information about Seabrook NPDES permit and permitted discharges.

The Emergency Planning and Community Right-to-Know Act (EPCRA) requires applicable facilities to supply information about hazardous and toxic chemicals to local emergency planning

authorities and the EPA (42 U.S.C. 11001). On October 17, 2008, the EPA finalized several changes to the Emergency Planning (Section 302), Emergency Release Notification (Section 304), and Hazardous Chemical Reporting (Sections 311 and 312) regulations that were proposed on June 8, 1998 (63 FR 31268). Seabrook is subject to Federal EPCRA reporting requirements; thus, Seabrook submits an annual Section 312 (Tier II) report on hazardous substances to local emergency response agencies.

2.1.3.2 Pollution Prevention and Waste Minimization

Seabrook has waste minimization measures in place, as verified during the Seabrook site visit conducted by NRC in October 2010. In support of nonradiological waste-minimization efforts, the EPA's Office of Prevention and Toxics has established a clearinghouse that supplies information about waste management and technical and operational approaches to pollution prevention (EPA 2010f). The EPA clearinghouse can be used as a source for additional opportunities for waste minimization and pollution prevention at Seabrook, as appropriate.

The EPA also encourages the use of environmental management systems (EMSs) for organizations to assess and manage the environmental impacts associated with their activities, products, and services in an efficient and cost-effective manner. The EPA defines an EMS as "a set of processes and practices that enable an organization to reduce its environmental impacts and increase its operating efficiency." EMSs help organizations fully integrate a wide range of environmental initiatives, establish environmental goals, and create a continuous monitoring process to help meet those goals. The EPA Office of Solid Waste especially advocates the use of EMSs at RCRA-regulated facilities to improve environmental performance, compliance, and pollution prevention (EPA 2010g). The Seabrook EMS is described in Section 5.0 of the ER.

2.1.4 Plant Operation and Maintenance

Maintenance activities conducted at Seabrook include inspection, testing, and surveillance to maintain the current licensing basis (CLB) of the facility and to ensure compliance with environmental and safety requirements. Various programs and activities currently exist at Seabrook to maintain, inspect, test, and monitor the performance of facility equipment. These maintenance activities include inspection requirements for reactor vessel materials, boiler and pressure vessel inservice inspection and testing, the Maintenance Structures Monitoring Program, and maintenance of water chemistry.

Additional programs include those carried out to meet technical specification surveillance requirements, those implemented in response to the NRC generic communications, and various periodic maintenance, testing, and inspection procedures (NextEra 2010a). Certain program activities are carried out during the operation of the unit, while others are carried out during scheduled refueling outages. Nuclear power plants must periodically discontinue the production of electricity for refueling, periodic inservice inspection, and scheduled maintenance. Seabrook refuels on an 18-month interval (NextEra 2010a).

2.1.5 Power Transmission System

Three 345-kV transmission lines connect Seabrook to the regional electric grid. Two of these lines are wholly owned and operated by Public Service Company of New Hampshire (PSNH), and one of the lines is owned and operated by PSNH (in New Hampshire) and National Grid (in Massachusetts). Unless otherwise noted, the discussion of the power transmission system is adapted from the Environmental Report (ER) (NextEra 2010a) or information gathered at NRC's environmental site audit in October 2010.

The transmission lines cross through Hillsborough and Rockingham Counties, NH, and Essex and Middlesex Counties, MA. In total, the transmission lines associated with the operation of Seabrook span 83 mi (134 km) and comprise approximately 1,759 ac (712 ha) of transmission line rights-of-way (ROWs).

Transmission lines considered in-scope for license renewal are those constructed specifically to connect the facility to the transmission system (10 CFR 51.53(c)(3)(ii)(H)); therefore, the Scobie Pond Line, the Tewksbury Line, and the Newington Line are considered in-scope for this SEIS and are discussed below in detail. All three of these transmission lines will remain a permanent part of the transmission system and will be maintained by PSNH and National Grid, regardless of Seabrook's continued operation.

Figure 2–4 is a map of the Seabrook transmission system. Table 2–1 summarizes the transmission lines. The three transmission lines are as follows:

Scobie Pond Line: This line extends westward for 5 mi (8 km) in a 245- to 255-ft (75- to 78-m)-wide ROW that it shares with the Tewksbury Line. The line then splits off and extends westward an additional 25 mi (40 km) in a 170-ft (52-m)-wide ROW to the Scobie Pond Station in Derry, NH. This line spans Rockingham and Hillsborough Counties, NH, and it is owned and operated by PSNH.

Tewksbury Line: This line extends westward for 5 mi (8 km) in a 245- to 255-ft (75- to 78-m)-wide ROW that it shares with the Scobie Pond Line. The line then splits off and extends southwestward an additional 35 mi (56 km) in a 170-ft (52-m)-wide ROW to the Tewksbury Station in Tewksbury, MA. This line spans Rockingham County, NH, and Essex and Middlesex Counties, MA. PSNH owns and operates the New Hampshire portion of the line, and National Grid owns and operates the Massachusetts portion of the line.

Newington Line: This line extends northward for 18 mi (29 km) in a 170-ft (52-m)-wide ROW to the Newington Generating Station in Newington, NH. This line is contained within Rockingham County, NH, and it is owned and operated by PSNH.

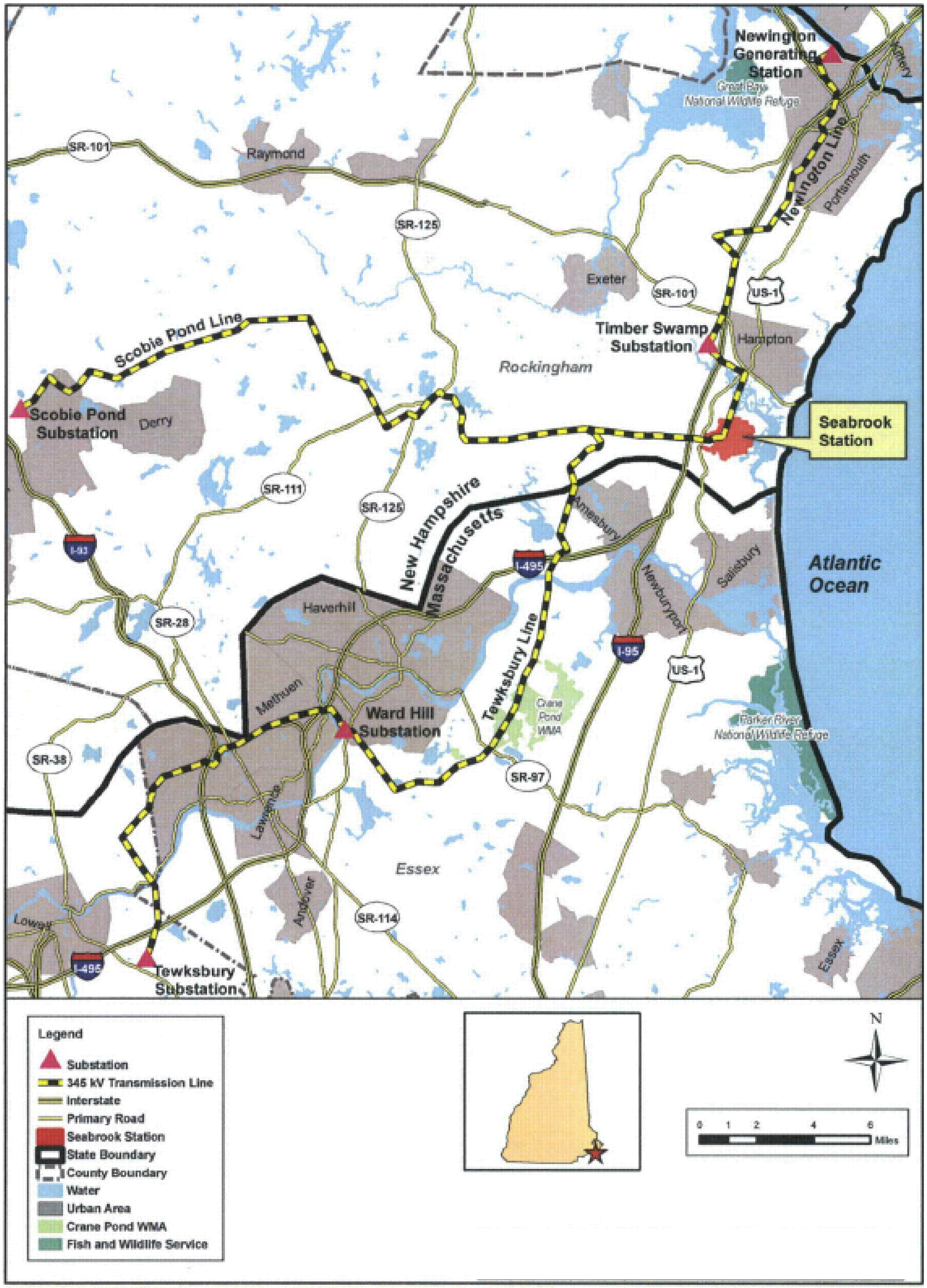
In order to ensure power system reliability and to comply with applicable Federal and State regulations, PSNH and National Grid maintain transmission line ROWs to prevent physical interference that could result in short-circuiting. This maintenance generally consists of removing or cutting tall-growing vegetation under the lines and removing or trimming of any trees near the edge of the ROWs that could fall on the lines.

Both PSNH and National Grid are required by law to comply with the North American Electric Reliability Corporation (NERC)'s FAC-003-1, Transmission Vegetative Maintenance Program (NERC 2006) and the Northeast Power Coordinating Council's Associated Vegetative Management Program compliance requirements. FAC-003-1 reliability standards require transmission owner to maintain a formal transmission Vegetation Management Program that includes an annual plan specifying each year's work, to maintain appropriate clearances between lines and any vegetation, and to report any vegetation-related outages to the appropriate Regional Reliability Organization. According to NERC's public listing of enforcement actions, neither PSNH nor National Grid have had a compliance violation associated with vegetative maintenance between June 2008[1] through the time that the draft SEIS was published (NERC 2013).

[1] NERC does not have a list of enforcement actions prior to June 2008 available on their public Web site.

Generally, vegetative maintenance practices target low-growing, early successional habitat and associated plant species to minimize the intensity of maintenance over time. Specific practices vary between PSNH and National Grid and are discussed in more detail below.

Figure 2–4. Seabrook Transmission Line Map



Source: (NextEra 2010a)

Table 2–1. Seabrook Transmission Lines

Line	Owner	kV	Approximate distance, mi (km)	ROW width,[a] ft (m)	ROW area, ac (ha)
Scobie Pond	PSNH	345	30 (48)	170 (52)	667 (270)[b]
Tewksbury	PSNH	345	40 (64)	170 (52)	873 (353)[b]
Newington	PSNH & National Grid	345	18 (29)	170 (52)	371 (150)

[a]Value given represents the typical width or typical width range along line, though ROW width may vary at intervals along the length of the line.

[b]Values given for ROW area are not mutually exclusive because the Scobie Pond and Tewksbury Lines share a 5-mi (8-km)-long stretch of ROW.

Source: (NextEra 2010a)

Vegetative Maintenance in New Hampshire

The Scobie Pond and Tewksbury Lines, as well as the New Hampshire portion of the Newington Line, are maintained by PSNH, a subsidiary of Northeast Utilities Service Company (NU).

To identify areas requiring maintenance, PSNH conducts aerial inspections twice per year and follows up by conducting ground inspections in those areas that are targeted for maintenance work. PSNH maintains ROWs on a 4- to 7-year cycle and targets about 15–25 percent of the total acreage to be maintained in a given year (PSNH 2010). PSNH only selectively hand cuts or mechanically mows vegetation; PSNH does not spray any herbicides within ROWs in the State of New Hampshire. PSNH may spray herbicides selectively in switchyards or other non-ROW areas only. NU standards also prohibit the use of mechanized vehicles within designated wetlands and wet areas.

Generally, PSNH's vegetative maintenance practices encourage the growth of low-growing native shrub and tree species such as bayberry (*Myrica* spp.), dogwood (*Cornus* spp.), elderberry (*Sambucus* spp.), hazelnut (*Corylus* spp.), honeysuckle (*Lonicera* spp.), meadowsweet (*Filipendula ulmaria*), mountain-laurel (*Kalmia latifolia*), juniper (*Juniperus* spp.), spicebush (*Lindera* spp.), and winterberry (*Ilex verticillata*) within the conductor zone. Species such as alder (*Alnus* spp.), hornbeam (*Carpinus* spp.), dogwood, sumac (*Rhus* spp.), willows (*Salix* spp.), and witch-hazel (*Hamamelis*) are encouraged in the border zone along the edges of the ROWs. Additionally, PSNH workers are trained to recognize Federally or State-protected plant species that may occur in the ROWs in order to avoid impacts to these species.

PSNH specifically targets the following invasive species for removal when conducting maintenance: multiflora rose (*Rosa multiflora*), common buckthorn (*Rhamnus cathartica*), glossy buckthorn (*Frangula alnus*), autumn olive (*Elaeagnus umbellate*), Russian olive (*Elaeagnus angustifolia*), Japanese barberry (*Berberis thunbergii*), and common barberry (*Berberis vulgaris*). PSNH has machine cleaning protocol for workers to follow in areas that contain invasive species to reduce the likelihood that vegetative maintenance activities would facilitate the spread of any invasive species.

Within wetlands, PSNH follows the New Hampshire Department of Resources and Economic Development (NHDRED)'s *Best Management Practices Manual for Utility Maintenance In and Adjacent to Wetlands and Waterbodies in New Hampshire* (NHDRED 2010). This document directs utility companies to avoid wetlands when at all possible, minimize the disturbed area, preserve low-growing native vegetation, and limit work within wetland areas to the winter

months when the ground is frozen and dry. The document also describes what types of equipment create the lowest impact on vegetation and wetland habitat, equipment maintenance strategies that can reduce the risk of oil or other chemical spills and reduce the spread of invasive species, and ways to minimize impacts on streams and near stream crossings.

Additionally, PSNH voluntarily follows the American National Standards Institute (ANSI) guideline document, *A300 Standards for Tree Care Operations*, which contains guidance and recommendations for tree care practices including pruning, lightning protection, and integrated vegetation management.

Vegetative Maintenance in Massachusetts

The Massachusetts portion of the Newington line is maintained by National Grid.

National Grid conducts vegetative maintenance on a 3- to 5-year cycle, following a yearly operation plan that is approved by the Massachusetts Department of Fish and Game (MDFG) Division of Fisheries and Wildlife to ensure that practices are not adversely affecting sensitive species or wetlands. Vegetation is generally targeted for maintenance when it reaches 6–10 ft (3 m) in height or when growth becomes moderate to high in density. National Grid follows an integrated vegetation management approach, which combines hand cutting, mechanical mowing, and selective herbicide application to encourage the long-term establishment of early successional habitat—characterized by low-growing species—over time. Ideal and encouraged habitats include wetlands, vernal pools, heaths, barrens, scrub land, fields, and meadows. Additionally, National Grid workers are regularly briefed on how to recognize Federally or State-protected plant species that may occur in the ROWs in order to avoid impacts to these species.

National Grid specifically targets the following invasive species for removal when conducting maintenance: multiflora rose, Japanese knotweed (*Fallopia japonica*), oriental bittersweet (*Celastrus orbiculatus*), glossy buckthorn, and others that are specified on the U.S. Department of Agriculture's (USDA's) (USDA 2010) list of Massachusetts invasive and noxious weeds.

National Grid does not spray herbicides during moderate to heavy rain, deep snowfall, or within 10 ft (3 m) of wetlands, waterways, or certified vernal pools per Title 333, Part 11 of the *Code of Massachusetts Regulations* (333 CMR 11). National Grid also restricts herbicide to limited use within 100 ft (30.5 m) of wetlands, agricultural areas, and certified vernal pools and limits application in these areas to once per 12 months. Within State-designated Priority Habitat for sensitive species, herbicide treatment is prohibited without prior written approval within the Commonwealth of Massachusetts, per 321 CMR 10.14(12). Additionally, land owners may request that their land be a "no spray zone" if they maintain the land with compatible (low-growing) vegetation that will not interfere with any transmission lines or structures.

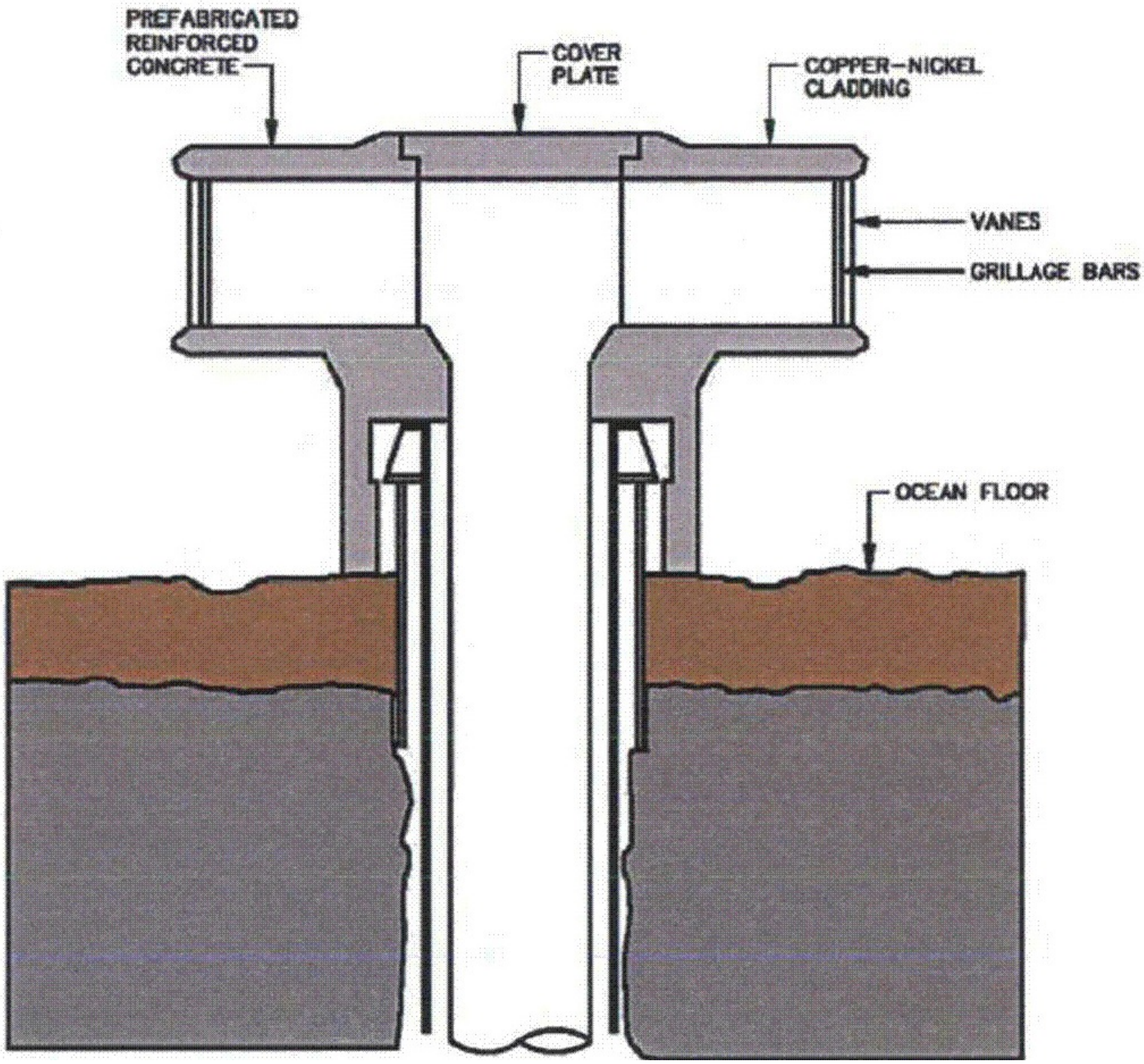
2.1.6 Cooling and Auxiliary Water Systems

Seabrook uses a once-through cooling system that withdraws water from the Gulf of Maine and discharges to the Gulf of Maine through a system of tunnels that have been drilled through ocean bedrock. Unless otherwise cited, the NRC staff drew information about Seabrook's cooling and auxiliary water systems from the NPDES Permit (EPA 2002, which is the permit of record since the NPDES Permit renewal has been under review since September 25, 2006) and the applicant's ER (NextEra 2010a).

Water withdrawn from the Gulf of Maine enters an intake tunnel—located at a depth of 60 ft (18.3 m)—and then travels through one of three concrete intake shafts. Each intake shaft extends upward from the intake tunnel above the bedrock. A velocity cap, which sits on top of each intake shaft (Figure 2–5), regulates flow and minimizes fish entrapment. The NPDES

permit limits the intake velocity to 1.0 ft per second (0.3 meters per second (m/s)) (EPA 2002, which is the permit of record since the NPDES Permit renewal has been under review since September 25, 2006). In 1999, NextEra modified the intake shafts with additional vertical bars to help prevent seal entrapment (NMFS 2002).

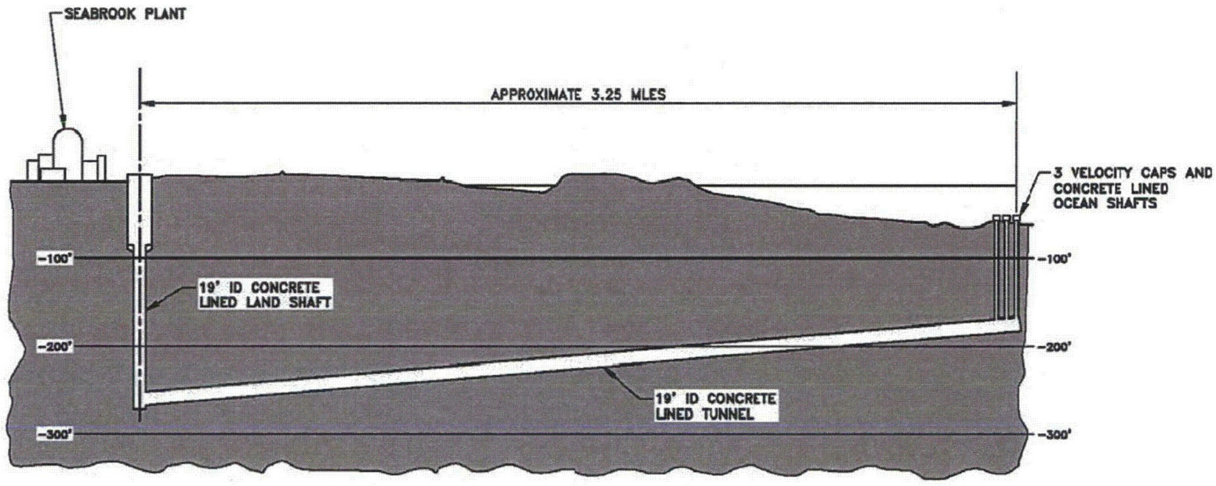
Figure 2–5. Intake Shafts and Caps at Seabrook



Source: (ARCADIS et al. 2008)

From the intake shafts, water flows through a 17,000-ft (5,182-m) intake tunnel that was drilled through the ocean bedrock. The beginning of the intake tunnel is 7,000 ft (2,134 m) from the Hampton Beach shoreline. The tunnel descends at a 0.5-percent grade from the bottom of the intake shaft, which is 160 ft (49 m) below the Gulf of Maine, to 240 ft (73 m) below mean sea level (MSL) at Seabrook (Figure 2–6). The 19-ft (5.8-m) diameter tunnel is concrete-lined.

Figure 2–6. Profile of Intake Tunnel and Shafts at Seabrook

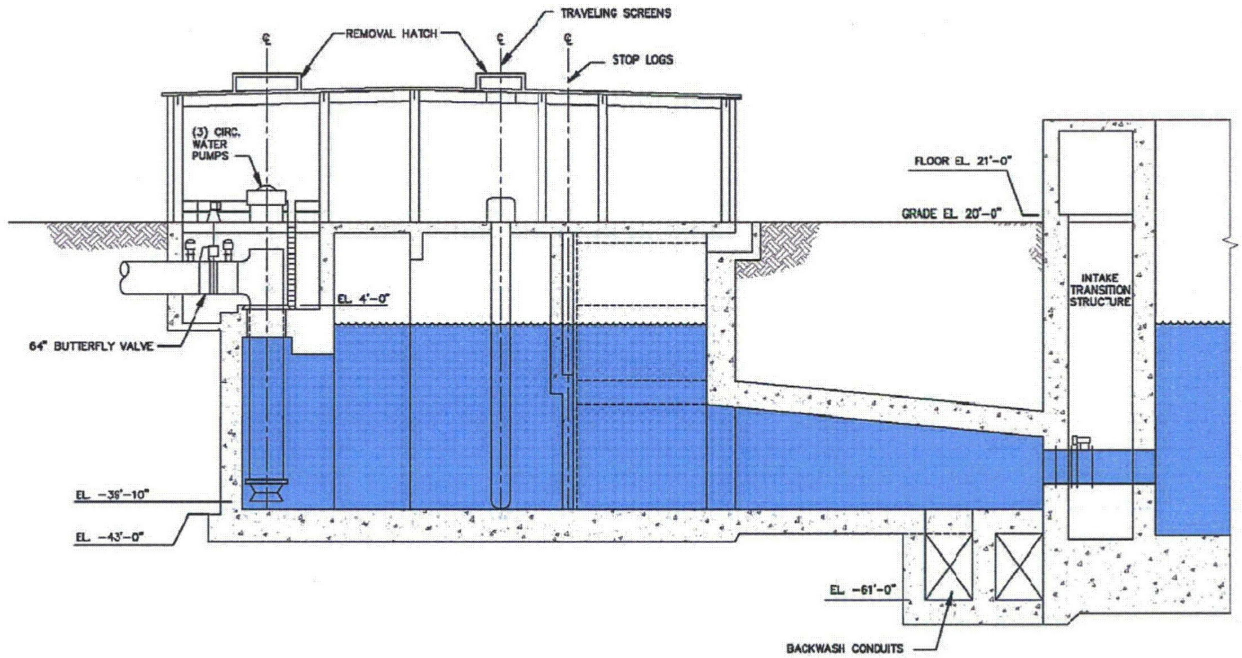


Source: (ARCADIS et al. 2008)

An intake transition structure, which includes three circulating water pumps that transport the water, is located beneath Seabrook (Figure 2–7). Butterfly valves, 11 ft (3.3 m) in diameter, direct the water flow from the transition structure to the circulating water pump house. The water then passes through three traveling screens with a 3/8-inch (0.95-centimeters (cm)) square mesh (NextEra 2010f). The traveling screens remove fish, invertebrates, seaweed, and other debris before the water is pumped to the main condensers and the service water system. The ocean debris is disposed as waste; therefore, none is discharged to the Gulf of Maine. The water passes to the condensers to remove heat that is rejected by the turbine cycle and auxiliary system. During normal operations, the circulating water system (CWS) provides a continuous flow of approximately 390,000 gallons per minute (gpm) (869 cubic feet per second (cfs) or 24.6 cubic meters (m^3) per second (m^3/s)) to the main condenser and 21,000 gpm (47 cfs or 1.3 m^3/s) to the service water system.

Water that has passed through Seabrook discharges to the Gulf of Maine through a 16,500-ft (5,029-m) long discharge tunnel, which has the same diameter, lining, depth, and percent grade as the intake tunnel. The end of the discharge tunnel is 5,000 ft (1,524 m) from the Seabrook Beach shoreline. The effluent discharges via 11 concrete shafts that are 70 ft (21.3 m) deep and approximately 100 ft (30.5 m) apart from one another. To increase the discharge velocity and more quickly diffuse the heated effluent, a double-nozzle fixture is attached to the top of each shaft. The NPDES permit limits this discharge flow to 720 million gallons per day (mgd) (2.7 million m^3/day), and the monthly mean temperature rise may not exceed 5 °F at the surface of the receiving water, which is considered to be surface water within 300 ft (91 m) of the discharge (EPA 2002; NHFGD 2011).

Figure 2–7. Circulating Water Pumphouse at Seabrook



Source: (ARCADIS et al. 2008)

Barnacles, mussels, and other subtidal fouling organisms can attach to concrete structures and potentially limit water flow through the tunnels. To minimize biofouling within the intake and discharge tunnels, NextEra uses a combination of physical scrubbing and a chlorination system (NextEra 2010f). Divers physically scrub the intake structures biannually to remove biofouling organisms—such as barnacles, mussels, or other organisms—that attach to hard surfaces to grow. During outages, the inside of the intake structures are physically scrubbed to the point that chlorine is injected into the tunnels, approximately 6 ft (1.8 m) into the intake shaft. In addition, NextEra inspects the discharge diffusers during outages. The circulating water pump house, pipes, and condensers are dewatered, inspected, and cleaned as needed (FPLE 2008). NextEra injects chlorine and other water treatment chemicals in accordance with NPDES permit limits (EPA 2002).

As described above, the Gulf of Maine provides water for both the CWS and the service water system. Water flows from the intake structures to the service water pump house, which is separated from the CWS portion of the building by a seismic-reinforced concrete wall. In the event that the regular supply of cooling water from the service water pump house is unavailable, NextEra would use a standby mechanical draft evaporative cooling tower (service water tower) and 7-day makeup basin (Figure 2–3). This cooling tower basin has a capacity of 4.0 million gal (15,140 m^3) and is fed from the Gulf of Maine via the service water system. If ocean water is unavailable, or additional water is required, NextEra would access emergency makeup water from the domestic water supply system or from the Browns River via a portable pump (FPLE 2008; NextEra 2010a).

2.1.7 Facility Water Use and Quality

Seabrook relies on the Atlantic Ocean as its source of water for its circulating (cooling) and service water systems. Ocean water reaches the plant via a tunnel system that is approximately 3 mi (5 km) long. Groundwater at the site is not used as a resource, but fresh

(potable) water for the plant is acquired from an offsite municipal system that uses groundwater. The following sections describe water use and relevant quality issues at Seabrook.

2.1.7.1 Surface Water Use

As discussed in Section 2.1.6, three concrete intake structures are positioned about 60 ft (18 m) below mean lower low water (MLLW) about 7,000 ft (2,100 m) offshore from Hampton Beach. Water flows through a tunnel approximately 3 mi (5 km) long to Seabrook and is returned to the ocean via a separate tunnel. The flow rate of ocean water for the once-through cooling system is approximately 390,000 gpm (869 cfs or 24.6 m^3/s) to the main condenser and 21,000 gpm (47 cfs or 1.3 m^3/s) to the service water system (NextEra 2010a).

Ocean water may also be used at the station's standby emergency mechanical draft cooling tower (service water tower) and 7-day makeup water reservoir. If ocean water is unavailable to the system, emergency makeup water for the tower could be taken from the municipal water supply system or from a portable pump in the Browns River (FPLE 2008).

2.1.7.2 Groundwater Use

Onsite groundwater is not currently used as a source of water for Seabrook. Potable water for Seabrook is currently obtained from the Town of Seabrook Water Department, which operates a system of ten municipal supply wells (NextEra 2010a). Potable water is used by Seabrook for drinking and sanitary purposes and as makeup water to the fire water storage tanks, cooling tower, and the water treatment system (WTS). The WTS is designed to process freshwater into demineralized and deoxygenated makeup water for secondary plant systems (FPLE 2008). Seabrook's annual average potable water use is approximately 42 million gal (159,000 cubic meters (m^3)) or about 80 gpm (300 liters per minute (L/min)) (NextEra 2010a).

A total of 15 wells were originally installed in the bedrock aquifer to supply freshwater to the station. These were installed in two well fields located about 2,000 ft (610 m) west and 3,000 ft (910 m) north of the site. Only seven of the wells were ultimately developed and were operated to provide approximately 200 gpm (760 L/min) of water for the plant. This water was in addition to about 35 gpm (130 L/min) of water obtained from the Town of Seabrook municipal system. Since 1986, Seabrook has relied solely on the municipal system for its freshwater needs (NextEra 2010a). During the site audit, NextEra confirmed that onsite groundwater was never used for drinking and that plans were being developed to properly abandon the seven existing supply wells and several other wells no longer used for monitoring, site characterization, or other purposes.

Groundwater is removed from building dewatering points for dewatering and tritium plume control. Approximately 32,000 gallons per day (gpd) (120 m^3) of groundwater is pumped from the subsurface of the Unit 2 containment building to control groundwater inflow (RSCS 2009a). As further discussed in Section 2.2.5, groundwater is also extracted at much lower rates (at approximately 3,000 gpd (11,400 L/day)) from five dewatering points in order to contain relatively high tritium levels at Unit 1 for a total onsite groundwater production of some 35,000 gpd (132 m^3) or about 24 gallons per minute (gpm) (91 L/min).

2.2 Surrounding Environment

Seabrook is located on 889 ac (360 ha) 2 mi (3.2 km) west of the Atlantic Ocean. The site is located about 2 mi (3.5 km) inland, in a marshland area located between Browns River to the north and Hunts Island Creek to the south, on an area of second-growth native forest.

Haverhill, MA, is the nearest population center and is located approximately 15 mi (24 km) southwest of the site. There are two metropolitan centers within 50 mi (80 km) of the site; Manchester, NH, located 31 mi (50 km) northwest, and Boston, MA, 41 mi (66 km) south.

2.2.1 Land Use

Broad open areas of low tidal marsh border Seabrook to the north, south, and east. Numerous tidal creeks and artificial linear drainage ditches divide the tidal marsh. The marsh is interrupted by wooded islands and peninsulas, which rise to elevations of 20–30 ft (6–9 m) above MSL. Seabrook is located on a peninsula, approximately 20 ft (6 m) in elevation, rising 16 ft (4.9 m) above the surrounding Hampton Flats Salt Marsh (AEC 1974; FPLE 2008). The Hampton Harbor Estuary, a shallow lagoon behind the barrier beaches of Hampton Harbor, Seabrook Beach, and Hampton Beach, borders the western edge of Seabrook approximately 1.7 mi (2.7 km) away. Approximately 10 percent of the surrounding marsh area is open water accessible only to small boats, with channel depths limited to 3–4 ft (0.9–1.2 m) at low tide (FPLE 2008; NRC 1982).

Seabrook is divided into two parcels: lot 1 and lot 2. Lot 1 consists of approximately 109 ac (44 ha) of developed land containing the reactor building and associated facilities, including the north and south access roads, which are owned by the Seabrook joint owners. Lot 2 is owned by NextEra and consists of approximately 780 ac (316 ha) of largely undeveloped land. During construction, approximately 194 ac (79 ha) were cleared (NRC 1982). By 2014, NextEra plans to have returned approximately 32 ac (13 ha), which are currently occupied by excavation spoil, to its natural state.

Major structures onsite include the Unit 1 containment and auxiliary building; fuel storage, waste processing, diesel generator, and turbine buildings; administration services building; and a cooling tower. There are also various structures that NextEra built for Unit 2, which are now used for storage. A dry spent fuel storage site is located west of Unit 2 and consists of a large concrete pad and horizontal storage modules (FPLE 2008).

The Town of Seabrook has designated the Seabrook site as Zone 3 (Industrial Use District). The East Coast Greenway, a non-motorized, shared-use trail system, makes use of former railway ROW, a section of which would run through the Seabrook property along the State-owned Hampton Branch Railroad Corridor. The railway roadbed is fenced off at the site's property lines to restrict public access (FPLE 2009). The Owascoag Nature Trail, a 1-mi (1.6-km) interpretive environmental education boardwalk and trail walk, offers a view of marsh and woodland habitats (FPLE 2008, 2009).

Public access is restricted and controlled by signs at the north and south access roads, and by fencing. Additionally, the U.S. Coast Guard established a security zone around Seabrook in 2002, requiring signage along the blanks of the Browns River and Hunts Island Creek. Public activities occurring on, or near, Seabrook include infrequent boat traffic along the Browns River and Hunts Island Creek and visits to the Seabrook Science and Nature Center, which is open to the general public and located about 1,500 ft (457 m) southwest of the plant. From 2007–2010, annual attendance at the Science and Nature Center ranged between 3,380–4,486 students and walk-in visitors (NextEra 2010f).

2.2.2 Air Quality and Meteorology

The terrain of New Hampshire ranges from hilly to mountainous, except at low elevations along the coastal plains in the southeast (NCDC 2010). The climate of New Hampshire is primarily affected by three air masses: (1) cold, dry air from subarctic North America; (2) warm, moist air

from the subtropical waters to the east—the Gulf Stream; and (3) cool, damp air from the North Atlantic. The air masses, having largely different characteristics, alternate and interact with storm systems that pass frequently, resulting in abrupt changes in temperature, moisture, sunshine, and wind patterns. Accordingly, the climate of New Hampshire is highly variable. The regional climate in New Hampshire is modified by the varying distances from relatively mild ocean waters, elevations, and types of terrain (FPLE 2008; NextEra 2010a).

The topography of the site is relatively flat and has no special influence on climate. Due to its proximity to the Atlantic Ocean, the site location experiences milder climate, smaller diurnal and seasonal temperature ranges, more precipitation, and less snow than at a location further inland of comparable latitude. New Hampshire lies in the prevailing westerlies, with winds from the northwest in winter and from the southwest in summer. Thus, the climate of the site is continental in character but moderated by the maritime influence of the Atlantic Ocean (FPLE 2008).

From 1944–2008, annual average temperature at Portsmouth, located about 12 mi (19 km) north-northeast of Seabrook, was 47.5 °F (8.6 °C). January is the coldest month with an average minimum temperature of 14.8 °F (-9.6 °C). July is the warmest month with an average maximum temperature of 81 °F (27.2 °C) (NHSCO 2010). Extreme temperatures at Seabrook are moderated by the marine influences from the Atlantic Ocean. In particular, onshore sea breezes from the relatively cool ocean make the site cooler than more inland areas (NextEra 2010a).

Precipitation around Seabrook is distributed consistently throughout the year, with monthly precipitation ranging between 3–5 inches (in) (7.6–12.7 cm) (NHSCO 2010). At Portsmouth, precipitation tends to be the highest in fall and lowest in summer. In New Hampshire, lower-pressure, or frontal, storm systems are the principal year-round moisture sources, except in summer when this activity tends to diminish and thunderstorm activity increases (NCDC 2010). On average, one in three days has measurable precipitation (0.01 in (0.025 cm) or higher) near Seabrook (FPLE 2008). From 1944–2008, annual precipitation at Portsmouth averaged about 50 in (127 cm) (NHSCO 2010). Snow falls as early as October and continues as late as April. The annual average snowfall at Portsmouth is about 69 in (175 cm).

Severe weather events—such as floods, hail, high winds, thunderstorm winds, snow and ice storms, hurricanes, and tornadoes—have been reported in Rockingham County (NCDC 2010a). Since 1995, 46 floods were reported in Rockingham County. Flooding has occurred most often in the spring due to a combination of rain and melting snow. In addition, tropical storms and their remnants can sometimes cause significant flooding. In Rockingham County, a total of 106 hailstorms have been reported since 1963, and they mostly occurred during the summer months. Hail measuring up to 2 in (5 cm) in diameter was reported in 2006. Since 1994, 29 high-wind events were reported in Rockingham County. A gust of 154 mph (69 m/s) was recorded in July 1996, which caused falling trees and power outages throughout New Hampshire. Across the state, thunderstorms occur on 15–30 days per year and mostly from mid-spring to early fall (NCDC 2010). The most severe are accompanied by hail. In Rockingham County, thunderstorm wind events up to a maximum wind speed of 112 mph (50 m/s) occurred mostly during the summer months. One hundred sixteen winter storm events—comprising heavy snow, freezing rain, and ice—were reported in Rockingham County since 1993. In particular, a few widespread and prolonged ice storms produced perilous travel and caused damage to trees and utility lines and poles (NCDC 2010a).

Historically, most of the tropical cyclones that have passed through New England had weakened from their peak due to cold waters and fast-moving winds. The hurricanes that do make landfall are normally weak, with Category 3 (i.e., sustained winds of 111–130 mph

(50−58 m/s)) being rare. Hurricane Donna in 1960 and Hurricane Floyd in 1999 attained Category 5 (sustained winds in excess of 155 mph (69 m/s)) at their peak but then were downgraded to a Category 2 hurricane and a tropical storm, respectively, around New Hampshire. Since 1851, 48 tropical storms have passed within 100 mi (161 km) of Seabrook, 10 of which were classified as hurricanes (CSC 2010). These storms occurred most frequently from August–October. A Category 3 hurricane in 1869 is believed to be the most powerful hurricane within about 100 mi (160 km) of Seabrook. This hurricane was not named, and no detailed records are available. Hurricanes encompass a large area and cause both loss of life and property damage not only from high winds, but also from storm surges, coastal flooding, and heavy rainfall.

Tornadoes in Rockingham County occur less frequently and are less destructive than those in the central U.S. From 1950–2010, 10 tornadoes were reported in Rockingham County, mostly occurring in summer months (NCDC 2010a). However, most of the tornadoes were relatively weak (i.e., two each were F0 or F1 (weak), five were F2 (strong), and one was F3 (severe) on the Fujita tornado scale). These tornadoes caused some property damage, one death, and 57 injuries. Most tornadoes in Rockingham County were reported far from the site, except one F2 tornado which hit Hampton Falls in 2006, about 1.3 mi (2.1 km) north of the station.

Historically, two weather-related interruptions of Seabrook operations have occurred according to NextEra: loss of queue (i.e., loss of priority for providing power to the grid) on December 13, 1992, and loss of offsite power due to a blizzard on March 5, 2001.

Implications of global climate change—including implications for severe weather and storm intensity—are important to coastal communities and to critical infrastructure such as Seabrook. Based on findings to date, published by the Intergovernmental Panel on Climate Change (IPCC), potential impacts from warming of the climate system include expansion of sea water volume; decreases in mountain glaciers and snow cover resulting in sea level rise; changes in arctic temperatures and ice; changes in precipitation, ocean salinity, and wind patterns; and changes in extreme weather (Solomon et al. 2007). The U.S. Global Change Research Program reports that from 1895 to 2012, U.S. average air surface temperatures have increased by 1.3 °F to 1.9 °F (0.72 to 1.06 °C). The effects of global climate change are already being felt in the northeastern United States, where Seabrook is located. For the Northeast region, average air temperatures between 1895 and 2011 increased by 2 °F (1.1 °C) and precipitation increased by more than 10 percent. Between 1958 and 2010, the Northeast experienced a 70 percent increase in heavy precipitation events, the largest increase of any region in the U.S. Other climate-related changes in the Northeast include sea level rise by 1 ft (0.3 m) since 1900, a rate that exceeds the global average of 8 in. (20 cm) (USGCRP 2014).

2.2.2.1 Ambient Air Quality

The Air Resources Division (ARD) of NHDES is the regulatory agency whose primary responsibility is to achieve and maintain air quality that is protective of public health and the natural environment (NHDES 2011). In doing so, ARD administers several programs to include a Statewide Permitting Program, a Compliance Program, an Air Toxics Control Program, an Atmospheric Science and Analysis Program, an Energy/Climate Change Program, a Mobile Sources Program, and an Environmental Health Program. These programs are designed to address many complex air quality issues through such tools as local, regional, and national collaborations, data gathering, analysis, and control efforts. ARD implements regulations through permit issuances to regulate air emissions from existing and new stationary sources.

A facility that has the potential to emit 100 tons (90.7 metric tons) or more per year of one or more of the criteria pollutants, or 10 tons (9.07 metric tons) or more per year of any of the listed hazardous air pollutants (HAPs), or 25 tons (22.7 metric tons) or more per year of an aggregate

total of HAPs is defined as a “major” source. Major sources are subject to Title V of the Clean Air Act (CAA) (42 U.S.C. 7401 et seq.), which standardizes air quality permits and the permitting process across the U.S. Permit stipulations include regulating source-specific emission limits, monitoring, operational requirements, recordkeeping, and reporting. Currently, Seabrook has a Title V Operating Permit (permit number: TV-017) issued by the NHDES (NHDES 2013a). Under the Title V permit, Seabrook is authorized to operate two auxiliary boilers, four large diesel-powered emergency generating units, some small emergency generating units, and a diesel-engine-driven air compressor. In addition, the plant has several small diesel-powered pumps and motors (permit exempt) that are operated infrequently and various small (permit-exempt) space heating units at the facility. Also, for the Seabrook Emergency Operations Facility (EOF) in Newington, NextEra previously held an NHDES-issued general state permit for an emergency diesel generator (permit number: GSP-EG-0398). The NHDES terminated the permit authorization in September 2013 at the request of NextEra because the generator was removed from the facility (NHDES 2013b).

Air emission sources at Seabrook emit criteria pollutants, volatile organic compounds (VOCs), and HAPs into the atmosphere. Emissions inventory data reported to the NHDES for calendar years 2005–2009 are presented in Table 2–2, which includes emissions from permitted sources specified in the permit. During the period 2005–2009, emissions of criteria pollutants, VOCs, and HAPs varied from year to year, but all reported annual emissions were well below the emission thresholds for a major source under Title V of the CAA.

Table 2–2. Annual Emissions Inventory Summaries for Permitted Sources at Seabrook, 2005–2009

	Annual emissions (tons/yr)[a]						
Year	CO	NO_x	PM_{10}	SO_x	VOCs	HAPs	CO_2e [b][c]
2005	6.29	24.65	0.59	9.71	0.59	0.04	7,893 (7,159)[d]
2006	3.48	13.90	0.36	8.38	0.31	0.03	21,933[e] (19,894)
2007	2.94	11.20	0.24	1.19	0.29	0.01	47,778 (43,336)
2008	4.07	16.23	0.42	9.66	0.36	0.04	21,568 (19,563)
2009	3.22	12.85	0.34	6.82	0.32	0.03	21,515 (19,515)

(a) CO = carbon monoxide; CO_2e = carbon dioxide equivalent; HAPs = hazardous air pollutants; NO_x = nitrogen oxides; PM_{10} = particulate matter ≤10 μm; SO_x = sulfur oxides; and VOCs = volatile organic compounds

(b) Total emissions at Seabrook, including permitted emissions and sulfur hexafluoride (SF_6) from the 345-kV Seabrook Transmission Substation

(c) CO_2 emissions for permitted sources were estimated by NRC staff using annual diesel consumption data from the applicant and the emission factors in EPA’s AP-42 (EPA 2011a): *Section 1.3 Fuel Oil Combustion* for auxiliary boilers; *Section 3.3 Gasoline And Diesel Industrial Engines* for small diesel engines (<600 horsepower); and *Section 3.4 Large Stationary Diesel And All Stationary Dual-fuel Engines* for large diesel engines (>600 horsepower).

(d) Values in parentheses are in metric tons (tonnes) carbon dioxide equivalent.

(e) FPL-NED did not use the methodology prescribed by the SF_6 Memorandum of Understanding between EPA and FPL-NED, effective February 3, 2005. Thus, SF_6 annual emissions during the year 2006 were not reported to the EPA. For comparison with emissions for other years, SF_6 emissions originally estimated by FPL-NED were presented.

Sources: (EPA 2011a; FPLE 2006, 2007, 2008b, 2008c, 2009a; FPL-NED 2006, 2007, 2008, 2009, 2010; NextEra 2009b, 2010b, 2010c)

Since the issuance of the permit, Seabrook has remained in compliance with its Title V permit. However, NHDES issued a letter of deficiency to Seabrook in April 2010, following a full site compliance evaluation for its failure to conduct an air toxics compliance determination per the state toxics rule (NHDES 2010a). In order to return to compliance, NextEra subsequently conducted and submitted to NHDES a dispersion modeling analysis for air toxics that demonstrated that air toxic emission levels are below *de minimis* levels and ambient air limits (NextEra 2010e).

Due to its stability and dielectric property, sulfur hexafluoride (SF_6) is widely used in the electrical industry and is contained in the switchyard breakers and bust ducts at the 345-kV Seabrook transmission substation. SF_6 is considered the most potent of greenhouse gases, with a global warming potential (GWP) of 23,900 times that of CO_2 over a 100-year time horizon (Solomon et al. 2007). In addition, SF_6 has an extremely long atmospheric lifetime of about 3,200 years, resulting in irreversible accumulation in the atmosphere once emitted. SF_6 is inadvertently released into the atmosphere during various stages of the equipment's lifecycle (e.g., leaks due to equipment age, leaks through valve fittings and joints). These emissions are regulated under New Hampshire Air Toxic Rules and subject to emission inventory reporting requirements under the plant's Title V Permit. SF_6 emissions are not subject to Federal regulations, but Seabrook, through FPL-New England Division (FPL-NED), is participating in a voluntary program with the EPA, the so-called SF_6 Emissions Reduction Partnership, to reduce greenhouse gas emissions from its operations via cost-effective technologies and practices (EPA 1999).

Annual CO_2 emissions were estimated by NRC staff for all permitted combustions sources at Seabrook for the period of 2005–2009. These estimates were based on annual diesel consumption data from the applicant and EPA's AP-42 emission factors (EPA 2011a). Estimated annual CO_2 emissions from all permitted combustion sources were added to SF_6 emissions from the 345-kV transmission substation to arrive at the total greenhouse gas emissions from Seabrook. As shown in Table 2–2, annual emissions for greenhouse gases were presented in terms of carbon dioxide equivalent (CO_2e). CO_2e is a measure used to compare the emissions from various greenhouse gases on the basis of their GWP, defined as the cumulative radiative forcing effects of a gas over a specified time horizon resulting from the emission of a unit mass of gas relative to a reference gas, CO_2. The CO_2e for a gas is derived by multiplying the mass of the gas by the associated GWP. For example, the GWP for SF_6 is estimated to be 23,900; thus, 1 ton of SF_6 emission is equivalent to 23,900 tons of CO_2 emission. Total greenhouse gas emissions from Seabrook are below the EPA's mandatory reporting threshold of 25,000 metric tons CO_2 equivalent per year (74 FR 56264; October 30, 2009), except in 2007 when SF_6 emissions exceeded the threshold due, in large part, to two equipment failures.

Under the CAA, the EPA has set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment (40 CFR Part 50). NAAQS are established for criteria pollutants—carbon monoxide (CO); lead (Pb); nitrogen dioxide (NO_2); particulate matter with an aerodynamic diameter of 10 microns or less and 2.5 microns or less (PM_{10} and $PM_{2.5}$, respectively); ozone (O_3); and sulfur dioxide (SO_2)—as shown in Table 2–3. The CAA established two types of NAAQS: primary standards to protect public health including sensitive populations (e.g., the young, the elderly, those with respiratory disease) and secondary standards to protect public welfare, including protection against degraded visibility and damage to animals, crops, vegetation, and buildings. Some states established State Ambient Air Quality Standards (SAAQS), which can adopt the Federal standards or be more stringent than the NAAQS. The State of New Hampshire has its own SAAQS (NHDES 2010),

which are also presented in Table 2–3. If both an SAAQS and an NAAQS exist for the same pollutant and averaging time, the more stringent standard applies.

Table 2–3. National Ambient Air Quality Standards and New Hampshire State Ambient Air Quality Standards

		NAAQS		
Pollutant[(a)]	**Averaging Time**	**Value**	**Type[(b)]**	**SAAQS**
CO	1-hour	35 ppm ($40\ mg/m^3$)	P	35 ppm ($40\ mg/m^3$)
	8-hour	9 ppm ($10\ mg/m^3$)	P	9 ppm ($10\ mg/m^3$)
Pb	Quarterly average	$1.5\ \mu g/m^3$	P, S	$1.5\ \mu g/m^3$
	Rolling 3-month average	$0.15\ \mu g/m^3$	P, S	-[(c)]
NO_2	1-hour	100 ppb	P	-
	Annual (arithmetic average)	53 ppb	P, S	0.053 ppm ($100\ \mu g/m^3$)
PM_{10}	24-hour	$150\ \mu g/m^3$	P, S	$150\ \mu g/m^3$
	Annual (arithmetic average)	-	-	$50\ \mu g/m^3$
$PM_{2.5}$	24-hour	$35\ \mu g/m^3$	P, S	$65\ \mu g/m^3$
	Annual (arithmetic average)	$15.0\ \mu g/m^3$	P, S	$15\ \mu g/m^3$
O_3	1-hour	0.12 ppm[(d)]	P, S	0.12 ppm ($235\ \mu g/m^3$)
	8-hour	0.08 ppm (1997 standard)	P, S	0.08 ppm
	8-hour	0.075 ppm (2008 standard)	P, S	-
SO_2	1-hour	75 ppm	P	-
	3-hour	0.5 ppm	S	0.5 ppm
	24-hour	0.14 ppm	P	0.14 ppm
	Annual (arithmetic average)	0.03 ppm	P	0.03 ppm

(a) CO = carbon monoxide; NO_2 = nitrogen dioxide; O_3 = ozone; Pb = lead; $PM_{2.5}$ = particulate matter $\leq 2.5\ \mu m$; PM_{10} = particulate matter $\leq 10\ \mu m$; and SO_2 = sulfur dioxide

(b) P = primary standards, which set limits to protect public health; S = secondary standards, which set limits to protect public welfare including protection against degraded visibility, damage to animals, crops, vegetation, and buildings.

(c) A hyphen denotes that no standard exists.

(d) EPA revoked the 1-hour ozone standard in all areas, although some areas have continuing obligations under that standard ("anti-backsliding").

Source: (EPA 2010c; NHDES 2010)

Areas considered to have air quality as good as, or better than, NAAQS are designated by EPA as "attainment areas." Areas where air quality is worse than NAAQS are designated as "non-attainment areas." Areas that previously were non-attainment areas but where air quality has since improved to meet the NAAQS are redesignated "maintenance areas" and are subject

to an air quality maintenance plan. Rockingham County, which encompasses Seabrook, is located in the Merrimack Valley-Southern New Hampshire Interstate Air Quality Control Region (40 CFR 81.81), including southern counties in New Hampshire and northeastern counties in Massachusetts. Within New Hampshire, portions of Hillsborough, Merrimack, Rockingham, and Strafford Counties are designated as moderate non-attainment areas with EPA's NAAQS for 8-hour ozone (40 CFR 81.330). Thus, the Town of Seabrook, encompassing Seabrook, is located in a non-attainment area for 8-hour ozone. In addition to local emissions, many of the ozone exceedances in New Hampshire are associated with the transport of ozone and its precursors from the upwind regions along prevailing winds. Cities of Manchester and Nashua in Hillsborough County are designated as a maintenance area for CO. With these exceptions, all counties in New Hampshire are designated as unclassifiable and attainment areas for all criteria pollutants.

In recent years, three revisions to NAAQS have been promulgated. Effective January 12, 2009, the EPA revised the Pb standard from a calendar-quarter average of 1.5 $\mu g/m^3$ to a rolling 3-month average of 0.15 $\mu g/m^3$ (73 FR 66964; November 12, 2008). Effective April 12, 2010, EPA established a new 1-hour primary NAAQS for NO_2 at 100 ppb (75 FR 6474; February 9, 2010), while, effective August 23, 2010, the EPA established a new 1-hour primary NAAQS for SO_2 at 75 ppb (75 FR 35520; June 22, 2010) (EPA 2014). The attainment status for Rockingham County has not changed.

Through operation of a network of air monitoring stations, NHDES has determined that the area is in compliance with the SAAQs. Air monitoring stations around the Seabrook include the following (EPA 2010c):

- Peirce Island in Portsmouth, located about 13 mi (21 km) north-northeast of Seabrook, where NO_2, PM_{10}, $PM_{2.5}$, O_3, and SO_2 are monitored and
- Seacoast Science Center in Rye, located about 12 mi (19 km) northeast of Seabrook, where ozone is monitored.

Nearby stations for CO are Manchester and Nashua in Hillsborough County. No measurements for Pb are available for New Hampshire.

In addition to capping increases in criteria pollutant concentrations below the levels set by the NAAQS, the Prevention of Significant Deterioration of Air Quality (PSD) Regulations (40 CFR 52.21) mandate stringent control technology requirements for new and modified major sources. As a matter of policy, EPA recommends that the permitting authority notify the Federal Land Managers (FLMs) when a proposed PSD source would locate within 62 mi (100 km) of a Class I area. If the source's emissions are considerably large, EPA recommends that sources beyond 62 mi (100 km) be brought to the attention of the FLMs. The FLMs then become responsible for demonstrating that the source's emissions could have an adverse effect on air quality-related values (AQRVs), such as scenic, cultural, biological, and recreational resources. There are two Class I areas in New Hampshire: Presidential Range-Dry River Wilderness Area and Great Gulf Wilderness Area, about 85 mi (137 km) north-northwest and about 97 mi (156 km) north-northwest, respectively, of the station (40 CFR 81.419). The next nearest one is Lye Brook Wilderness Area in Vermont (40 CFR 81.431), which is located about 108 mi (174 km) west of the Seabrook. All these Class I areas are managed by the U.S. Forest Service. None of these Class I areas are situated within the aforementioned 62-mi (100-km) range. Considering the locations and elevations of these Class I areas, prevailing westerly wind directions, distances from Seabrook, and minor nature of air emissions from Seabrook, there is little likelihood that activities at Seabrook would adversely impact air quality and AQRVs in any of these Class I areas.

The onsite meteorological monitoring system currently in operation will continue to serve in that capacity for the period of extended Seabrook operations with no major changes or upgrades anticipated. The current system consists of two independent subsystems that collect meteorological data and process the information into useable data. The primary meteorological tower is located about 1,700 ft (518 m) northwest of the Unit 1 Containment Structure (NextEra 2010c). The primary tower has instruments at 3 levels (43 ft (13 m), 150 ft (46 m), and 209 ft (64 m)); the base of the tower is 10 ft (3 m) above MSL. Wind speed and wind direction are collected at 43-ft (13-m) and 209-ft (64-m) levels. Temperature is collected at the 43-ft (13-m) level, while solar radiation is collected at the 10-ft (3-m) level. Temperature differences are measured between 150- and 43-ft levels and between the 209- and 43-ft levels to compute the atmospheric stability. Precipitation data from a rain gauge are also collected near the base of the tower.

The signal translators convert sensor information from the tower and output at strip chart recorders in the instrument shelter; outputs are also monitored by the main plant computer system (MPCS), which samples once every 5 seconds. The most recent instantaneous data are available for on-demand display on MPCS terminals at the control room (CR) and other locations for emergency response and meteorological-related functions. In addition, every fourth 15-minute data values are archived for long-term storage by the MPCS, and the previous 24 hours of archived data values can also be displayed on-demand at the CR, the technical support center, and the EOF.

The backup meteorological tower is located about 200 ft (61 m) southeast of the primary meteorological tower. The backup meteorological tower collects wind speed and wind direction at the 37-ft (11-m) level. Signals from the backup tower are routed to a data acquisition system (DAS) located in a nearby instrument shelter. The DAS samples wind speed and wind direction every 3 seconds and transmits the data to the computer at the CR. These data are available for on-demand display on a video terminal at the CR.

2.2.3 Geologic Environment

This section describes the current geologic environment of the Seabrook site and vicinity including landforms, geology, soils, and seismic conditions.

Physiography and Geology. Seabrook is situated in the Seaboard Lowland section of the New England physiographic province. The topography is characterized by broad open areas of level tidal marshes, which are dissected by numerous meandering tidal creeks and linear, man-made drainage ditches, interrupted locally by wooded “islands” or peninsulas, which rise to elevations of 20–30 ft (6−9 m) above MSL. The plant is sited on one such peninsula, which is underlain by quartz diorite and includes quartzitic bedrock of generally Middle Paleozoic Age (i.e., about 400–300 million years before present). On the site, this bedrock forms a partially buried ridge trending in an approximately easterly direction. All safety-related site structures are founded on sound bedrock, on concrete fill extending to sound bedrock, or on controlled backfill extending to sound bedrock. A large portion of the site, including Unit 1, is founded on Newburyport quartz diorite, characterized as a hard, durable crystalline igneous rock consisting of medium to coarse-grained quartz diorite with inclusions of dark gray, fine-grained diorite. The bedrock is intruded by northeasterly trending diabase dikes at widely spaced intervals. Faults in the bedrock, that were identified and mapped during plant construction, were found to be discontinuous in nature and to die out at one or both ends within the excavated area or were transected by younger mafic dikes. Detailed observations of the bedrock surface and overlying stratified soils have revealed no evidence of post-glacial fault offsets (FPLE 2008).

Prior to plant construction, the bedrock underlying the plant site was generally overlain by a thin veneer of glacial and post-glacial sediments comprised of Late Pleistocene (Wisconsinan) glacial till and locally overlain by post-glacial sandy outwash deposits and marine clay. Recent swamp, marsh, dune, and alluvial deposits are the youngest geological materials in the area. As indicated above, all surficial materials have been removed in the area of all major plant facilities to base these structures on competent bedrock or concrete backfill. To the south and north of the plant, the depth to bedrock increases under the tidal marshes where it is as much as 70 ft (21 m) or more below MSL, as verified by NRC staff review of geologic cross sections for the plant and vicinity. A sequence of marine and recent marsh deposits normally rests on the till along or just north of the Browns River, near the northern site boundary, and also in adjoining areas to the south (FPLE 2008).

Soils. Soil unit mapping by the National Resources Conservation Service (NRCS) identifies the majority of the Seabrook site as Udorthents, smoothed. In general, the Udorthents classification is used to identify disturbed land with soil materials that are excessively well-drained and heterogeneous in nature. This is consistent with the developed and engineered nature of the main Seabrook site. Small areas and strips—corresponding to relatively undisturbed wooded areas along the northern strip and southern border of the plant complex encompassing the Seabrook Science and Nature Center—include soils mapped as Unadilla very fine sandy loam, 3–8 percent slopes, and Chatfield-Hollis-Canton complex, 3–8 percent slopes, very stony. These soils are derived from glacial till and other glacial materials. Chatfield-Hollis-Canton complex corresponds to inclusions of very thin soils derived from till and underlain by hard bedrock at a depths of less than 35 in (89 cm). A small inclusion of soils mapped as Deerfield fine sandy loam, 0–3 percent slopes, occurs to the west of the main plant complex along Rocks Road. These moderately well-drained soils derive from sandy outwash deposits. Marsh areas to the north, south, and east of the plant complex consist of soils mapped as Ipswich mucky peat (NRCS 2011).

Seismology. The historical seismicity of the tectonic province encompassing Seabrook is characterized by broad areas of little to no historical earthquake activity, interrupted locally by clusters of small to moderate events located in eastern-most Maine, south-central Maine, south-coastal Maine, and near Portsmouth in southeastern New Hampshire (FPLE 2008). A total of 66 small earthquakes (most ranging in magnitude from 2.5–3) have been recorded within a radius of 62 mi (100 km) of Seabrook. The largest was a magnitude 4.7 event in 1982, centered 56 mi (90 km) northwest of the site to the north of Concord, NH. The closest was a magnitude 2.3 event that was epicentered approximately 1.9 mi (3 km) southeast of the station (USGS 2011).

However, larger earthquakes have occurred. Most notably, the earthquakes of 1755 and 1727, the largest historic events recorded in New England, were centered offshore of Cape Ann, MA, about 14 and 30 mi (23 and 48 km), respectively, to the southeast of the station. The larger, November 18, 1755, event produced modified Mercalli intensity (MMI) VIII shaking at its epicenter (FPLE 2008). Its estimated magnitude was 6.0 (NESN 2011). Ground motion in this range could cause considerable damage to ordinary substantial buildings with only slight damage to specially designed structures (USGS 2011a). An epicenter intensity MMI VIII event was, therefore, established as the maximum earthquake for Seabrook. Nonetheless, as detailed in the updated final safety analysis report, it is inconceivable that an MMI VIII earthquake could occur on the crystalline bedrock at this site, as a nearby earthquake occurring on the adjacent tidal marsh and beach materials would be attenuated to MMI VI or less on the site bedrock. Still, the 1755 Cape Ann earthquake was used to establish the safe shutdown earthquake (SSE) for Seabrook. The horizontal peak ground acceleration (PGA) associated

with this maximum earthquake potential is 0.25g (i.e., force of acceleration relative to that of Earth's gravity, "g") (FPLE 2008).

For the purposes of comparing the SSE with a more contemporary measure of predicted earthquake ground motion, the NRC staff reviewed current PGA data from the U.S. Geological Survey (USGS) National Seismic Hazard Mapping Project. The PGA value cited is based on a 2 percent probability of exceedance in 50 years. This corresponds to an annual frequency (chance) of occurrence of about 1 in 2,500 or 4×10^{-4} per year. For Seabrook, the calculated PGA is approximately 0.155g (USGS 2011b).

Under the right conditions, very large undersea earthquakes may cause tsunamis or seismic sea waves. However, tsunami activity is extremely rare on the U.S. Atlantic coastline as the only major subduction zones that are more prone to produce large tsunamis are along the Caribbean Sea (FPLE 2008; USGS 2011c). Although the possibility of tsunami impacts along the Gulf of Maine does exist from earthquakes and submarine landslides that occur in the Atlantic Ocean, the chances of a catastrophic event are minimal. The closest tectonic boundary to the Gulf of Maine area is the Mid-Atlantic Ridge, which is a seafloor-spreading center where most of the motion does not involve vertical movement necessary to produce large tsunamis (MGS 2011). The only significant tsunami recorded on the northeastern U.S. coast resulted from the Grand Banks earthquake of 1929 (FPLE 2008; MGS 2011). The 7.2 magnitude earthquake on the south coast of Newfoundland triggered an underwater landslide and resulting tsunami. The tsunami was comprised of three waves ranging from 7–23 ft (2–7 m) in height, and it struck the coast of Newfoundland about 2.5 hours after the earthquake. Runup heights (the height of water onshore as measured from sea level) on Newfoundland's Burin Peninsula ranged from 28–89 ft (8.5–27 m) at the heads of some long, narrow bays (MGS 2011). However, the southward propagation of the tsunami was insignificant and was only observable on tidal gauges down the U.S. East Coast (FPLE 2008; NWS 2011). In addition, there are no historical reports for this tsunami having affected the Gulf of Maine (MGS 2011). For Seabrook, design analyses indicated that the maximum suspected tsunami would result in only minor wave action, which would be insignificant compared to the maximum expected hurricane storm wave effects (FPLE 2008).

2.2.4 Surface Water Resources

Seabrook is located nearly 2 mi (3 km) from the Atlantic Ocean on the western shore of Hampton Harbor. The station site is situated on an upland with tidal marshland to the east and bounded on the north by tidally influenced Browns River and its tributaries and on the south by Hunts Island Creek (see Figure 2–3). All site surface drainage flows toward these two tidal streams. Between the marsh area and the ocean is the shoreline community of Hampton Beach. The Atlantic Ocean's western Gulf of Maine is the source of cooling water for Seabrook (FPLE 2008; NextEra 2010a).

Seabrook's discharge to surface water is permitted under its NPDES permit (EPA 2002), which was issued April 1, 2002. The permit allows chlorine or the commercial product EVAC, or both, to be used to control biofouling. Chlorine Minimization Reports are to be submitted annually to the EPA to document the amount of chlorine used. The permit allows discharge at outfall 001 of 720 mgd (2.7 million m^3/day) on both an average monthly and maximum daily basis. This outfall collects all site discharges, including once-through cooling water discharge, stormwater, dewatering system discharge, groundwater containment system discharge, and internal outfalls, and it conveys the combined water via tunnel to the discharge structure in the Atlantic Ocean. The discharge of radioactive effluents is allowed in accordance with NRC regulations (10 CFR Part 20 and the Seabrook Operating License, Appendix A, Technical Specifications).

The permit also has limits for outfall 001 on temperature rise, total residual oxidants (TROs), pH, whole effluent toxicity, and the molluscicide EVAC. EVAC may be applied twice per year during an application of less than 48 hours. The internal outfalls include various discharges, such as blowdown from the standby cooling tower, drains, sumps, and oil and water separators. Monitoring parameters at these outfalls include flow, oil and grease, total suspended solids, metals, pH, and TROs. NRC staff performed an informal walkover survey of these systems during the environmental site audit.

The 5-year permit expired in 2007. An NPDES permit renewal application was submitted to EPA in 2006. The EPA noted that the application was timely and complete; therefore, plant operations may continue under the current permit—which remains valid—until a new permit is issued (EPA 2007). NextEra stated during the site audit that the current expired permit remains valid for chemical usage.

A recent NPDES compliance evaluation inspection (CEI) (NHDES 2010b) noted occasional errors in submitted monthly discharge monitoring reports (DMRs) and indicated that corrected DMRs had been submitted. The recent errors were subsequently corrected by Seabrook to the satisfaction of the State (NHDES 2010c).

An EPA online database indicated that Seabrook has had no Clean Water Act formal enforcement actions in the prior 5 years (EPA 2010d). The database indicated, during a 12-quarter period from 2007–2010, three limit violations of pH at outfall 001, one limit violation of pH at internal outfall 026 (metal cleaning wastes), and one total suspended solids limit violation at internal outfall 025 (SG blowdown or other processes or both).

The plant's Stormwater Pollution Prevention Plan (SWPPP) identifies potential sources of pollution and lists three past spills or leaks (NextEra 2009). These incidents took place in 2000–2001 and involved leaks of lubricating oil, fuel oil, and gasoline and diesel fuel lines. Spill response or remediation took place in each case. NextEra reported during the site audit that, since the completion of the SWPPP, they have had no reportable spills.

No dredging takes place at intake or discharge structures, as noted by NextEra during the site audit. NextEra also described that divers are used to clean the station's ocean intakes twice per year, and they have not observed ocean sediment building up near the structures.

Sanitary wastewater is discharged to the municipal wastewater treatment system. Seabrook is authorized by the Town of Seabrook to discharge a daily maximum of 1,120 gpd (4, 240 L/day) of process wastewater or 16,420 gpd (62,160 L/day) of combined process and sanitary wastewater during normal operations (NextEra 2010a; Town of Seabrook 2014).

2.2.5 Groundwater Resources

Groundwater in the Seabrook vicinity is present in unconsolidated glacial and recent deposits and in fractured bedrock. In the glacial drift, thick, coarse-grained deposits of sand and gravel are the main aquifers; they are used as the source of municipal water supplies in Seabrook and other towns. Other unconsolidated materials, such as glacial till and marine clay deposits, have low permeability and restrict groundwater movement. The tidal marshes contain brackish groundwater and have low permeability. In general, groundwater occurs under water table conditions except in places where it is confined by marine sediments. Groundwater recharge is principally via infiltrating precipitation, but recharge is greatly retarded in areas where the soil is composed of marine clays. The regional water table approximates the surface topography and frequently occurs within 10 ft (3 m) of the ground surface. Groundwater movement is limited to drainage areas where streams intersect the water table and in areas where streams are tributary to tidewater. Because these drainages are relatively small, groundwater flow paths

from points of recharge to discharge generally do not exceed 1 mi (1.6 km). As such, prior to development of the plant site, natural groundwater flow from site upland areas was toward the tidal marshes (FPLE 2008). This general pattern continues, as is shown in current site water level maps for the shallow glacial and bedrock aquifers (RSCS 2009a), though the shallow system has a localized cone of depression due to dewatering at the Unit 2 containment building.

The nearest groundwater supply wells include several private wells located at least 3,000 ft (910 m) north of the site (NextEra 2010a). The nearest municipal well system is that of the Town of Seabrook, with wells located at least 2 mi (3.2 km) from the site, drawing from glacial-drift aquifers (FPLE 2008). There are no designated sole source aquifers in the vicinity of Seabrook; the closest is over 50 mi (80 km) away (EPA 2010e).

In September 1999, groundwater with elevated tritium activity concentrations was detected in the annular space around the Unit 1 containment structure. A leak of 0.1 gpd (0.38 liters per day (L/day)) was determined to be present from the cask loading area and transfer canal adjacent to the SFP. After the drain collection lines were cleaned, leakage increased over 2 years to about 30–40 gpd (110–150 L/day) (NextEra 2010a; RSCS 2009a). The SFP leakage contaminated the surrounding concrete of the structure and resulted in diffusion of tritium into groundwater around the FSB. This leak was not directly to groundwater but to the interstitial space between the stainless steel fuel pool liner and the concrete building foundation. As part of mitigation efforts, the interstitial space was drained, and the leak in the stainless steel liner was repaired (RSCS 2009a). Additionally, to control tritium, a dewatering system was installed in 2000–2001 in the PAB and containment area of Unit 1 (NextEra 2010a). Five dewatering points now withdraw approximately 3,000 gpd (11,400 L/day) of groundwater (NextEra 2010a; RSCS 2009a), though variation is observed, especially seasonally. The dewatering points, along with estimated withdrawal rates, according to NextEra staff interviewed during the site audit, include the following:

- 1,000 gpd (3,800 L/day) from the containment enclosure ventilation area (CEVA),
- 150 gpd (560 L/day) from the PAB adjacent to the SFP,
- 200 gpd (760 L/day) from the residual heat removal (RHR) B-equipment vault, and
- a small volume from the B electrical tunnel and the emergency feedwater (EFW) pump house I.

The depths of these dewatering wells and dewatering points range from -16 to -61 ft (-4.8 to -18 m) MSL (RSCS 2009a). As discussed in Section 2.2.4, disposal of groundwater from the tritium dewatering points and the Unit 2 dewatering system is allowed at outfall 001.

Monitoring of the dewatering system has taken place since 2000, and NRC staff reviewed data from 2000–2009, as presented in the 2009 Site Conceptual Ground Water Model for Seabrook Station (RSCS 2009a). The results indicate tritium concentrations over 3,500,000 picocuries per liter (pCi/L) in the CEVA in 2003, approaching 19,000 pCi/L in the PAB, up to nearly 3,000 pCi/L in the RHR and B electrical tunnel, and over 7,000 pCi/L in the EFW. Since 2005, the CEVA readings have generally been below 50,000 pCi/L, and the PAB levels have generally trended below 5,000 pCi/L, although periodic spikes in tritium levels have been recorded in some dewatering points over the period (NextEra 2011a). This general decrease is attributed to a non-metallic liner that was added to the canal as part of repairs in 2004 (RSCS 2009a).

As noted earlier in this section, a groundwater dewatering system continues to be operated to contain and treat the tritium plume. During the site audit, NRC staff inspected the interior piping

of the dewatering system, a sampling port, and a connection to the containment building roof drainpipe. A demineralizer system prevents scaling in the narrow pipes. Monitoring of the dewatering system, which receives both storm water and the dewatering system discharge, takes place at the storm drain rad monitor (housed in the auxiliary boiler room of the PAB). Tritium measurements, from approximately weekly sampling from December 2008–November 2010, were generally less than the detection limit of approximately 6×10^{-7} µCi/ml (or 600 pCi/L) (NextEra 2010f). Several samples had measurable amounts of tritium. The highest value was 1.58×10^{-5} µCi/ml (or 15,800 pCi/L), which is below the EPA standard of 20,000 pCi/L. Other detections were an order of magnitude lower. This monitoring is conducted by NextEra, independent of any regulatory requirements.

Based on the most recent (2011) dewatering system monitoring data available for the site, tritium concentrations in the CEVA have ranged from in 2,150 to 50,000 pCi/L, 2,060 to 4,240 pCi/L in the PAB, up to 582 pCi/L in the RHR and 800 pCi/L in the B electrical tunnel, and 577 pCi/L in the EFW (NextEra 2011a).

In response to the tritium detections, NextEra also instituted a groundwater monitoring network consisting of 22 wells. In 2004, 15 wells were installed, and 4 more were installed in 2007−2008. These are arranged as single shallow wells up to 10 ft (3 m) deep or as pairs of single and deep wells, with the deep wells ranging up to 174 ft (53 m) deep. (RSCS 2009a). The wells are located within the nuclear protected area and around its periphery. Most of the monitoring wells are flush-mounted. At the site audit, NRC staff observed rainwater ponding atop some flush-mounted well covers but not entering the wells. In 2009, three temporary wells (TW-1, TW-2, and TW-3), up to 10 ft (3 m) deep, were installed in the marsh along the south seawall, outside the sheet piling, and south of the PAB (RSCS 2009a). In 2010, five additional wells were installed (NextEra 2011b).

Results of groundwater sampling, generally conducted on a quarterly basis from September 2004–March 2009, are presented in RSCS (2009a). The data indicate tritium concentrations in a shallow aquifer well (SW-1) near the Unit 1 containment ranging from less than 601–2,930 pCi/L, with no apparent trend. Detections were observed in two other shallow wells in November 2004, ranging up to 1,570 pCi/L (in SD-2) and in one bedrock well (in BD-3) with a concentration of 880 pCi/L. Levels have been below the detection limit of approximately 600 pCi/L ever since. The other shallow wells and bedrock wells have consistently had results below the detection limit. Additional data from June–August 2009 indicate tritium at two wells that previously had levels below the detection limit. These two wells (SD-1 and BD-2) are located approximately 75 ft (23 m) southwest of SW-1. Shallow well SD-1 had results from 14 samples during this period with concentrations ranging from 969–2,360 pCi/L, with no apparent trend. The adjacent bedrock well (BD-2) had results from 13 samples with concentrations ranging from greater than 568–1,880 pCi/L. Data from this well indicate a decreasing trend to levels below the detection limit of about 600 pCi/L but with a final measurement of 1,104 pCi/L in late August 2009 (NextEra 2010g; RSCS 2009b). The tritium detections at these wells were attributed to heavy rainfall and a high water table during the data collection period as well as issues concerning well construction (RSCS 2009b).

At the three temporary wells installed in the marsh south of the PAB and downgradient of the tritium leak source, four quarters of sampling data during 2009–2010 yielded tritium results below the detection limit of approximately 600 pCi/L (NextEra 2010f).

NextEra continues to conduct groundwater monitoring as part of its participation in the Nuclear Energy Institute's Groundwater Protection Initiative (NextEra 2010a). Monitoring results obtained through the onsite Groundwater Protection Program are reported in NextEra's radioactive effluent release reports, which are submitted to the NRC. Based on monitoring

results from the above-referenced wells spanning the whole of 2010 through the end of 2011, tritium levels have ranged from 1,370 to 2,850 pCi/L in SW-1 based on nine positive samples. There were also two detections out of nine samples in SD-1 at 804 and 1,030 pCi/L, both in August 2011. Tritium was also detected in one sample from BD-2 at 1,400 pCi/L in December 2011. Again, no apparent trend in tritium concentrations is evident from these results. There were no detections in samples from SD-2, BD-3, or from the marsh perimeter wells (wells TW-1, TW-2, and TW-3). Likewise, sample results from the five new wells (i.e., BD-6, SD-5, SW-4, SW-5, and SW-6) yielded no detections of tritium above analytical detection limits. Finally, NextEra reported no unplanned, unanticipated, or abnormal releases of liquid effluents from the site to unrestricted areas during 2010 and 2011 (NextEra 2010g, 2011b, 2012a).

Water level maps for both the shallow aquifer and bedrock aquifer indicate hydraulic containment of most of the site groundwater, including the five tritium dewatering points, by the Unit 2 dewatering system (NextEra 2010f; RSCS 2009a). Overall groundwater monitoring continues to suggest that offsite migration of tritium above the standard of 20,000 pCi/L is not occurring.

Groundwater monitoring of two wells at the vehicle maintenance building has continued since 2001 for methyl tert-butyl ether (MTBE) due to a prior release of gasoline. Haley and Aldrich (2009) summarized the decrease in MTBE from as much as 27,000 µg/L in 2001 to 25 µg/L in November 2009. Monitoring may cease when data from 2 consecutive years are below the State standard of 13 µg/L.

2.2.6 Aquatic Resources

2.2.6.1 Description of the Gulf of Maine and Hampton-Seabrook Estuary

Gulf of Maine

The Gulf of Maine is a semi-enclosed sea bounded in the south by Cape Cod, MA, and in the north by Nova Scotia, Canada. This large area extends approximately 20 mi (320 km) into the Atlantic Ocean and includes Jeffrey's Ledge, Bay of Fundy, and Georges Bank. The Gulf of Maine is located within the Acadian biogeographic province. The unique geology, topography, and oceanographic conditions within the Gulf of Maine support large phytoplankton and zooplankton populations that form the trophic basis of many commercial fisheries and their prey. Marine mammals, such as whales, seals, and porpoises, also inhabit the Gulf of Maine due in part to the abundance of fish and other prey (Thompson 2010). Approximately 3,317 known species inhabit the Gulf of Maine (Valigra 2006).

Habitat within the Gulf of Maine is generally more complex and diverse than in more southern temperate coastal areas due to the geologically diverse coastal and ocean basin. This complex geology includes deep basins, shallow banks, and various channels as well as smaller-scale geological features, such as canyons, pinnacles, and shoals. In the southwestern portion of the Gulf of Maine, a thick layer of sediments and glacial deposits cover a relatively flat ocean floor that gradually slopes deeper with distance from shore (Thompson 2010).

Currents within the Gulf of Maine generally move in a counter-clockwise, or cyclonic, direction. Along the coast, water flows south around Nova Scotia, into the Bay of Fundy, and then continues in a southerly direction along the coast, which is known as the Maine coastal current. The Maine coastal current is strongly influenced by the large discharge of fresh spring melt water off the Canadian and U.S. coasts. Large-scale oceanographic circulations transport water from as far as Cape Hatteras in North Carolina and the Labrador Sea in Canada. Thus, local

conditions, as well as ocean waters from as far as 1,000 mi (1,609 km) away, influence the water properties and dynamics within the Gulf of Maine.

Common Habitats and Taxa in the Gulf of Maine

Rocky Intertidal and Subtidal Habitats. Rocky subtidal habitats are one of the most productive habitats in the Gulf of Maine (Mann 1973; Ojeda and Dearborn 1989). Rocky subtidal is the prominent habitat type near the Seabrook intake and discharge structures (NAI 2010). Algae, mussels, and oysters attach to the bedrock on the seafloor and form the basis of a complex, multi-dimensional habitat for other fish and invertebrates to use for feeding and hiding from predators (Thompson 2010; Witman and Dayton 2001). Spawning fish, such as herring (*Clupea* spp.) and capelin (*Mallotus villosus*), shield eggs from currents and predators within rock crevices or sessile organisms attached to the bedrock (Thompson 2010). In the subtidal, predatory fish—such as pollock (*Pollachius virens*), cunner (*Tautogolabrus adspersus*), and sculpin (*Myoxocephalus octodecemspinosus*)—and predatory invertebrates—such as the American lobster (*Homarus americanus*), Jonah crabs (*Cancer borealis*), and Atlantic rock crabs (*Cancer irroratus*)—forage in rocky habitats (Ojeda and Deaborn 1991). Ojeda and Dearborn (1991) determined that the most common prey items included Jonah and rock crabs, blue mussels (*Mytilus edulis*), juvenile green sea urchins (*Strongylocentrotus droebachiensis*), and Atlantic herring (*Clupea harengus*). In the rocky intertidal, mussels, crabs, sea urchins, and other marine organisms can be important prey items for mammals and seabirds (Carlton and Hodder 2003; Ellis et al. 2005)

Species often compete for space within rocky subtidal and intertidal habitats. The area where species eventually settle is often a trade-off between accommodating physiological stress and avoiding predation or competition with other species. For example, lower depths may provide a more ideal habitat in terms of physical requirements (temperature, pressure, salinity, avoiding desiccation, etc.), but shallower areas may provide a refuge from predation. As a result, many organisms that use rocky subtidal and intertidal habitats are restricted to a depth zone that balances physiological and biological pressures (Witman 1987).

The species distribution of common seaweeds displays vertical zonation, whereby certain species are most common at a specific depth. In the splash zone of the intertidal, which is one of the harshest environmental conditions due to desiccation and physical scouring by waves, cyanobacteria are most common. With increasing depth, green algae, brown algae, and then red algae become most common (Stephenson and Stephenson 1972; Witman and Dayton 2001). Common brown algae species in the shallow subtidal (13–26 ft (4–8 m) below MLLW) include sea belt (*Saccharina latissima*) and *Laminaria digitata*, whereas *Agarum clathratum*, *Laminaria* spp., and *Alaria esculenta* are more common in deeper areas (NAI 2010; Ojeda and Dearborn 1989; Witman 1987). Common red algae taxa in shallow subtidal areas near Seabrook include Irish moss (*Chondrus crispus*), *Ceramium virgatum*, *Phyllophora* spp., and *Coccotylus* spp. (NAI 2010). *Phyllophora* spp., *Coccotylus* spp., *Phycodrys ruben*, and *Euthora cristata* become more common with increasing depth (NAI 2010). An estimated 271 species of macroalgae, or algae large enough to been seen with the naked eye, grow in the Gulf of Maine (Thompson 2010).

Invertebrates also display distinct vertical zonation along rocky habitats in the Gulf of Maine. In the intertidal, barnacles (*Semibalanus balanoides*) often dominate in the splash zone and blue mussels dominate lower areas (Menge and Branch 2001). Predation by whelks (*Nucella lapillus*), sea stars (*Asterias* spp.), and green crabs (*Carcinus maenas*) limit the population of blue mussels in lower depths (Lubchenco and Menge 1978). In the shallow subtidal, the infralittoral zone is the area dominated by macroalgae, which generally ends when there is insufficient light for photosynthesis. Below the infralittoral zone is the circalittoral zone,

which is defined as the area dominated by sessile and mobile invertebrates below the infralittoral zone (Witman and Dayton 2001). With increasing depth, the general zonation of invertebrates includes sponges, sea anemones, soft corals, mussels (blue mussels and northern horsemussel (*Modiolus modiolus*)), sea stars, and sea urchins (Witman and Dayton 2001). Approximately 1,410 species of invertebrates live in the Gulf of Maine (Thompson 2010).

Demersal fish are those that live on, or near, the bottom of the sea floor. Common demersal fish include Gadids—such as cods, burbot, hake, pollock, and rocklings—and flatfish—such as flounders, halibut, plaice, and sole (NAI 2010; Thompson 2010). Near Seabrook, the most common species include winter flounder (*Pleuronectes americanus*), hake (*Urophycis* spp.), yellowtail flounder (*Pleuronectes ferruginea*), longhorn sculpin, Atlantic cod (*Gadus morhua*), *Raja* spp., windowpane (*Scopthalmus aquosus*), rainbow smelt (*Osmerus mordax*), ocean pout (*Macrozoarces americanus*), whiting or silver hake (*Merluccius bilinearis*), and pollock (NAI 2010).

Kelp Beds. Kelp seaweeds, brown seaweeds with long blades, attach to hard substrates and can form the basis of undersea "forests," commonly referred to as kelp beds. The long blades of kelp species—such as *A. clathratum*, *L. digitata*, and sea belt—provide the canopy layer of the undersea forest, while shorter foliose and filamentous algae, such as Irish moss, grow in between or at the bottom of kelp similar to the understory layer in a terrestrial forest (NAI 2010; Thompson 2010). The multiple layers of seaweeds provide additional habitat complexity for other fish and invertebrates to find refuge from predators and harsh environmental conditions, such as strong currents or ultraviolet light (Thompson 2010). Lobsters often molt, or shed their exoskeleton to grow, while hiding in kelp beds (Harvey et al. 1995, cited in Thompson 2010). Due to the ecological services provided by kelp, these organisms play a large role in the productivity and species diversity within kelp forests. Biologists refer to such species as "habitat formers."

Sandy Bottom and Mud Flats. Soft sediments, such as sand or mud, covering the ocean floor are a common habitat within the Gulf of Maine. A wide variety of organisms inhabit sandy or muddy bottom areas by living within (infauna) or on top of (epifauna) the sand or mud. The most common organisms includes polychaete worms, isopods and amphipods, larger crustaceans (e.g., crabs and shrimp), echinoderms (e.g., sea stars and sea urchins), and mollusks (e.g., surf clams (*Spisula solidissima*), soft shell clams (*Mya arenaria)*, truncate softshell clam (*Mya truncate*), and sea scallops (*Placopecten magellanicus*)) (Lenihan and Micheli 2001; NAI 2010). Species distribution is often a combination of several factors such as the size and chemical properties of the sandy substrate, exposure to waves or tidal action, recruitment patterns, availability of organic matter for food, and biological interactions with other species, such as predation, competition, parasitism, and positive interactions (Lenihan and Micheli 2001).

Pelagic Habitats. The water column is an important habitat for plankton, fish, marine mammals, turtles, and other pelagic organisms. Different water masses at various depths provide unique habitats with varying temperatures, salinities, flow, and pressure.

Phytoplankton—microscopic floating photosynthetic organisms—are pelagic organisms that form the basis of the Gulf of Maine food chain. Phytoplankton play key ecosystem roles in the distribution, transfer, and recycling of nutrients and minerals. Zooplankton are small animals that float, drift, or weakly swim in the water column of any body of water. Zooplankton include, among other forms, fish eggs and larvae with limited swimming ability, larvae of benthic invertebrates, medusoid forms of hydrozoans, copepods, shrimp, and krill (Euphausiids). Plankton are often categorized by how and where they inhabit the water column, including

holoplankton (plankton that spend their entire lifecycle within the water column), meroplankton (plankton that spend a portion of their lifecycle in the water column), and hyperbenthos (benthic species that primarily reside on the seafloor but migrate into the water column on a regular basis).

Approximately 652 species of fish live in, or migrate through, the Gulf of Maine, although only 13 percent (87 species) live their entire lives within Gulf of Maine (Thompson 2010). Pelagic fish are those that live within the water column but not at the bottom of the water column. Overholtz and Link (2006) determined that Atlantic herring is a keystone species in the Gulf of Maine due to its importance as a prey item for marine mammals, fish, and seabirds (Overholtz and Link 2006). Common shark species include spiny dogfish (*Squalus acanthias*), which has become an important fish predator in the past few decades due to the decline in Atlantic cod, and other commercial-sought predatory fish. Other relatively common species in the vicinity of Seabrook include Atlantic mackerel (*Scomber scombrus*), blueback herring (*Alosa aestivalis*), pollock, silver hake, alewife (*Pomolobus pseudoharengus*), and rainbow smelt (*Osmerus mordax*) (NAI 2010).

<u>Connectedness of Habitats</u>. Each habitat type within the Gulf of Maine is highly connected to other habitats due to various biological, physical, and oceanographic processes. Most species inhabit multiple habitat types throughout their life cycle. For example, the movement of water connects biological communities by transporting food, nutrients, larvae, sediment, and pollutants. Movement of water may be vertical, such as upwelling, or horizontal, as in the currents described above. Upwelling occurs in areas where the underwater topography and currents force cold, nutrient-rich currents to rise towards the sea surface. The influx of nutrients support the growth of phytoplankton, which, in turn, attracts dense aggregations of smaller pelagic fish, such as Atlantic herring and mackerel, and their predators, such as larger fish, mammals, and birds. Since the various physical and chemical characteristics within the water column—such as temperature, light, salinity, density, and nutrients—change with depth and distance from shore, aquatic organisms often migrate to find ideal conditions, such as food, refuge from predators, or less physiological stress. For example, several benthic organisms, such as lobsters, live and grow in the water column during early life stages to avoid benthic predators. As juveniles and adults, lobsters inhabit rocky or soft-bottom habitats in order to find prey.

Hampton-Seabrook Estuary

The Seabrook site is located within the Hampton-Seabrook Estuary, which is part of the Hampton-Seabrook watershed that provides freshwater inputs to the Gulf of Maine. The estuarine currents are tidally dominated, meaning that that the ocean tides play a dominant role in the circulation and transport of sediments within the estuary. Freshwater inputs to the watershed primarily come from the following bodies of water: Tide Mill Creek, Taylor River, Hampton Falls River, Browns River, Cain's Brook, Blackwater River, and Little River.

The Hampton-Seabrook Estuary is a highly productive ecosystem that provides a variety of ecological services and functions (NHNHB 2009; NMFS 2010a). Several recreational fisheries exist within the Hampton-Seabrook Harbor, including the most productive soft-shell clam beds in New Hampshire (Eberhardt and Burdick 2009). A recreational and commercial fishery for the American lobster also exists within the estuary.

The streams, rivers, and estuaries within this watershed are a primary migration route for many anadromous fish, which are fish that migrate between freshwater and the Gulf of Maine throughout their life cycle. The Hampton-Seabrook Estuary is also an important habitat for several species of juvenile fish that inhabit the Gulf of Maine as adults (Fairchild et al. 2008; NHFGD 2010a). Therefore, many of the species that could be entrained or impinged at the

Seabrook intake structures may also inhabit the Hampton-Seabrook Estuary and associated rivers and tributaries.

Common Habitats and Taxa in Hampton-Seabrook Estuary

Several important habitats occur within the Hampton-Seabrook Estuary. Salt marshes, seagrass, and shellfish beds are the main biogenic habitats, or areas where a single type of organism forms the basis of the habitat. The predominant biogenic habitat within the estuary is salt marsh, which cover approximately 4,000 ac (1,618 ha) (Eberhardt and Burdick 2009). In fact, the Hampton-Seabrook Estuary is home to the majority of the estimated 6,200 ac (2,509 ha) of salt marsh in New Hampshire (NHNHB 2009). In the Gulf of Maine coastal region, NHDES (2004a) considers salt marshes the most biologically productive ecosystems. For example, vegetation within the salt marsh provides food for birds, insects, snails and crustaceans and refuge for crabs, shrimp, other shellfish, and juvenile fish to hide from predators. Dead vegetation, which is broken down into detritus, plays an important role in the food web since it is eaten by crabs and shellfish. In addition, waves or other currents often carry the detritus to offshore habitats or other near shore habitats, further promoting the ecological productivity within the vicinity. Salt marshes provide several other ecosystem functions. For example, the roots and stems of marsh plants help trap waterborne sediments that may harbor contaminants. Salt marsh plants also absorb atmospheric carbon dioxide, which is a greenhouse gas, and excess nutrients from fertilizers and sewage discharges, which can lead to eutrophication and oxygen depletion (Thompson 2010).

Shellfish beds, such as blue mussel (*Mytilus edulis*) and soft-shell clam (*Mya arenaria*) beds, provide habitat for other aquatic organisms and help filter the water within the estuary. Small organisms attach to mussel shells, and mobile organisms can hide within crevices (Thompson 2010). Both blue mussels and soft-shell clams are filter feeders, meaning that water flows through their gills or other filtering structures as they strain organic matter and food particles, such as plankton and detritus. While filtering water for food, these organisms also help clean the water, recycle nutrients, detoxify pollutants, and provide an essential transfer of energy from plankton to larger species (Gili and Coma 1998; Lenihan and Micheli 2001). For example, mussels and clams are prey for fish, larger invertebrates, and marine mammals and, in shallower areas, birds and terrestrial mammals that forage in aquatic environments (Lenihan and Micheli 2001). In Hampton-Seabrook Estuary, green crabs (*Carcinus maenas*) are an important predator of soft shell clams (Glude 1955; Ropes 1969).

Eelgrass beds (*Zostera marina*) also provide important habitat for other aquatic organisms and are often referred to as underground meadows (NHDES 2004b). Eelgrass provides food, a structurally complex habitat, areas to hide from predators, and spawning grounds for many species. Commercially and ecologically important species that inhabit seagrass beds include blue mussels, lobster, winter flounder, Atlantic silverside (*Menidia menidia*), Atlantic cod, and other fish and invertebrates (Thompson 2010). In addition, eelgrass increases dissolved oxygen in the estuary as a byproduct of photosynthesis and helps control erosion by slowing currents and stabilizing the sandy bottom (Thompson 2010). Eelgrass is sensitive to changes in water quality, especially sedimentation and turbidity, since sufficient light must reach its leaves to complete photosynthesis.

Soft sediments, such as sand or mud, are a common habitat within the Hampton-Seabrook Estuary. When exposed during low tides, these areas are often called mudflats (NHDES 2004c). A wide variety of organisms inhabit mud or sandy bottom areas by living within (infauna) or on top of (epifauna) the substrate. The most common organisms include polychaete worms, crustaceans (e.g., isopods, amphipods, green crabs, shrimps), and mollusks (e.g., soft shell clams) (Lenihan and Micheli 2001). Although similar types of organisms may

inhabit soft sediment habitats in the Gulf of Maine and Hampton-Seabrook Estuary, the species may differ due to shallower depth and lower salinity in the estuary. In addition, some species that inhabit sandy habitats in Gulf of Maine may inhabit sandy habitats in Hampton-Seabrook Estuary during earlier life stages. In the Hampton-Seabrook Estuary, sandy-bottom habitats are important substrates for eelgrass, blue mussels, and soft-shell clams, all of which help form biogenic habitats as described above.

The pelagic, or open water, environment is an important habitat for several species of fish. Several juvenile fish species use the Hampton-Seabrook Estuary as a refuge from predators and to consume prey (Fairchild et al. 2008; NHFGD 2010a). Common fish species within Hampton-Seabrook Estuary include Atlantic silverside, winter flounder, killifish, ninespine stickleback, rainbow smelt, American sandlance, and pollock (NAI 2010; NHFGD 2010a).

Several anadromous fish—such as alewife, blueback herring, American shad, and rainbow smelt—migrate through Hampton-Seabrook Estuary in order to reach freshwater rivers for spawning (Eberhardt and Burdick 2009). Each species has particular habitat requirements (e.g., dissolved oxygen, temperature, salinity) for spawning, feeding, and growing. As described further in Section 2.1.3.2, alewife, blueback herring, and rainbow smelt experienced precipitous population declines in the past few decades due to human-induced impacts, and the National Oceanographic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) currently classifies these fish as "species of concern" (NMFS 2010a). A species is designated as a species of concern if NMFS has some concerns regarding the species' status and threats, but there is insufficient information to indicate a need to list the species under the Endangered Species Act (ESA) (NMFS 2011f).

2.2.6.2 Environmental History of the Gulf of Maine and Hampton-Seabrook Estuary

The below sections provide a brief environmental history of the Gulf of Maine and the Hampton-Seabrook Estuary. The discussion concentrates on the major industries and actions that have influenced the current populations of aquatic organisms in the Gulf of Maine and Hampton-Seabrook Estuary.

Gulf of Maine

Pre-1900s: Whaling and Cod Industries

In the past 500 years, this Gulf of Maine region experienced increased settlement and exploitation of resources. Whaling was a major industry in colonial New England. Initially, early settlers concentrated efforts on whales relatively close to shore using small boats. Eventually, settlers built vessels to pursue the more profitable offshore sperm whales (Allen 1928). Sperm whales were pursued for their blubber, which was used to make oil, and bones, which were used to make candles, corsets, and other products. Demand for whale oil declined in the mid-1800s, with the discovery of oil underground. From 1800–1987, whalers harvested approximately 436,000–1 million sperm whales (NMFS 2011). Presently, all whales in U.S. waters are protected under the Marine Mammal Protection Act (MMPA) due to low populations.

In the 1700s, the Atlantic cod fishery was another large industry in New England. Cod was salted, and it became a prime export of the region (Thompson 2010). The cod fishery continued to grow as the shipping industry boomed in New England, providing an efficient means to trade with Europe. The Atlantic cod fishery continued throughout the 21st century, resulting in a precipitous decline in the species, as discussed in more detail below

1900s–2000s: Direct and Indirect Impacts from Fishing

During the 20th century, one of the major human influences on aquatic organisms in the Gulf of Maine was from the direct and indirect effects of commercial fishing. Highly productive habitats

in the Gulf of Maine support large populations of commercially sought fish, such as Atlantic cod, haddock (*Melanogrammus aeglefinus*), yellowtail flounder, halibut, other gadids (cod family), and flatfish. From the 1960s through the mid-1970s, many Gulf of Maine fisheries experienced an intense increase in fishing pressure, in part due to the arrival of distant water fishing fleets. As fish landings of commercially sought species increased, the stock biomass subsequently declined precipitously throughout the 1970s and 1980s (Sosebee et al. 2006). Despite fisheries management regulations that limited fishing pressure on several overfished fisheries, stock biomass for many fisheries remained low during the 1990s. Currently, some monitoring studies suggest the recovery of certain groundfish (commercially sought demersal fish), but the biomass of several overfished species are still below 1960's levels (Sosebee et al. 2006).

In addition to the direct impacts from harvesting commercially sought fish, commercial fishing has indirectly influenced the abundance of non-targeted species due to increases or decreases in predation pressure or other trophic interactions. In the Gulf of Maine, the decline in fish predators resulted in a shift in community dynamics that propagated throughout the food chain, as explained below and illustrated in Figure 2–8. When the populations of commercially fish significantly declined, there was insufficient density of key fish predators to limit prey populations. Steneck et al. (2004) refer to this concept as "trophic-level dysfunction."

In the 1970s–1990s, the decrease in predation led to the increase in sea urchins and fish that graze on kelp (Steneck et al. 1994). Grazing pressure from urchins and herbivorous fish dramatically increased and overgrazed kelp forests, which transformed highly productive kelp forests into less productive urchin barrens, or areas dominated by crustose coralline algae (Pringle 1986). Since the crustose coralline algae is relatively flat, this habitat has minimal structural complexity. Kelp forests have recovered in some areas since the 1980s, when a fishery for urchins intensified.

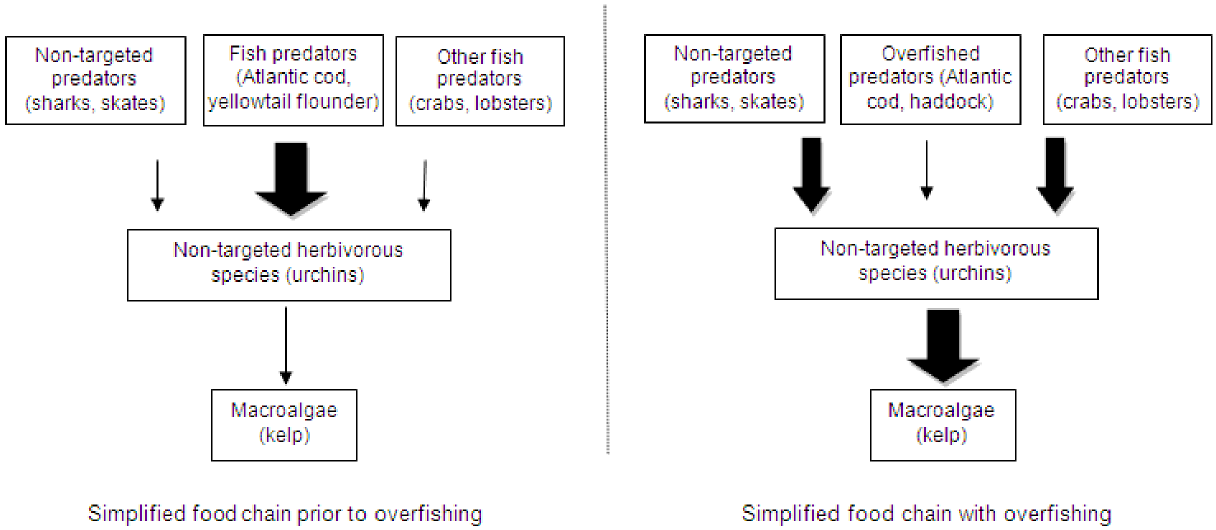
By the mid-1990s, fewer fish predators resulted in less competition with other piscivores (species that eat fish), such as sharks (e.g., spiny dogfish), skates, and predatory crustaceans (e.g., lobsters and *Cancer* crabs) (Link and Garrison 2002; Zhang and Chen 2007). Lower competition resulted in an increase in population for non-commercially sought piscivores. Currently, these taxa are the main predators in the Gulf of Maine.

Hampton-Seabrook Estuary

Pre-1990s: Salt Marsh Hay Harvesting and Dams

Native Americans inhabited the area surrounding the Hampton-Seabrook Estuary at least 4,000 years ago (Eberhardt and Burdick 2009). Native Americans used the estuary as a source of food and harvested fish and shellfish. By the 1700s, colonial settlements also established near the Hampton-Seabrook Estuary. In addition to harvesting food resources for settlers, the colonial population also used salt marsh hay (*Spartina patens*) as feed for livestock (Eberhardt and Burdick 2009). In an attempt to increase the quality and abundance of highly valued salt marsh hay, settlers dug several ditches throughout the marsh. These ditches changed the water flow patterns within the estuary and caused habitat fragmentation in areas where aquatic life could no longer pass through due to the discontinuation of sufficient water.

Figure 2–8. Simplified Gulf of Maine Food Chain Prior to Overfishing and With the Effects of Overfishing



The simplified food chain on the left reflects the general groups of predators and herbivores within the Gulf of Maine, prior to intense commercial pressure in the 1960s. The simplified food chain on the right reflects the shift in dominance as the abundance of fish predator species, such as Atlantic cod and haddock, precipitously declined. With the removal of key fish predators, competition with other predators (sharks, skates, crabs, and lobsters) declined and predation pressure on non-targeted herbivorous fish (urchins) declined, resulting in an increase in abundance for these species. Populations of non-targeted herbivorous fish and invertebrates increased and created intense grazing pressure on kelp resulting in the precipitous decline of kelp forest, an important subtidal habitat for fish, invertebrates, and other algae.

Settlers also built dams along the Taylor River and other nearby rivers in the beginning of the 17th century. Dams harvested energy from the rivers to power sawmills, windmills, grist, and fulling mills (Eberhardt and Burdick 2009). Dams blocked the migration routes of anadromous fish that use freshwater to spawn and marine habitats as adults.

1900s–2000s: Tourism, Dams, and Urbanization

With the rise of the industrial revolution, the number and size of farms declined while urban areas expanded (Thompson 2010). In the Gulf of Maine region, urban areas concentrated along the coast. In addition, upland farming became more efficient than harvesting hay in estuaries (Eberhardt and Brudick 2009). By the 1930s, the combination of increased coastal population growth and upland farming influenced the growth of Hampton Beach as a popular vacation area (Eberhardt and Burdick 2009). In attempts to control the mosquito population for tourists, developers dug additional ditches in marsh areas. However, these efforts had the opposite of the intended effects since they removed fish habitat and lowered fish populations that consume mosquitoes. In addition, these ditches restricted movement for aquatic species and reduced water flow within the estuary. The remnants of these ditches can still be seen today.

In response to the tourism boom in the 1930s, developers built jetties, bridges, roads, residences, and commercial areas along the shoreline and within sand dunes and marshes. These permanent structures decreased the dynamic nature of the estuary, whereby barrier islands, sand bars, and sand dunes would move depending on water currents and wind. As a

result, a narrow inlet connecting the estuary with the Gulf of Maine filled with sediment (Eberhardt and Burdick 2009). To this day, the Army Corps of Engineers continually dredges this inlet to allow boat and ship traffic in and out of the estuary (Hampton 2001). Filled wetlands also permanently removed valuable habitat, fragmented available habitat for organisms to travel through, and decreased water quality due to restricted water flow.

In the last quarter of the 20th century, historical and more recent dams along the rivers connected to the Hampton-Seabrook Estuary continued to block the migration path of several anadromous fish and resulted in precipitous declines in populations (Eberhardt and Burdick 2009). For example, the number of river herring (i.e., alewife and blueback herring) using a fish ladder at the Taylor River Dam was approximately 450,000 in 1976 but only 147 in 2006 (Eberhardt and Burdick 2009). Furthermore, dams can create areas with low-dissolved oxygen. Anadromous fish are especially sensitive to changes in water quality since they require specific physical conditions during various parts of their life cycle and because of the physiological stress of migrating through water with different salinity and temperature as they move from the ocean to freshwater rivers to spawn (Eberhardt and Burdick 2009).

At the beginning of the 21st century, moderate commercial and residential development surrounded the Hampton-Seabrook Estuary (NHNHB 2009). Runoff from developed and agricultural areas has increased the concentration of nutrients, bacteria, and other pollutants to the estuary. Increased nitrification can lead to algal blooms, where the populations of algae or other plankton increase exponentially. Plankton populations can become so dense that sunlight does not reach the bottom of the estuary, making it difficult or impossible for eelgrass and other aquatic plants to photosynthesize. In addition, algal blooms can deplete available oxygen in the water and release harmful toxins. Sections of the Hampton-Seabrook Estuary are listed on New Hampshire’s 303(d) list as being impaired due to high concentrations of bacteria (NHDES 2004). NHDES (2004) also lists the estuary as impaired for fish and shellfish consumption due to polychlorinated biphenyl, dioxin, and mercury concentrations in fish tissue and lobster tomalley.

2.2.6.3 Monitoring of Aquatic Resources Located Near Seabrook Station

The Seabrook cooling water comes from an intake structure located 60 ft (18.3 m) below MLLW in the Gulf of Maine (see Section 2.1.6). The seafloor in this area is relatively flat, with bedrock covered by sand, algae, or sessile invertebrates (NAI 2010). The immediate vicinity surrounding Seabrook is the Hampton-Seabrook Estuary. No intake or discharge structures are located in the estuary. From construction until 1994, Seabrook discharged to an onsite settling basin into the Browns River.

Below is summary of the community structure and population trends for phytoplankton, zooplankton, fish, invertebrates, and macroalgae located within the vicinity of the intake and discharge structures or the Hampton-Seabrook Estuary. Protected species, including marine mammals, turtles, fish and invertebrates, are discussed in Section 2.2.8.1.

Monitoring Overview

NextEra created a monitoring plan to survey the aquatic communities in the Gulf of Maine and the Hampton-Seabrook Estuary prior to, and during, operations to help determine if operation of the nuclear plant has had an effect on aquatic communities. Since the mid-1970s, NextEra has monitored plankton, multiple life stages of fish and invertebrates, and macroalgae. NextEra sampled areas near the intake and discharge structures, referred to as the nearfield sampling sites, and areas approximately 3–4 nautical mi (5–8 km) from the intake and discharge structures, referred to as the farfield sampling sites. Sampling sites within the Hampton-Seabrook Estuary include a nearfield site, near the area previously used to discharge

sewage, and two farfield sites in 0–10 ft (0–3 m) of water. Figure 2–9 shows the location of all sampling sites.

Normandeau Associates, Inc., (NAI) (2010) used a before-after control-impact (BACI) design to test for potential impacts from operation of Seabrook. This monitoring design examined the statistical significance of differences in community structure between the pre-operation and operational period at the nearfield and farfield sites. Working with Normandeau Associates and Public Service of New Hampshire (PSNH) staff, NextEra selected farfield sampling sites that would likely be outside the influence of Seabrook operations (NextEra 2010f). The farfield sampling stations were between 3–4 nautical mi (5–8 km) north of the intake and discharge structures. NextEra selected a northern farfield location since the primary currents run north to south. NextEra selected specific sampling sites based on similarities with the nearfield sites regarding depth, substrate type, algal composition, wave energy, and other relevant factors (NextEra 2010f).

Below, NRC summarized NextEra's aquatic monitoring of phytoplankton, zooplankton, fish, invertebrates, and macroalgae. NRC staff also summarized monitoring studies from research or sampling programs not funded by NextEra in order to provide a comparison with the trends found by NextEra, as well as trends in other nearby coastal habitats. Some species are highlighted below due to their ecological role, dominance in the community, or commercial or recreational importance. Section 2.2.8.1 and Appendix D-1 provide more detailed information on threatened and endangered species, and essential fish habitat (EFH). Changes in community structure or abundance prior to, and during, operations are described in Section 4.5.

Phytoplankton

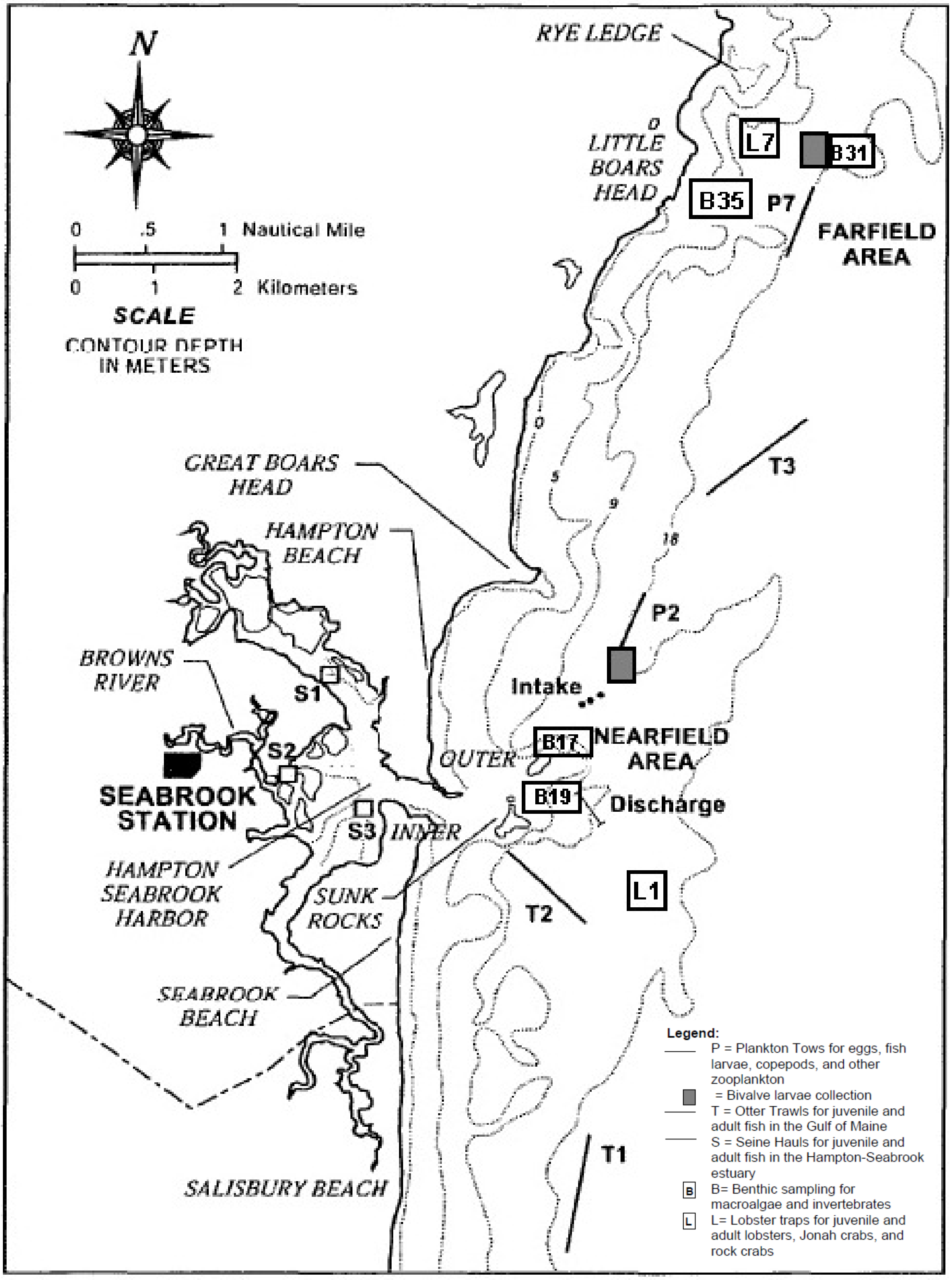
NextEra monitored phytoplankton at two nearfield sites (P2 and P5) and one farfield site (P7) (Figure 2–9). NextEra collected samples less than 3.3 ft (1 m) from the ocean surface once a month from December–February and twice a month the rest of the year (NAI 1998).

The total abundance of phytoplankton peaked during late spring-early summer and the again during early fall. The exact timing of these peaks varied annually (NAI 1998). Diatoms (Bacillariophyceae) generally dominated the phytoplankton community assemblage. During certain collection periods, diatoms comprised more than 90 percent of the phytoplankton community. During most years, the most common diatom taxon was *Skeletonema costatum*, which accounted for 71–81 percent of all diatoms by number of cells and 20–35 percent of all phytoplankton (NAI 1998).

In early spring, the yellow-green alga *Phaeocystis pouchetii*, which may be toxic to some fish larvae, dominated the phytoplankton community, which was the only time when diatoms were not the most common type of plankton. During a few years, this yellow-green alga was the most common taxon (NAI 1998).

Monthly arithmetic mean total chlorophyll *a* concentrations at the nearfield site (P2) peaked in early spring and again in the fall. Although chlorophyll *a* can be used as an indicator of total phytoplankton biomass, NAI (1998) did not find a consistent relationship between chlorophyll *a* concentrations and phytoplankton abundance in number of cells. NAI (1998) hypothesized that the difference was likely due to the various dominant taxa that had different proportions of cell size and chlorophyll *a* content.

Figure 2–9. Sampling Stations for Seabrook Aquatic Monitoring



Zooplankton

NextEra monitored zooplankton at two nearfield sites (P2 and P5) and one farfield site (P7) (Figure 2–9). NextEra conducted 1–2 duplicate oblique tows using paired 3.3-ft (1-m) diameter, 0.02-in (0.505-mm) mesh nets for fish eggs and larvae and other zooplankton and one 1.6-ft (0.5-m) diameter, 0.003-in (0.076-mm) mesh plankton net for bivalve eggs and larvae (NAI 2010). NextEra collected two to four samples per sampling period, which varied from one to four times per month (NAI 2010).

Throughout 23 years of monitoring studies, NAI (2010) collected approximately 27 species of fish eggs and 62 species of fish larvae near Seabrook. The most common taxa of eggs were Atlantic mackerel, followed by cunner/yellowtail flounder, hakes (primarily red and white hake), fourbeard rockling (*Enchelyopus cimbrius*), Atlantic cod, haddock, windowpane, and silver hake. The most common species of larvae were cunner, followed by American sand lance, Atlantic mackerel, fourbeard rockling, Atlantic herring, rock gunnels, winter flounder, silver hake, radiated shanny (*Ulvaria subbifurcata*), and witch flounder (*Glyptocephalus cynoglossus*).

NAI (2010) reported variations in the community structure and density of bivalve larvae over time. From the 1980s–1996, blue mussels and the rock borer *Hiatella* sp. dominated community assemblages of bivalves. However, from 1996–2002, the abundance of the prickly jingle (*Heteranomia squamula*) and blue mussels increased exponentially. As a result, prickly jingle and, to a lesser extent, blue mussels dominated monitoring samples collected by NAI from 1996–2002. The abundance of bivalve larvae for most species increased from 1996–2002. Bivalve larvae densities from 2003–2009 were similar to pre-1996 levels, although prickly jingle continue to dominate (NAI 2010). Other common species of bivalve larvae observed within the vicinity of Seabrook include northern horsemussel, surf clam, soft shell clams, truncate softshell clam, and sea scallops.

Holoplankton near Seabrook is generally dominated by copepods, an important prey species for many fish, whales, and other aquatic life. The most abundant holoplankton species vacillated between *Calanus finmarchicus* and *Centropages typicus*, two species of copepods (NAI 2010). When *C. typicus* dominated the holoplankton assemblage, *Metridia* sp. copepods and Appendicularia, free swimming tunicates, were more common in NAI (2010) monitoring collections. Pershing et al. (2005) reported similar fluctuations in the abundance of *Calanus finmarchicus* and *Centropages typicus* throughout the Gulf of Maine.

Meroplankton assemblages collected near Seabrook included the larvae or planktonic stages of invertebrates that inhabit the seafloor as adults. The most common species in this assemblage included the larvae of several common shallow and deep water coastal species, such as a shrimp (*Eualus pusiolus*), sand shrimp (*Crangon septemspinosa*), and cancer crabs (*Cancer* spp.), while larvae of estuarine shrimp species—such as *Hippolyte* sp. and *Palaemonetes* sp.—were relatively rare. Adult populations of such species are relatively wide-spread throughout the Gulf of Maine. The density of meroplankton assemblages were highest from 1983–2000. Other than relatively small shifts in the community assemblage and species dominance, NAI (2010) reported relatively stable abundances and community structure for meroplankton over time.

Hyperbenthos assemblages collected near Seabrook included a variety of organisms that primarily reside near the seafloor as adults. The most common taxa included the mysid shrimp (*Neomysis americana*), a cumacean hooded shrimp (*Diastylis* sp.), the amphipod *Pontogeneia inermi*, Harpacticoida copepods, and Syllidae polychaete worms. As further explained in Section 4.5, the density of hyperbenthos was generally an order of magnitude larger at the nearfield site compared to the farfield site. NAI (2010) did not observe significant changes over time.

Juvenile and Adult Fish

NextEra conducted monitoring of juvenile and adult fish by trawling for demersal fish (fish that live on or near the seafloor) in the Gulf of Maine, pulling gill nets to monitor pelagic fish (fish that live in the water column) in the Gulf of Maine, and pulling seine nets in the Hampton-Seabrook Estuary to monitor estuarine, and primarily juvenile, fish.

Demersal Fish Sampling. To monitor populations of demersal fish in the Gulf of Maine in the vicinity of Seabrook, NextEra trawled four replicate tows along the seafloor for 10 minutes at three sampling sites. NextEra used a 32.2-ft (9.8-m) shrimp otter trawl with a 1.5-in (3.8-cm) nylon stretch mesh body, a 1.3-in (3.2-cm) stretch mesh trawl bag, and a 0.5-in (1.3-cm) stretch mesh codend liner (NAI 2010). NextEra trawled at a nearfield site (T2), which is near the intake and discharge structures, and at two farfield sites (T1 and T3) (Figure 2–9). NAI (2010) reported fish abundance by the geometric mean catch per 10-minute tow, which is referred to as the catch per unit effort (CPUE). The most abundant species at all three sampling stations in 2009 were winter flounder (4.8 CPUE), hake (3.2 CPUE), and longhorn sculpin (2.8 CPUE) (NAI 2010). NextEra monitoring data indicate large changes in species abundance and composition over time. The most abundant species, during monitoring studies in the 1970s and 1980s, were yellowtail flounder (9.4 CPUE), longhorn sculpin (3.0 CPUE), and winter flounder (2.9 CPUE). Other relatively common demersal species observed during monitoring studies include Atlantic cod, *Raja* spp., windowpane, rainbow smelt, ocean pout, silver hake, and pollock.

NAI (2010) compared the CPUE for all species during the 1970s and 1980s, and during more recent years, by using an analysis of variance (ANOVA) procedure. At two (T1 and T2) of the three sampling stations, the abundance of fish was significantly higher in the 1970s through the 1980s when compared to more recent years (NAI 2010). The combined abundance for all fish species peaked in 1980 and then decreased until 1992. From 1992–2009, NAI (2010) reported a slight increase in the combined abundance for all fish species, but abundances were lower than the peak levels observed in 1980. In 2009, the combined abundance for all fish species was similar to that found in the mid-1980s at the farfield stations but below preoperational levels at the nearfield station (NAI 2010). Sosebee et al. (2006) analyzed trawl survey data from over 40 years to determine trends for seven species assemblages in the Gulf of Maine. Two of those assemblages, principal groundfish and flounders, included several of the dominate species collected in NextEra's monitoring data, including yellowtail flounder, winter flounder, hake (red, white, and spotted), Atlantic cod, windowpane, and silver hake. Sosebee et al. (2006) reported similar trends for principal groundfish and flounders as the farfield stations from NextEra's monitoring, whereby flounder and principal groundfish biomass peaked in the late 1970s–early 1980s, were at record lows during the late 1980s through mid-1990s, and peaked again in 2000. In the past few years, some flounders and principal groundfish have begun to recover, but populations of many species continue to decline. Sosebee et al. (2006) associates the peak in the early 1980s with increasing international and national management efforts and subsequent reduced fishing effort. Record-high fishing intensity occurred in the late 1980s and early 1990s when fish abundances were at very low levels.

Pelagic Fish Sampling. NextEra monitored pelagic fish populations near the intake structures from 1976–1997 using gill nets at a nearfield site (G2), located near the discharge structures, and at two farfield sites (G1 and G3), located approximately 0.75 nautical mi (2 km) north of the intake and 1 nautical mi (2.5 km) south of the discharge structure. NextEra set one 100 ft (30.5 m) by 12 ft (3.7 m) net at each station. Net arrays included four panels with stretch mesh dimensions of 1 in (2.5 cm), 2 in (5.1 cm), 4 in (10.2 cm), and 6 in (15.2 cm). Net arrays included surface and near-bottom nets. NextEra set the nets for two consecutive 24-hour periods twice each month from 1976–June 1986 and once a month from July 1986–1997 (NAI,

1998). In 1997, EPA directed NextEra to end gill net monitoring after NextEra found a dead harbor porpoise in the farfield gill net (NextEra 2010f).

The geometric mean CPUE for all pelagic fish species peaked in 1977 and declined through 1996 (NAI 1998). Sosebee et al. (2006) reported a different trend for principal pelagic species, which included Atlantic herring and Atlantic mackerel, two of the dominant fish in NAI monitoring surveys. Sosebee et al. (2006) reported record low biomass for principal pelagic species from 1975–1979, an increase in biomass from the mid-1980s through the 1990s, and slightly declining biomass since 2000. NAI (1998) reported a change in the community composition, or the relative abundance of the most dominant species in the 1970s and 1980s compared to monitoring during more recent years. In the 1970s and 1980s, the most abundant species were Atlantic herring (1.1 CPUE), blueback herring (0.3 CPUE), silver hake (0.3 CPUE), pollock (0.3 CPUE), and Atlantic mackerel (0.2 CPUE). During the 1990s and 2000s, the most common fish species collected were Atlantic herring (0.3 CPUE), Atlantic mackerel (0.3 CPUE), pollock (0.2 CPUE), and blueback herring (0.2 CPUE) (NAI 1998). Other relatively common species include spiny dogfish, alewife, rainbow smelt, and Atlantic cod.

Estuarine Fish Sampling. To monitor populations of estuarine fish in the Hampton-Seabrook Estuary, NextEra pulled seine nets once a month from April–November at three sampling sites, starting in 1975. Sampling generally focused on juvenile fish, and NextEra used a 100 ft (30.5 m) by 7.8 ft (2.4 m) bag seine with a 14.1 ft (4.3 m) by 7.8 ft (2.4 m) nylon bag with 0.55-in (1.4-cm) stretch mesh, and 43 ft (13.1 m) by 7.8 ft (2.4 m) wings with 1-in (2.5-cm) stretch mesh. NextEra pulled two replicate hauls per sampling period. The nearfield site (S2) is located approximately 200 m upstream from the mouth of the Browns River, where discharge from an onsite settling pond was released until April 1994. The farfield stations, S1 and S3, were located approximately 300 m upriver from Hampton Beach Marina and approximately 300 m from Hampton Harbor Bridge in the Seabrook Harbor, respectively (Figure 2–9). NAI (2010) reported fish abundance by catch per seine haul or geometric mean CPUE.

The geometric mean CPUE for all species of fish was significantly higher in the 1970s through the early 1990s when compared to more recent years (NAI 2010). Fish abundances peaked in 1980 and have been decreasing or steady ever since (NAI 2010). NAI (2010) observed peaks at some sampling stations during various years from 1990–2009. Atlantic silverside has been the most abundant species in monitoring samples since the 1970s (NAI 2010). New Hampshire Fish and Game Department (NHFGD) (2010a), Marine Fisheries Department, conducted seine hauls in the Hampton-Seabrook Estuary, Great Bay, Piscataqua River, and Little Harbor from 1997–2009. Similar to NAI's findings, NHFGD (2010a) observed relatively steady fish abundance, with peaks during various years. NHFGD (2010a) also observed the Atlantic silverside as the most abundant fish species during each year of sampling.

Invertebrates

Beginning in 1978, NextEra sampled two nearfield stations (B17 and B19) and one farfield station (B31) for epifaunal macroinvertebrates in the rocky subtidal (see Figure 2–9). In 1982, NextEra added an additional farfield station (B35). NextEra considered B17 and B35, located at 16.4 ft (5 m) and 19.7 ft (6 m) depth, respectively, to be representative of the shallow subtidal. NextEra considered B19 and B31, located at 39.4 ft (12 m) and 29.5 ft (9 m) depth, respectively, to be representative of the mid-depth subtidal. NextEra gathered samples of sessile invertebrates three times a year, in May, August, and November, by scraping off all organisms from five randomly selected 0.67 ft^2 (0.0625 square meter (m^2)) areas on rock surfaces (NAI 2010). NextEra also visually assessed the percent cover and abundance of larger invertebrates not adequately represented in the previously described sampling method. NextEra visually assessed six randomly placed replicate 3.3 ft (1 m) by 23 ft (7 m)

band-transects at each sampling site in April, July, and October. To evaluate recruitment and settlement patterns of sessile benthic invertebrates, NextEra placed 24-in (60-cm) by 24-in (60-cm) panels 1.6 ft (0.5 m) off the seafloor at the mid-depth stations (B19 and B31). Panels remained submerged for 4 months. NextEra deployed panels three times throughout each year, beginning in 1982.

NAI (2010) collected a total of 339 noncolonial invertebrate taxa since 1978, including sessile and mobile mollusks, crustaceans, echinoderms, and annelids. At the shallow subtidal sampling sites, the herbivorous snail, *Lacuna vincta*, was the most abundant biological group prior to 1995, followed by mytillid spat (the larval stage of mussels) and the isopod *Idotea phosphorea*. After 1995, *L. vincta* was still the most common species, but *I. phosphorea* was more common than mytillid spat. At the mid-depth sampling sites, mytillid spat was the most common biological group. Other relatively common taxa include *Anomia* sp. bivalves, skeleton shrimp (*Caprella septentrionalis*), the rock borer, *L. vincta*, and sea stars (Asteriidae).

NAI (2010) collected benthic sessile organisms on settling plates, as described above. The barnacles *Balanus* spp., which were primarily juvenile *Balanus crenatus* but may include some *Balanus balanus*, was the most common species on the settling plates. NAI (2010) observed the greatest recruitment in April. The second most abundant taxon was rock borer, a bivalve.

The following provides monitoring information for Jonah crab and rock crabs, which are important components of the rocky subtidal food web, and for lobsters and soft shell clams, both of which are commercially and recreationally harvested in the vicinity of Seabrook.

<u>Crabs</u>. NextEra monitored crab larvae at two sampling locations: P2, near the intake structure, and P7, which they considered the farfield site (Figure 2–9). NextEra conducted two replicate (two paired-sequential) oblique tows twice a month throughout the year. Nets were 3.3 ft (1 m) in diameter and lined with 0.02-in (0.505-mm) mesh nets. NextEra also monitored juvenile and adult crabs by setting fifteen 1-in (25.4-mm) mesh experimental lobster traps without escape vents at a nearfield site near the discharge structure (L1) and at a farfield site (L7) (Figure 2–9). NextEra checked traps at 2-day intervals approximately three times per week from June–November. Monitoring began in 1975 at L1, 1978 at P2, and 1982 at P7 and L7.

The geometric mean density of crab larvae ranged from 0.2–65 (NAI 2010). The monthly mean CPUE for juvenile and adult Jonah crabs generally ranged from 4–23 and from 0–5 for rock crabs.

<u>Lobsters</u>. Lobsters (*Homarus americanus*) in the vicinity of Seabrook help support a substantial commercial and recreational fishery (Hampton 2001). NextEra monitored lobster larvae at three sampling locations: P2, near the intake structure; P5, near the discharge structure; and P7, which was considered the farfield site (Figure 2–9). NextEra conducted 2,624-ft (800-m) long tows once a week from May–October using a 0.4-in (1-mm) mesh net that was 3.3 ft (1 m) deep by 6.6 ft (2 m) wide by 14.8 ft (4.5 m) long. NextEra also monitored juvenile and adult lobsters by setting 15.1-in (25.4-mm) mesh experimental lobster traps without escape vents at a nearfield site near the discharge structure (L1) and at a farfield site (L7) (Figure 2–9). NextEra checked traps at 2-day intervals approximately three times per week from June–November. Monitoring began in 1975 at L1, 1978 at P2, 1982 at P7 and L7, and 1988 at P5.

The geometric mean density of lobster larvae increased from the 1970s–2000s. The annual mean CPUE for juvenile and adult lobsters generally increased from about 35 to 150 from the 1970s–2000s. Changes in lobster abundance prior to, and during, operations are described in Section 4.5.

<u>Soft Shell Clams</u>. NextEra monitored clam larvae at three sampling locations: P1, in the Hampton-Seabrook Estuary; P2, near the intake structure; and P7, which was considered the

farfield site (Figure 2–9). NextEra conducted plankton-tows once a week from mid-April–October. Nets were 1.6 ft (0.5 m) diameter with a mesh of 0.003-in (0.076-mm). NextEra also monitored juvenile and adult clams at five of the largest clam flats in the Hampton-Seabrook Estuary and sites throughout Plum Island Sound (NAI 2010). NextEra classified clams as follows: young-of-the year (YOY), 0.04-0.99 in (1-25 mm); seed clams, 0.04-0.47 in (1-12 mm); yearlings, 1-2 in (26-50 mm); and adults, greater than 2 in (50 mm) (generally at least 2 years of age (Brousseau 1978)).

Larval density remained relatively constant from 1978–1995 and then peaked from 1996–2002. Annual mean log 10 (x+1) density (no./m^2) of YOY ranged annually from 0–3.5. The abundance of yearling clams peaked from 1978–1984, and there was a smaller peak from 1992–1997. The abundance of adult clams peaked from 1979–1986, and there were additional peaks from 1989–2001 and from 2005–2009.

Macroalgae

Beginning in 1978, NextEra sampled two nearfield stations (B17 and B19) and one farfield station (B31) for macroalgae in the rocky subtidal (see Figure 2–9). In 1982, NextEra added an additional farfield station (B35). NextEra considered B17 and B35, located at 16.4 ft (5 m) and 19.7 ft (6 m) depth, respectively, to be representative of the shallow subtidal. NextEra considered B19 and B31, located at 39.4 ft (12 m) and 29.5 ft (9 m) depth, respectively, to be representative of the mid-depth subtidal. NextEra gathered samples of macroalgae three times a year, in May, August, and November, by scraping off all algae on five randomly selected 0.67 square feet (ft^2) (0.0625 m^2) areas on rock surfaces (NAI 2010). NextEra also visually assessed the percent cover and abundance of larger algae not adequately represented in the previously described collection method. NextEra visually assessed six randomly placed replicate 3.3 ft (1 m) by 23 ft (7 m) band-transects at each sampling site in April, July, and October.

NAI (2010) observed a total of 160 taxa of macroalgae in the vicinity of Seabrook since 1978. The mean annual number of algal taxa at each sampling site fluctuated between 6–18 per 0.67 ft^2 (0.0625 m^2) (NAI 2010). Annual mean biomass fluctuated between 500–1,200 g/m^2 at the shallow subtidal sampling sites and between 100–600 g/m^2 at the mid-depth subtidal sampling sites (NAI 2010). The most common red algae species in the shallow subtidal was Irish moss, *Ceramium virgatum*, and the genera *Phyllophora* and *Coccotylus*. The most common red algae taxa in the mid-depth subtidal was *Phyllophora*, *Coccotylus*, *Phycodrys ruben*, and *Euthora cristata*. The most common brown algae, or kelp species, in the shallow subtidal was sea belt followed by *L. digitata*. The most common kelp species in the mid-depth subtidal was *A. clathratum*, followed by *L. digitata*, sea belt, and *A. esculenta*.

Transmission Lines

Three 345-kV transmission lines connect Seabrook to the regional electric grid. The transmission corridors are within the vicinity of a variety of aquatic habitats, including intertidal flats, salt marsh, wetlands, bogs, floodplains, rivers, streams, and ponds (NextEra 2010a; NHNHB 2010b). The Tewksbury Line crosses the Merrimac River in Massachusetts three times (NextEra 2010a). As described in Section 2.1.3, within wetlands, PSNH follows the NHDRED's *Best Management Practices Manual for Utility Maintenance In and Adjacent to Wetlands and Waterbodies in New Hampshire* (NHDRED 2010). In addition, transmission line owners and applicators may need to apply for coverage under the Pesticide General (NPDES) Permit if any herbicides are to be applied in the vicinity of surface waters (EPA 2011b). Special status species that may occur along transmission lines are discussed in Section 2.2.8, and potential impacts to these species are discussed in Section 4.7.1.

2.2.7 Terrestrial Resources

2.2.7.1 Seabrook Site and Surrounding Vicinity

Seabrook lies in the Gulf of Maine Coastal Lowland subsection of the Lower New England Ecoregion. This ecoregion is characterized by delta plains, broad plateaus, gentle slopes, and coastal areas and has an elevation range of sea level to 1,500 ft (450 m) (McNab and Avers 1994). The Gulf of Maine Coastal Lowland subsection is comprised of a narrow region along the coast with low topographic relief, a moderate climate, and tidal marshes, dunes, beaches, and rocky coastline (Sperduto 2005). Vegetation is characterized by temperate deciduous forest, and pine-oak and white cedar swamp tend to be the dominant forest types (Bailey 1995).

The Seabrook site is composed of two lots totaling 889 ac (360 ha). Lot 1 is 109 ac (44 ha) and contains the operating facility, associated buildings, parking lots, and roads, and Lot 2 is 780 ac (320 ha) and is mostly composed of undeveloped natural areas (NextEra 2010a). Over 58 ac (23 ha) on the Seabrook site—split into 11 parcels—are legally preserved through conservation easements with the Society for Protection of New Hampshire Forests, the Audubon Society of New Hampshire, or the NHFGD. The land in easement is composed primarily of salt marsh or other unspecified marsh type. The Seabrook site also contains the Owascoag Nature Trail, a nearly 1-mi (0.6-km) trail that surrounds the Seabrook Science and Nature Center, both of which are located adjacent to the developed portion of the site. New Hampshire Nature Conservancy ecologists have identified four State-listed threatened plant species—salt marsh gerardia (*Agalinis maritime*), Missouri rock-cress (*Boechera missouriensis*), hackberry (*Celtis occidentalis*), and the American plum tree (*Prunus americana*)—and one State-listed critically imperiled plant species—the orange horse-gentian (*Triosteum aurantiacum*)—within the area surrounding the trail (FPL 2010). These species, as well as other Federally and State-protected species are discussed in more detail in Section 2.2.8 of this SEIS.

The site, as a whole, is situated on an area of second-growth native forest bordering the Hampton-Seabrook Estuary. Tidal salt marsh surrounds the site to the northeast, east, and southeast. The upland portions of the site are dominated by hardwood-red cedar, oak-hickory, and hardwood-conifer stands, and the marsh areas are dominated by bands of switch grass (*Panicum virgatum*) and black-grass (*Juncus gerardi*), common reed (*Phragmites australis*) monostands, and smooth cordgrass (*Spartina alternaflora*) monostands (NextEra 2010a).

The majority of the marsh areas and some forested areas on and around the Seabrook site are designated as the Hampton Marsh Core Conservation Area in the *Land Conservation Plan for New Hampshire's Coastal Watersheds* (Zankel et al. 2006). The Hampton Marsh Core Conservation Area is composed of 7,490 ac (3,031 ha) and contains a contiguous 3,310.8-ac (1,339.8-ha) area of tidal marsh habitat and a 920-ac (372-ha) block of unfragmented forest habitat. In the conservation plan, Zankel et al. (2006) assessed the quality of New Hampshire's unfragmented forest blocks by considering two major factors: (1) their ability to absorb infrequent, devastating natural disasters including fire and hurricanes, and (2) their ability to support a variety of interior species at population levels that ensure long term viability. Zankel et al. (2006) consider the 920-ac (372-ha) unfragmented forest block within the Hampton Marsh Core Conservation Area to be of a locally significant size and to have the capability to provide habitat for some interior forest species with smaller ranges but to likely not be able to absorb large-scale natural disturbance (Zankel et al. 2006). The Hampton Marsh Core Conservation Area also contains 12 exemplary natural communities and system types, of which three types are located on the Seabrook site: brackish marsh, high salt marsh, and low salt marsh (NHNHB 2010; Zankel et al. 2006).

In addition to the exemplary communities discussed above, the Seabrook site contains the following habitats: Appalachian pine-oak forest, grasslands, hemlock-hardwood-pine forest, rocky ridge or talus slope, wet meadow and shrub wetland, brackish marsh, and intertidal flats (NHNHB 2010; Sperduto 2005). Detailed descriptions of these habitats can be found in the New Hampshire Natural Heritage Bureau's (NHNHB's) report, *Natural Communities of New Hampshire* (Sperduto 2005).

Forested areas provide habitat to a variety of native wildlife, including white-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), eastern cottontails (*Sylvilagus floridanus*), painted turtles (*Chrysemys picta*), garter snakes (*Thamnophis* spp.), ribbon snakes (*T. sauritus*), wood frogs (*Rana sylvatica*), American toads (*Bufo americanus*), and various species of squirrels, voles, shrews, and foxes. Common bird species in forested and developed areas include blue jays (*Cyanocitta cristata*), black-capped chickadees (*Poecile atricapillus*), robins (*Turdus migratorius*), black-and-white warblers (*Mniotilta varia*), whip-poor-wills (*Caprimulgus vociferus*), purple finches (*Carpodacus purpureus*), and numerous hawk species (NextEra 2010a; NHFGD 2005a, 2008).

In 2003, the New Hampshire Audubon Society recognized the Hampton-Seabrook Estuary as an Important Bird Area by the New Hampshire Audubon due to the extensive area of unfragmented marsh habitat that it provides to migratory shorebirds and birds that breed in salt marshes. During a 2006–2007 bird survey (McKinley and Hunt 2008), the New Hampshire Audubon recorded observations of bird use of the estuary from July–November 2006 and May–September 2007 over multiple locations through the estuary. During the survey, 23 species of migratory shorebirds were recorded, and an estimated 3000–3500 individual birds used the estuary between late July and late September, the peak migration period for this area. The semipalmated plover (*Charadrius semipalmatus*) and semipalmated sandpiper (*Calidris pusilla*) were the most abundant species and accounted for approximately one-third of the total individuals. Black-bellied plovers (*Pluvialis squatarola*), greater yellowlegs (*Tringa melanoleuca*), lesser yellowlegs (*T. flavipes*), least sandpipers (*C. minutilla*), and short-billed dowitcher (*Limnodromus griseus*) were considered common, but not as abundant as the semipalmated plover or semipalmated sandpiper. The saltmarsh sharp-tailed sparrow (*Ammodramus caudacutus*) was the most common saltmarsh breeding bird identified during the survey, but this species does not regularly inhabit any of the marsh areas adjacent to the Seabrook site. The North Flats survey site, which is adjacent and to the east of the Seabrook site, contains large exposed flats, mussel flats, and peat banks with Spartina species. It is used as a roost site by black-bellied plovers, dunlins (*Calidris alpina*), and short-billed dowitchers and a foraging area by whimbrels (*Numenius phaeopus*), short-billed dowitchers, and willets (*T. semipalmata*) (McKinley and Hunt 2008).

2.2.7.2 Transmission Line ROWs

The three in-scope transmission lines that connect Seabrook to the regional electric grid traverse a variety of habitats including forest, shrubland, marsh, residential land, agricultural land, and other developed areas. Section 2.1.5 discusses vegetative maintenance practices along the ROWs.

Within the Town of Kingston, NH, the Scobie Pond Line runs outward to the west of the site, crosses near a swamp white oak (*Quercus bicolor*) floodplain forest that is considered to be of excellent quality and is dominated by swamp white oak, red maple (*Acer rubrum*), and shagbark hickory (*Carya ovata*) (NHNHB 2010b). The line also runs near an Atlantic white cedar (*Chamaecyparis thyoides*)-yellow birch (*Betula alleghaniensis*)-pepperbush (*Clethra* spp.) swamp that is considered to be of good quality and have a healthy population of Atlantic white cedar, black spruce (*Picea mariana*), hemlock (*Tsuga* spp.), and larch (*Larix* spp.), and an

excellent variety of bog plants by the NHNHB (NHNHB 2010b). This swamp was designated as an exemplary natural community by the Nature Conservancy (NextEra 2010a). The Tewksbury Line, which runs outward southwest of the site and into Massachusetts, crosses portions of the Crane Pond Wildlife Management Area, a 2,123-ac (859-ha) parcel of land that is managed by the Massachusetts Division of Fisheries and Wildlife (MDFW) containing Crane Pond and Little Crane Pond as well as low-lying rolling pine and mixed hardwood forest (ENHA 2010). Crane Pond hosts woodcock (*Scolopax* spp.), ruffed grouse (*Bonasa umbellus*), wild turkey (*Meleagris gallopavo*), and spring-migrating waterfowl, as well as a variety of nesting songbirds in the wetland and uplands areas (ENHA 2010).

2.2.8 Protected Species and Habitats

As delegated by the ESA (16 U.S.C. 1531), the NMFS and the U.S. Fish and Wildlife Service (FWS) are responsible for listing aquatic and terrestrial species as threatened and endangered at the Federal level. The State may list additional species that are regionally threatened or endangered. For the purposes of this SEIS, all Federally and State-listed species that occur, or potentially occur, in the vicinity of the Seabrook site are included in Table 2–4 and Table 2–7. Those species protected under the Marine Mammal Protection Act (MMPA) and the Magnuson–Stevens Fishery Conservation and Management Act (MSA) are discussed in Section 2.2.8.1.

2.2.8.1 Protected Aquatic Species

This section provides information on aquatic species that are protected by Federal and State laws. Protected marine species include those that are Federally protected under the MMPA, the ESA, and the MSA as well as those managed by the FWS or the NMFS, or both. Also included are aquatic species listed as endangered, threatened, or species of special concern by the State of New Hampshire or the State of Massachusetts. In the Gulf of Maine in the vicinity of Seabrook or along transmission lines, 14 Federally or State-listed marine species could occur, including seven fish, one mussel, three sea turtles, and three whales (NextEra 2010; NMFS 2010a). These listed aquatic species appear in Table 2–4.

Table 2–4. Listed Aquatic Species

The species below are Federally listed, New Hampshire-listed, or Massachusetts-listed as proposed, threatened, endangered, or species of special concern. These species have been recorded as occurring within the counties associated with Seabrook and its transmission line ROWs.

Scientific name	Common name	Federal status[(a)]	NH[(b)]	MA[(b)]	County(ies) of occurrence at site or along transmission lines or Gulf of Maine or both	Habitat
			Fish			
Acipenser brevirostrum	Shortnose sturgeon	E	E	E	Gulf of Maine; Merrimac & West Newbury, MA	Adults spawn in fast-flowing, rocky rivers; Migrate through rivers and estuaries to Gulf of Maine
Acipenser oxyrinchus oxyrinchus	Atlantic sturgeon	P		E	Gulf of Maine	Adults spawn in fast-flowing, rocky rivers; Migrate through rivers and estuaries to Gulf of Maine
Enneacanthus obesus [(7,8,9)]	Banded sunfish	--	SC		Hillsborough & Rockingham, NH	Vegetated areas of ponds, lakes, and the backwaters of lowland streams
Esox americanus americanus	Redfin pickerel	--	SC		Hillsborough & Rockingham, NH	Densely vegetated slow-moving, acidic, tea-colored streams
Pomolobus aestivalis	Blueback Herring	SC	SC		Hampton-Seabrook Watershed and Gulf of Maine	Spawn in fast and slow moving streams; Migrate from freshwater through estuaries to Gulf of Maine
Osmerus mordax	Rainbow smelt	SC	SC		Hampton-Seabrook Watershed & Gulf of Maine	Spawn in rivers with gravel substrate and fast currents; Migrate from freshwater to estuaries and the Gulf of Maine
Alosa pseudo-harengus	Alewife	SC	SC		Hampton-Seabrook Watershed & Gulf of Maine	Spawn in riverine oxbows, ponds, and mid-river sites; Migrate from freshwater through estuaries to Gulf of Maine

Scientific name	Common name	Federal status[a]	NH[b]	MA[b]	County(ies) of occurrence at site or along transmission lines or Gulf of Maine or both	Habitat
			Mussels			
Ligumia nasuta	Eastern pond mussel	--	SC	SC	Hillsborough & Rockingham, NH; Amesbury, MA	Ponds, lakes, and the low velocity segments of streams and rivers; Occur in Great Pond, NH
			Turtles			
Caretta caretta	Logger-head sea turtle	T		T	Gulf of Maine	Seasonally present off the coast of New Hampshire
Dermochelys coriacea	Leather-back sea turtle	E		E	Gulf of Maine	Seasonally present off the coast of New Hampshire
Lepidochelys kempi	Kemp's ridley turtle	E		E	Gulf of Maine	Seasonally present off the coast of New Hampshire
			Whales			
Balaenoptera physalus	Fin whales	E		E	Gulf of Maine	Deep waters off the coast of New Hampshire
Eubalaena glacialis	Northern right whale	E		E	Gulf of Maine	Deep waters off the coast of New Hampshire
Megaptera novaeangliae	Humpback whale	E		E	Gulf of Maine	Deep waters off the coast of New Hampshire

(a) P = Proposed for Federal listing as a Federally Threatened species in the Gulf of Maine; E = Federally Endangered; T = Federally Threatened

(b) E = Endangered; T = Threatened; SC = Special concern

Sources: (MDFW 2009a; MFGD 2010; NextEra 2010a; NHFGD 2005, 2009; NHNHB 2009, 2010, 2010b; NMFS 1998, 2010, 2010a, 2011h)

Marine Mammals

The Gulf of Maine Program of the Census of Marine Life documented 32 marine mammal species within the Gulf of Maine (Valigra 2006). The two major groups of marine mammals that occur within the Gulf of Maine include cetaceans (whales, dolphins, and porpoises) and pinnipeds (seals). All marine mammals are protected under the MMPA of 1972, as amended. The MMPA prohibits the direct or indirect taking of marine mammals, except under certain circumstances including non-fishery commercial activities. Several of these marine mammal species are Federally listed whales, which are additionally protected under the ESA of 1976, as amended.

Northern right whales (*Eubalaena glacialis*), humpback whales (*Megatera novaeangliae*), and fin whales (*Balaenoptera physalus*) are Federally endangered species that inhabit waters off the coast of New Hampshire (NMFS 2010a). The Gulf of Maine is an important feeding ground for whales. Primary prey for right whales includes zooplankton, such as copepods, euphausiids (krill), and cyprids (NMFS 2011b). Humpbacks whale can consume up to 3,000 lb (1,360 kg) of food per day while eating tiny crustaceans (mostly krill), plankton, and small fish (NMFS 2011c). Fin whales also consume krill, as well as small schooling fish (e.g., herring, capelin, and sand lance) and squid (NMFS 2011d). These whale species are unlikely to occur in the vicinity of the Seabrook facility or the facility's intake or discharge structures since these whale species generally inhabit deeper waters (NMFS 2010a).

Among the non-Federally listed whale species that occur within the Gulf of Maine are the beluga whale (*Delphinapterus leucas*), killer whale (*Orcinus orca*), minke whale (*Balaenoptera acutorostrata*), and long-finned pilot whale (*Globicephala melaena*) (Provincetown Center for Coastal Studies 2011; Thompson 2010). Of these four species, only the long-finned pilot whale and the minke whale are regularly observed in the Gulf of Maine (Provincetown Center for Coastal Studies 2011). Minke whales and the long-finned pilot whale generally inhabit deeper waters than the location of the Seabrook intake and discharge structures (NMFS 2009; Provincetown Center for Coastal Studies 2011). There are no known occurrences of Seabrook operations affecting whales.

Non-Federally listed dolphin and porpoise species that may occur in this area include the whitebeaked dolphin (*Lagenorhynchus albirostris*), Atlantic white-sided dolphin (*L. acutus*), common dolphin (*Delphinus delphis*), bottlenose dolphin (*Tursiops truncatus*), Risso's dolphin (*Grampus griseus*), striped dolphin (*Stenella coeruleoalba*), and the harbor porpoise (*Phocoena phocoena*) (Provincetown Center for Coastal Studies 2011; Thompson 2010). Of these seven species, only the Atlantic white-sided dolphin and the harbor porpoise are regularly observed in the Gulf of Maine (Provincetown Center for Coastal Studies 2011; Thompson 2010). There are no known occurrences of Seabrook operations affecting dolphins or porpoises.

Four species of seals are regularly observed in the Gulf of Maine. These include harbor seals (*Phoca vitulina*), gray seals (*Halichoerus grypus*), harp seals (*P. groenlandica*), and hooded seals (*Cystophora cristata*) (GOMA 2011; Provincetown Center for Coastal Studies 2011). All four species of seals inhabit the Gulf of Maine during the winter. During warmer months, seals migrate south although some harbor seals and grey seals may remain in the Gulf of Maine year round. Seals use ocean habitats for feeding and rocky shores or outcrops, reefs, beaches and glacial ice for hauling out to rest, thermal regulation, social interaction, avoiding predators, giving birth, and rearing pups (NMFS 2011f). Seal prey consistent primarily of fish, shellfish, and crustaceans (NMFS 2011f). Seals occur within the vicinity of the Seabrook intake and discharge structures (NextEra 2010a).

Turtles

Three species of sea turtles—loggerhead (*Caretta caretta*), Kemp's ridley (*Lepidochelys kempii*) and leatherback (*Dermochelys coriacea*)—regularly occur in the Gulf of Maine (Thompson 2010). Under ESA, the leatherback and Kemp's ridley sea turtles are listed as endangered species, and the loggerhead sea turtle is listed as threatened. In September 2011, NMFS and FWS listed nine distinct population segments of loggerhead sea turtles, including the Northwest Atlantic Distinct Population Segment near Seabrook, which are considered Federally threatened (NMFS 2011h). Sea turtles reside most of their life within the ocean, although they will migrate long distances to breed on sandy beaches (NMFS 2011a). Sea turtles seasonally migrate to Gulf of Maine in order to find prey. Primary feeding habitats include northerly areas on, or along, the continental shelf (Shoop 1987, cited in Thompson 2010). Leatherback turtles

and loggerhead turtles would be most likely to be seasonally present off the coast of New Hampshire and occasionally within the vicinity of the Seabrook, including the intake and discharge structures (NMFS 2010a). It is less likely for Kemp's ridley sea turtle to be present in the vicinity of Seabrook (NMFS 2010a).

NextEra has not documented any known occurrences of Seabrook operations affecting turtles. In addition, the installment of additional vertical bars on the intake structure as part of the seal deterrent barrier should also help prevent any future incidental takes (NextEra 2010a).

Fish, Squids, and Mollusks

Endangered, Threatened, or Species of Concern

NMFS (2010) proposed listing the Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) as threatened in the Gulf of Maine. Shortnose sturgeon (*Acipenser brevirostrum*) is listed as endangered (NMFS 1998). NMFS considers blueback herring, alewife, and rainbow smelt species of concern due to the declines in population (NMFS 2010a). A species is designated as a species of concern by NMFS if NMFS has some concerns regarding the species' status and threats, but has insufficient information to indicate a need to list the species under the ESA (NMFS 2011f). This status level does not carry any procedural or substantive protections under the ESA (NMFS 2011f).

Along the transmission lines, the banded sunfish (*Enneacanthus obesus*) and redfin pickerel (*Esox americanus americanus*), two species of fish listed as species of special concern by the State of New Hampshire, may occur in Rockingham and Hillsborough Counties, NH (NHNHB 2009, 2010, 2010b). The eastern pond mussel (*Ligumia nasuta*), which is listed as a species of special concern by the States of New Hampshire and Massachusetts, may occur in the vicinity of the transmission lines in Hillsborough and Rockingham Counties, NH, and Amesbury County, MA (MDFW 2009; MFGD 2010; NHNHB 2010b, 2010). In addition, the shortnose sturgeon, which is listed as endangered by the State of New Hampshire and the State of Massachusetts, may occur in the vicinity of the transmission lines in Merrimac and West Newbury Counties, MA (MDFW 2009; MFGD 2010).

Below is a brief description of these listed species.

<u>Atlantic Sturgeon</u>. NMFS (2010) proposed listing distinct population segments of Atlantic sturgeon in the Gulf of Maine as a threatened species. The Atlantic sturgeon is a very large anadromous fish that averages 6–9 ft (1.8–2.7 m) in length, but can exceed a length of 13 ft (4 m) and a weight of 800 lb (363 kg). This species is long-lived, and its lifespan can reach 60 years (NMFS 2010). Spawning generally occurs in rocky, fast flowing rivers in July in Maine (NHFGD 2005). Spawning occurs every 1–5 years for males and every 2–5 years for females (NMFS 2010). Eggs are deposited on hard bottom substrate and are highly adhesive, generally attaching to stones or vegetation (NHFGD 2005). Larvae are also demersal and develop into juveniles while migrating downstream into more brackish waters (NMFS 2010). Juveniles will spend up to 4 years in riverine or tidal habitats (NHFGD 2005). NMFS (2010) does not believe that any rivers in New Hampshire or Massachusetts support spawning populations of Atlantic sturgeon.

Atlantic sturgeon are omnivorous benthic feeders, meaning that they consume a wide range of plants and animals that live on the ocean floor. While searching for food in soft sediment habitats, they filter mud along with their food. Adult diets include mollusks, gastropods, amphipods, isopods, and fish (NMFS 2010).

Historically, Atlantic sturgeon likely inhabited the Connecticut, Merrimack, and Coastal watersheds (NHFGD 2005). More recently, NHFGD (2005) reported only two Atlantic sturgeon

upstream of the Great Bay Estuary System since 1981. Population decline has been attributed to over-harvesting, habitat degradation, and barriers (e.g., dams) along water bodies connecting spawning grounds with ocean habitats (Smith 1995).

Atlantic sturgeon currently occur in coastal waters off the coast of New Hampshire and are likely to occur within the vicinity of Seabrook (NMFS 2010a). Seabrook captured a single Atlantic Sturgeon during site gill-net monitoring from 1976–1997 (NextEra 2010a). Seabrook did not report impingement or entrainment of any Atlantic sturgeon since operations began in 1990 (NAI 2010; NextEra 2010a).

Shortnose Sturgeon. The shortnose sturgeon is Federally listed as endangered throughout its range and was placed on the endangered species list in 1967 (NMFS 1998). Critical habitat has not been designated for this species. The shortnose sturgeon is often confused with the Atlantic sturgeon, but the two species can be distinguished by comparing the width of the mouths—the shortnose sturgeon has a much wider mouth than the Atlantic sturgeon. The shortnose sturgeon is much smaller than the Atlantic sturgeon, rarely exceeding 3 ft (0.9 m) in length.

The shortnose sturgeon is amphidromous, meaning that the fish spawns in freshwater, and spend time in both marine and freshwater habitats during its lifespan. Spawning occurs in fast-flowing, rocky rivers in April and May.

The shortnose sturgeon has not been observed in New Hampshire since 1971 (NHFGD 2005). Seabrook has not captured any shortnose sturgeon within monitoring, entrainment, or impingement studies since studies began in 1975 (NextEra 2010a).

Rainbow Smelt. Rainbow smelt is listed as a species of special concern by NMFS due to declining populations (NMFS 2010a). Adult rainbow smelt generally migrate from marine waters to estuaries during late fall and winter and then migrate to freshwater streams to spawn in March or April, soon after the breakup of ice. Preferred spawning grounds include rivers with gravel substrate and fast flows (Scarola 1987, cited in NHFGD 2005). Rainbow smelt usually travel less far into rivers than other diadromous fish. Freshwater and tidal currents carry larvae from freshwater to marine waters, such as the Gulf of Maine, from April–June (Collette and Klein-MacPhee 2002; Ganger 1999). Adults return to estuaries or saltwater after spawning (Collette and Klein-MacPhee 2002; NHFGD 2005). Dams have severely limited movement of rainbow smelt to and from spawning grounds (NHFGD 2005). Rainbow smelt occur within the Hampton-Seabrook Estuary and within the vicinity of the Seabrook intake and discharge structures (NAI 2010).

Blueback Herring. Blueback herring are listed as a species of special concern by NMFS due to declining populations (NMFS 2010a). Blueback herring also spawn in freshwater during the spring and migrate to estuaries or marine waters during the summer and cooler months. Juveniles often migrate from fresh to brackish water later than adults do and as late as October or early November (NHFGD 2005). Dams have severely limited movement of blueback herring to and from spawning grounds. Herring are an important component of freshwater, estuarine, and marine food webs since they are prey for many predatory fish, and they help transport nutrients to freshwater systems (NHFGD 2005). Blueback herring occur within the Hampton-Seabrook Estuary and within the vicinity of the Seabrook intake and discharge structures (NAI 2010).

Alewife. Alewife is listed as a species of special concern by NMFS due to declining populations (NMFS 2010a). Alewife have similar habitat requirements as blueback herring, although alewife begin their spring migration to freshwater earlier than bluebacks, and alewife spawn earlier (Collette and Klein-MacPhee 2002). Dams have severely limited movement of alewife to and from spawning grounds. Alewife is an important component of freshwater, estuarine, and

marine food webs since they are prey for many predatory fish, and they help transport nutrients to freshwater systems (NHFGD 2005). Alewife occur within the Hampton-Seabrook Estuary and within the vicinity of the Seabrook intake and discharge structures (NAI 2010).

Banded Sunfish. Preferred habitat for the banded sunfish includes vegetated areas of ponds, lakes, and the backwaters of lowland streams (Scarola 1987, cited in NHFGD 2005). In New Hampshire, banded sunfish are most often found in coastal watersheds (NHFGD 2005). This species is highly tolerant of acidic water and can survive in waters with pH levels as low as 4.0 (Gonzales and Dunson 1989). Populations tend to be locally abundant, but wide-spread distribution of the species is limited (NHFGD 2005).

Redfin Pickerel. Redfin pickerel primarily inhabit densely vegetated, slow-moving, acidic, tea-colored streams. Steiner (2004) also observed this species in brackish waters and swampy areas with low dissolved oxygen. Spawning habitat includes shallow flood margins of stream habitats with thick vegetation (NHFGD 2005). Spawning mainly occurs in the early spring, and may also occur in fall (Scarola 1987, cited in NHFGD 2005). Within New Hampshire, redfin pickerel exclusively inhabit the coastal and lower Merrimack watersheds (NHFGD 2005).

Eastern Pond Mussel. Eastern pond mussels grow in soft sediments at the bottom of ponds, lakes, and the low velocity segments of streams and rivers (NHFGD 2005). Eastern pond mussels grow in Great Pond, Kingston, which is in the vicinity of the Scobie Pond Transmission Line (NextEra 2010a; NHNHB 2010b). In New Hampshire, this mussel is found in three other ponds in the southeast part of the State (NHFGD 2005). The introduction of zebra mussel (*Dreissena polymorpha*) is the primary threat to this species (NHFGD 2005).

Eastern pond mussels spawn in summer, and larvae attach and encyst on host species, usually fish. Host fish species are unknown (NHFGD 2005).

Species with Essential Fish Habitat in the Vicinity of Seabrook

The MSA, as amended in 1996, focuses on the importance of habitat protection for healthy fisheries. The MSA amendments, known as the Sustainable Fisheries Act, require eight regional fishery management councils to describe and identify EFH in their regions, to identify actions to conserve and enhance their EFH, and to minimize the adverse effects of fishing on EFH. EFH is defined as “those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity” (16 U.S.C. 1802(10); 50 CFR 600.10).

NMFS (2011g) has designated the Gulf of Maine, within the vicinity of Seabrook, as EFH for 23 species. In compliance with Section 305(b)(2) of MSA, NRC has completed an EFH assessment, which can be found in Appendix D of this SEIS. A summary of the species discussed in the EFH assessment is provided below.

In their *Guide to Essential Fish Habitat Designations in the Northeastern United States*, NMFS (2011g) identifies EFH by 10 minute squares of latitude and longitude as well as by major estuary, bay, or river for estuarine waters outside of the 10 minute square grid. The waters in the vicinity of Seabrook are within the “Gulf of Maine” EFH Designation that extends from Salisbury, MA, north to Rye, NH, and includes Hampton Harbor, Hampton Beach, and Seabrook Beach. The 23 species with designated EFH in this area appear in Table 2–5.

Table 2–5. Species of Fish, Squids, and Mollusks With Designated EFH Within the Vicinity of Seabrook

Species	Eggs	Larvae	Juveniles	Adults
American plaice (*Hippoglossoides platessoides*)			x	x
Atlantic butterfish (*Peprilus triacanthus*)	x	x	x	x
Atlantic cod (*Gadus morhua*)	x	x	x	x
Atlantic halibut (*Hippoglossus hippoglossus*)	x	x	x	x
Atlantic herring (*Clupea harengus*)			x	x
Atlantic mackerel (*Scomber scombrus*)	x	x	x	x
Atlantic sea scallop (*Placopecten magellanicus*)	x	x	x	x
Bluefin tuna (*Thunnus thynnus*)				x
Haddock (*Melanogrammus aeglefinus*)			x	
Long-finned squid (*Loligo pealei*)			x	x
Monkfish (*Lophius americanus*)	x	x	x	x
Ocean pout (*Macrozoarces americanus*)	x	x	x	x
Pollock (*Pollachius virens*)			x	
Redfish (*Sebastes fasciatus*)		x	x	x
Red hake (*Urophycis chuss*)	x	x	x	x
Short-finned squid (*Illex illecebrosus*)			x	x
Scup (*Stenotomus chrysops*)			x	x
Summer flounder (*Paralicthys dentatus*)				x
Surf clam (*Spisula solidissima*)			x	x
Whiting & silver hake (*Merluccius bilinearis*)	x	x	x	x
Windowpane flounder (*Scopthalmus aquosus*)			x	x
Winter flounder (*Pleuronectes americanus*)	x	x	x	x
Yellowtail flounder (*Pleuronectes ferruginea*)			x	x

As described in Section 2.2.6, Seabrook has monitored fish and shellfish eggs, larvae, juveniles, and adults since the mid-1970s. In addition, Seabrook regularly records annual estimates of entrainment and impingement, as described in Section 4.5.

Table 2–6 presents a summary of the occurrence of EFH species within Seabrook monitoring, entrainment, and impingement studies.

Table 2–6. Commonality of EFH Species in Seabrook Monitoring, Entrainment, and Impingement Studies

Species	Eggs		Larvae		Juveniles & Adults			
	Plankton monitoring	Entrainment	Plankton monitoring	Entrainment	Trawl monitoring	Gill Net monitoring	Seine monitoring	Impingement
American plaice	Common[b]	Occasional[c]	Common	Occasional	Occasional			Rare[d]
Atlantic butterfish	Occasional	Rare	Occasional	Rare	Rare	Occasional	Rare	Rare
Atlantic cod [a]	Common	Common	Common	Rare	Common	Occasional	Rare	Rare
Atlantic halibut					Rare			
Atlantic herring			Common	Occasional	Occasional	Abundant[e]	Occasional	Common
Atlantic mackerel	Abundant	Abundant	Abundant	Rare	Rare	Common	Rare	Rare
Atlantic sea scallop				Rare				
Bluefin tuna								
Haddock [a]	Common	Rare	Occasional	Rare	Common	Rare		Rare
Monkfish & Goosefish	Rare	Rare	Occasional	Rare	Occasional	Rare		Rare
Ocean pout			Occasional	Rare	Common	Rare		Rare
Pollock	Common	Rare	Common	Rare	Common	Common	Occasional	Common
Redfish [a]			Occasional					
Red hake [a]	Common	Common	Common	Occasional	Abundant	Occasional	Common	Common
Scup			Rare		Occasional	Rare		Rare
Summer flounder			Rare	Rare	Rare			Rare
Surf clam				Rare				
Whiting & silver hake	Common	Abundant	Common	Occasional	Common	Common	Rare	Rare
Windowpane flounder	Common	Occasional	Common	Rare	Common	Rare	Occasional	Common
Winter flounder		Rare	Common	Occasional	Common	Occasional	Common	Common
Yellowtail flounder [a]	Abundant	Occasional	Common	Rare	Abundant	Rare	Rare	Common

Species	Eggs		Larvae		Juveniles & Adults			
	Plankton monitoring	Entrainment	Plankton monitoring	Entrainment	Trawl monitoring	Gill Net monitoring	Seine monitoring	Impingement

[(a)] During monitoring surveys, NAI (2010) combined certain groups of species if eggs were morphologically similar and spawning periods overlapped during the sampling period. In such cases, the estimate for the entire group of species is recorded in the table above. Groups of species include Atlantic cod/Haddock/witch flounder, cunner/yellowtail founder, red hake/white hake/spotted hake, and golden redfish/deepwater redfish/and Acadian redfish. For egg entrainment estimates of these groups of species, NextEra (2010f) estimated single species entrainment rates by applying the ratio of larval species to the egg species groups.

[(b)] Common: Occurring in >10% of samples, but <10% of total catch; 5-10% of entrainment samples averaged over all years

[(c)] Occasional: Occurring in <10%–1% of samples; 1–5% of entrainment samples averaged over all years

[(d)] Rare: Occurring in <1% of samples; <1% of entrainment samples averaged over all years

[(e)] Abundant: >10% of total catch or entrainment over all years

Sources: (NAI 2010; NextEra 2010f)

The NRC staff's EFH assessment can be found in Appendix D of this SEIS.

2.2.8.2 Protected Terrestrial Species

2.2.8.2.1 Federally Listed Species

Two Federally listed species—the piping plover (*Charadrius melodus*) and the roseate tern (*Sterna dougallii*)—potentially occur on or in the vicinity of the Seabrook site or its associated transmission line ROWs (FWS 2010a).

<u>Piping Plover</u>. The piping plover is Federally listed as threatened and State-listed as endangered in both New Hampshire and Massachusetts. The species occurs in Rockingham County, NH, and Essex County, MA. Piping plovers are small and stocky shorebirds with a sand-colored upper body, white underside, and orange legs. Piping plovers prefer flat, sandy beaches with scarce to no vegetation. Females generally lay four eggs per year, and both parents care for chicks (FWS 2001). Because piping plovers nest on beaches, nest abandonment due to human presence or disturbance—as well as predation from fox, cats, and other birds—poses a major threat to the piping plover. Habitat loss due to increased commercial and residential development along coastlines has also decreased the species' available habitat (FWS 2001). A 5-Year Review of the Recovery Plan published in 2009 (FWS 2009) also cited oil spills, wind turbine generators, and climate change as three additional threats to the species since its 1986 listing (FWS 2009).

Although the piping plover is a migratory bird, it is listed under the ESA as three distinct population segments—the Great Lakes population, the North Great Plains, and the Atlantic Coast Population—all of which were listed under the ESA in 1986. A Recovery Plan for the Atlantic Coast Population was published in 1996 (FWS 1996), and a 5-Year Review of the Recovery Plan was published in 2009 (FWS 2009). No critical habitat has been designated for the Atlantic Coast Population. Abundance of the Atlantic Coast Population has increased drastically since the species' listing. In 2009, three of the four New England population units had reached their minimum target population size for at least 1 year (FWS 2009).

Piping plovers are known to nest in the Town of Seabrook and inhabit the nearby coastal beaches (FWS 2010a; NHFGD 2008a); however, no suitable nesting or foraging habitat for the

species exists on the Seabrook site or along its associated transmission line ROWs (NextEra 2010a). In a letter to NRC, the FWS concluded that the piping plover is unlikely to be present on or in the immediate vicinity of the Seabrook site (FWS 2010a).

Roseate Tern. The roseate tern is a Federally and State-listed as endangered in both New Hampshire and Massachusetts. The species occurs in Rockingham County, NH, and Essex County, MA. The roseate tern is a medium-sized coastal bird that grows to 14–16 in. (35–40 cm) in length and has a pronounced forked tail (FWS 1998). It has a light gray back, white underbelly, black on its head, and long white tail feathers. Both males and females have black bills that turn reddish-orange during breeding season (FWS 1998). The species breeds on small islands along the Northeastern coast from New York to Maine and up into Canada, and it nests in colonies mixed with common terns along the coastlines. Roseate terns feed on small schooling marine fish such as bluefish (*Pomatomus saltatrix*), American sand lance (*Ammodytes americanus*), Atlantic herring (*Clupea harengus*), and mackerel (*Scomber scombrus*) (FWS 1998).

The roseate terns' population was initially depleted in the late 1800s when the species was harvested for feathers (FWS 1998). The species recovered significantly after the promulgation of the Migratory Bird Treaty Act of 1918 (FWS 1998). Since the 1930s and continuing today, human population growth and development along coastlines threaten the species' continued existence. The roseate tern population has declined an estimated 75 percent since the 1930s (NYDEC 2010).

The roseate tern is known to occur along the Atlantic coast beaches to the east of the Seabrook site, but, according to the FWS (2010a), the species is unlikely to occur on or in the immediate vicinity of the Seabrook site.

2.2.8.2.2 New Hampshire-Listed Species

To gather information on New Hampshire-listed species, the NRC contacted the NHNHB (NRC 2010b). In NHNHB's response to the NRC, the NHNHB noted that four State-listed plant species—salt-marsh gerardia (*Agalinis maritime*), dwarf glasswort (*Salicornia bigelovii*), orange horse-gentian (*Triosteum aurantiacum*), and Missouri rock cress (*Boechera missouriensis*)—and one State-listed bird—the willet (*Tringa semipalmata*)—have been recorded as occurring on the Seabrook site (NHNHB 2010a). Additionally, the New Hampshire Nature Conservancy had previously identified the hackberry (*Celtis occidentalis*) and American plum tree (*Prunus americana*) as occurring along or near the Seabrook Science and Nature Center and Owascoag Nature Trail (NextEra 2010a).

Within the Hampton Marsh Core Conservation Area (described in Section 2.2.7), which includes the Seabrook site and the surrounding 7,490 ac (3,031 ha), some State-listed species are known to occur or are likely to occur, according to Zankel et al. (2006). Plant species (excluding those mentioned above) include: sea-beach needle grass (*Aristida tuberculosa*), yellow thistle (*Cirsium horridulum*), Gray's umbrella sedge (*Cyperus grayi*), small spike-rush (*Eleocharis parvula*), salt-loving spike rush (*Eleocharis uniglumis*), hairy hudsonia (*Hudsonia tomentosa*), and slender blue flag (*Iris prismatica*). State-listed wildlife species that are known to occur or are likely to occur within the Hampton Marsh Core Conservation Area (excluding those mentioned above) include horned lark (*Eremophila alpestris*), osprey (*Pandion haliaetus*), and common tern (*Sterna hirundo*) (Zankel et al. 2006).

No State-listed plant species occur in areas on the Seabrook site that are regularly maintained or that would be disturbed in any way during the proposed license renewal term. Therefore, State-listed plants are not discussed in any further detail in this section. A short description of

State-listed wildlife species that are known to occur in the vicinity of the Seabrook site is included below.

Along the in-scope transmission lines within New Hampshire, the NHNHB noted that the following species have been recorded as occurring along, or near, the transmission line ROWs (NHNHB 2010b):

- four plant species—tall wormwood (*Artemisia campestris* ssp. *caudata*), robust knotweed (*Persicaria robustior*), northern blazing star (*Liatris scariosa* var. *novaeangliae*), and dwarf huckleberry (*Gaylussacia dumosa*);
- two reptiles—Blanding's turtle (*Emydoidea blandingii*) and spotted turtle (*Clemmys guttata*); and
- one bird—the vesper sparrow (*Pooecetes gramineus).*

Because PSNH does not use herbicides within New Hampshire ROWs or any mechanized vehicles within designated wetlands and wet areas, and because PSNH workers are trained to recognized Federally or State-protected species (see Section 2.1.5), species within the New Hampshire ROWs are not expected to be impacted during the proposed license renewal term (See Section 4.7.2). Therefore, they are not discussed in any further detail in this section.

The species mentioned in this section as well as additional species that have the potential to occur within the Seabrook site or along the in-scope portions of the New Hampshire transmission line ROWs, along with their State and Federal status, range of occurrence, and habitat, are listed in Table 2–7.

Table 2–7. Listed Terrestrial Species

The species below are Federally listed, New Hampshire-listed, or Massachusetts-listed, as threatened, endangered, or candidate species. These species have been recorded as occurring within the counties associated with Seabrook site and its transmission line ROWs. Federally listed species are in bold.

Scientific name	Common name	Federal Status[(a)]	NH[(b)]	MA[(b)]	County(ies) of occurrence	Habitat
			Amphibians			
Ambrystoma laterale	blue-spotted salamander	--	SC	SC	Hillsborough; Rockingham; Essex; Middlesex	moist, deciduous hardwood forests; swampy woodlands
			Birds			
Catoptrophorus semipalmatus	willet	--	SC	--	Rockingham	coastal beaches; marshes; lakeshores; mudflats; wet prairies
Charadrius melodus	**piping plover**	**T**	**E**	**T**	**Essex; Hillsborough; Middlesex; Rockingham**	**sandy, sparsely vegetated coastlines**
Eremophila alpestris	horned lark	--	SC	--	Rockingham	open, sparsely vegetated areas with no grass or short grass
Falco peregrinus anatum	peregrine falcon	--	T	E	Essex; Hillsborough; Rockingham	grasslands; meadowlands
Haliaeetus leucocephalus	bald eagle	D	T	E	Essex; Rockingham	forested areas near open water
Pandion haliaetus	osprey	--	SC	E	Hillsborough; Rockingham	near lakes, rivers, marshes, and other bodies of water
Pooecetes gramineus	vesper sparrow	--	--	T	Rockingham	open habitats including prairie and sage brush steppe; abandoned fields; pastures; meadows
Sterna dougallii	**roseate tern**	**E**	**E**	**E**	**Essex; Rockingham**	**open, sandy beaches with minimal human activity**
Sterna hirundo	common tern	--	T	SC	Essex; Rockingham	sandy beaches; sparsely vegetated shorelines; back bays; marshes
Vermivora chrysoptera	golden-winged warbler	--	--	E	Essex	deciduous forests with thick undergrowth

Scientific name	Common name	Federal Status[(a)]	NH[(b)]	MA[(b)]	County(ies) of occurrence	Habitat
			Insects			
Enallagma laterale	New England bluet	--	SC	SC	Essex	coastal plain ponds; swampy open water
Gomphus vastus	cobra clubtail	--	SC	SC	Essex	large, sandy-bottomed rivers and lakes
Neurocordulia obsolete	umber shadowdragon	--	SC	SC	Essex; Hillsborough; Middlesex; Rockingham	sparsely vegetated lakes and rivers; artificially created reservoirs and dams
Somatochlora Georgiana	coppery emerald	--	--	E	Essex	forest clearings; small, sluggish streams
Stylurus spiniceps	arrow clubtail	--	--	T	Essex	medium to large, fast-flowing, sandy-bottomed rivers and surrounding riparian areas
			Mammals			
NONE						
			Plants			
Agalinis maritime	salt-marsh gerardia	--	E	--	Rockingham	salt marshes
Anemone cylindrical	long-fruited anemone	--	E	--	Rockingham	dry, open woods; prairies
Aristida tuberculosa	sea-beach needle grass	--	E	T	Essex; Rockingham	sandy fields; roadsides
Artemisia campestris ssp. *caudate*	tall wormwood	--	T	--	Rockingham	sparsely vegetated sandy soils
Artemisia campestris ssp. *prolificum*	prolific knotweed	--	E	--	Rockingham	dry prairies; wooded areas
Boechera missouriensis	Missouri rock cress	--	T	T	Essex; Rockingham	bluffs; rocky woods
Celtis occidentalis	hackberry	--	T	--	Rockingham	limestone outcrops in river valleys and uplands
Cirsium horridulum	yellow thistle	--	E	--	Rockingham	pinelands; prairie; well-drained sandy soils
Cyperus grayi	Gray's umbrella sedge	--	E	--	Rockingham	maritime shrublands
Eleocharis parvula	small spike-rush	--	T	--	Rockingham	brackish and saltwater marshes
Eleocharis uniglumis	salt-loving spike-rush	--	T	--	Rockingham	upland marshes

Scientific name	Common name	Federal Status[a]	NH[b]	MA[b]	County(ies) of occurrence	Habitat
Gaylussacia dumosa	dwarf huckleberry	--	T	--	Hillsborough; Rockingham	sandy soils; pine savannahs
Hudsonia tomentosa	hairy hudsonia	--	T	--	Rockingham	coastal sand dunes
Iris prismatica	slender blue flag	--	T	--	Rockingham	brackish to freshwater marshes; sandy shores; meadows along coasts
Liatris scariosa var. *novaeangliae*	northern blazing star	--	E	--	Rockingham	dry grasslands; barrens; forest openings
Persicaria robustior	robust knotweed	--	E		Rockingham	wet soils along coastal plains; pond or stream margins
Polygonum erectum	erect knotweed	--	E	--	Rockingham	disturbed areas; salt marshes
Polygonum ramosissimum ssp. *Prolificum*	prolific knotweed	--	E	--	Rockingham	disturbed areas; roadsides
Prunus Americana	American plum	--	E	--	Rockingham	woodland edges; stream banks; upland pastures
Pluchea odorata var. *succulent*	salt marsh fleabane	--	E	--	Rockingham	coast salt marshes
Salicornia ambigua	perennial glasswort	--	E	--	Rockingham	coastal salt marshes
Salicornia bigelovii	dwarf glasswort	--	E	--	Rockingham	coastal salt marshes
Sparganium eurycarpum	large bur-reed	--	T	--	Hillsborough	coastal plain marshes
Sporobolus cryptandrus	sand dropseed	--	E	--	Rockingham	prairie; disturbed areas; roadsides
Triosteum aurantiacum	orange horse-gentian	--	E	--	Rockingham	deciduous forest

Scientific name	Common name	Federal Status[a]	NH[b]	MA[b]	County(ies) of occurrence	Habitat
			Reptiles			
Clemmys guttata	spotted turtle	--	T	--	Hillsborough; Rockingham	shallow wetlands; woodlands near clean, slow-moving streams and rivers
Emydoidea blandingii	Blanding's turtle	--	E	T	Essex; Hillsborough; Middlesex; Rockingham	areas near shallow backwater pools, marshes, ponds, and streams
Glyptemys insculpta	wood turtle	--	SC	SC	Essex; Hillsborough; Middlesex; Rockingham	forested areas and grasslands near shallow, clear, sandy-bottomed streams

[a] C = Candidate for Federal listing; D = Delisted; E = Federally Endangered; T = Federally Threatened

[b] E = Endangered; T = Threatened; SC = Special concern

Sources: (FWS 2009a, 2010, 2010a; MDFW 2009, 2009a; MFGD 2010; NextEra 2010a; NHNHB 2009, 2010, 2010a, 2010b; Zankel et al. 2006)

Willet. The willet breeds in salt marshes and grass-dominated tidal wetlands in transitional zones between ocean and upland along the Atlantic and Gulf coasts (NHFGD 2005e). Within the Hampton-Seabrook Estuary, willets are most commonly found in the northeast portion of the estuary and the southern edge of the estuary near the mouth of the Blackwater River (McKinley and Hunt 2008). During a 2006–2007 survey by the New Hampshire Audubon, no willets were observed in the central portion of the estuary near the Seabrook site (McKinley and Hunt 2008). However, the NHNHB noted that willets are known to occur in the vicinity of the Seabrook site in its letter to NRC dated September 7, 2010 (NHNHB 2010a). The species primarily feeds on crustaceans, mollusks, polychaetes, and insects near marsh edges, mud flats, and mussel beds (NHFGD 2005e). Therefore, the mussel beds and mud flats within the marsh that borders the Seabrook site may provide some marginal foraging habitat for the species.

Horned Lark. The horned lark inhabits sparsely vegetated areas including beaches, agricultural fields, residential, and developed areas (NHFGD 2005c). The species is a year-round resident of North America, and within New Hampshire, has been recorded throughout the state, including near the Hampton Harbor Inlet and in Hampton Beach State Park (NHFGD 2005c). The NHNHB noted that adult individuals have been observed along the Atlantic coast in the town of Seabrook (NHNHB 2010a). Because the species' habitat requirements and the known occurrences of horned larks in the town of Seabrook, the horned lark may use the Seabrook site as habitat.

Osprey. The osprey is a migratory bird of prey that is found worldwide. Those that breed along the North American east coast return from wintering grounds in Florida, Cuba, and South America, beginning in early spring (NHFGD 2005d). Within New Hampshire, the species is known to nest in the White Mountains, along the Androcscoggin, Merrimack, and Connecticut rivers, and in the Great Bay area (NHFGD 2010). In a letter to NRC dated September 7, 2010, the NHNHB noted that two osprey nests exist to the northeast and southeast of the site along the Hampton-Seabrook Estuary (NHNHB 2010a). Because of the proximity of the nests, ospreys are likely to pass through the Seabrook site.

Common Tern. Historically, the common tern bred on several islands with the Isles of Shoals off the coast of New Hampshire and Maine. Human disturbance and predator pressure caused the common tern to search for breeding sites on the mainland starting in the mid-1900s, and, until population restoration efforts began in 1997, the Hampton-Seabrook Estuary served as a major breeding area (NHFGD 2005b). During a 2006–2007 survey by the New Hampshire Audubon, 10–15 pairs of common terns were found to nest within the northeast and southern portions of the Hampton-Seabrook Estuary, but the survey did not record any evidence of the species breeding on the mainland (McKinley and Hunt 2008). The NHNHB also noted that the species is known to occur in the vicinity of the Seabrook site and along the in-scope transmission line ROWs in its letters to NRC dated September 7, 2010 (NHNHB 2010a), and September 13, 2010 (NHNHB 2010b). The Seabrook site may provide some marginal foraging and breeding habitat, but is unlikely to regularly support the common tern. The species is more likely to occur to the east of the site near to the Atlantic coastline where it would have access to open, bare ground, or beach.

2.2.8.2.3 Massachusetts-Listed Species

To gather information on Massachusetts-listed species, the NRC contacted the MDFG to request information on State-protected species that may occur in the area (NRC 2010a). In the MDFG's response to the NRC, the MDFG confirmed that the information contained in their previous letter to NextEra remains current for the proposed license renewal (MDFG 2010). In their previous letter to NextEra, dated June 15, 2009 (MDFW 2009), the MDFG noted the occurrence of priority habitat or estimated habitat for the bald eagle (*Haliaeetus leucocephalus*), Banding's turtle, wood turtle (*Glyptemys insculpta*), blue-spotted salamander (*Ambrystoma laterale*), and five species of dragonflies along the Massachusetts portion of the in-scope transmission line ROWs.

The NRC expects no impacts to species with Massachusetts ROWs during the proposed license renewal term because:

- National Grid is prohibited from using herbicides within State-designated Priority Habitat without prior written approval within the Commonwealth of Massachusetts per 321 CMR 10.14(12).
- MDFG approves National Grid's yearly operation plan to ensure that vegetative maintenance practices are not adversely affecting sensitive species or wetlands.
- National Grid workers are trained to recognize and avoid impacts to Federally or State-listed species (See Section 2.1.5).

Therefore, those species are not discussed in any further detail in this section.

The species mentioned in this section, as well as additional species that have the potential to occur within the Seabrook site or along the in-scope portions of the Massachusetts transmission line ROWs, along with their State and Federal status, range of occurrence, and habitat, are listed in Table 2–7.

2.2.9 Socioeconomic Factors

This section describes current socioeconomic factors that have the potential to be directly or indirectly affected by changes in operations at Seabrook. Seabrook, and the communities that support it, can be described as a dynamic socioeconomic system. The communities provide the people, goods, and services required to operate the nuclear power plant. Plant operations, in turn, provide wages and benefits for people as well as dollar expenditures for goods and

services. The measure of a communities' ability to support Seabrook operations depends on the ability of the community to respond to changing environmental, social, economic, and demographic conditions.

The socioeconomic region of influence (ROI) is defined by the area where Seabrook employees and their families reside, spend their income, and use their benefits, thereby affecting the economic conditions of the region. The Seabrook ROI consists of a two-county area (Rockingham and Strafford counties), where approximately 67 percent of Seabrook employees reside (NextEra 2010a).

Seabrook employs a permanent workforce of approximately 1,093 employees (NextEra 2010a). Approximately 67 percent live in Rockingham County and Strafford County (Table 2–8). Most of the remaining 33 percent of the workforce are divided among eight counties in Maine, Massachusetts, and New Hampshire, with numbers ranging from 10–102 employees per county, with 4 percent living in other locations. Given the residential locations of Seabrook employees, the most significant impacts of plant operations are likely to occur in Rockingham County and Strafford County. Therefore, the focus of the socioeconomic impact analysis in this SEIS is on the impacts of continued Seabrook operations in these two counties.

Table 2–8. Seabrook—Employee Residence by County

County	Number of employees	Percentage of total
Rockingham, NH	516	47
Strafford, NH	219	20
York, ME	102	9
Essex, MA	85	8
Hillsborough, NH	39	4
Middlesex, MA	27	2
Merrimack, NH	26	2
Cumberland, ME	12	1
Belknap, NH	11	1
Kennebec, ME	10	1
Other locations	46	4
Total	**1,093**	**100**

Source: (NextEra 2010a)

Refueling outages at Seabrook normally occur at 18-month intervals. During refueling outages, site employment increases by as many as 800 temporary workers for approximately 30 days (NextEra 2010a). Most of these workers are assumed to be similarly distributed across the same geographic areas as Seabrook employees. The following sections describe the housing, public services, offsite land use, visual aesthetics and noise, population demography, and the economy in the ROI surrounding Seabrook.

2.2.9.1 Housing

Table 2–9 lists the total number of occupied and vacant housing units, vacancy rates, and median value in the two-county ROI. According to the 2000 Census, there were approximately 158,600 housing units in the ROI, of which approximately 147,100 were occupied. The median value of owner-occupied housing units in Rockingham and Strafford counties in 2000 were

$164,900 and $121,000, respectively. The vacancy rate was lower in Strafford County (6.5 percent) than in Rockingham County 7.5 percent (USCB 2011).

Table 2–9. Housing in Rockingham County and Strafford County in New Hampshire

	Rockingham	Strafford	ROI
		2000	
Total	113,023	45,539	158,562
Occupied housing units	104,529	42,581	147,110
Vacant units	8,494	2,958	11,452
Vacancy rate (percent)	7.5	6.5	7.2
Median value (dollars)	164,900	121,000	142,950
		2009 estimates	
Total	124,904	50,918	175,822
Occupied housing units	113,957	48,355	162,312
Vacant units	10,947	2,563	13,510
Vacancy rate (percent)	8.8	5.0	7.7
Median value (dollars)	294,500	228,500	261,500

Source: (USCB 2011)

The number of housing units grew in both counties from 2000–2009. In Rockingham County, the number of housing units grew by approximately 12,000 units (approximately 10 percent) to total of 124,904 housing units. In Strafford County, the total number of housing units increased by an estimated 11.8 percent over the same period to a total of 50,918 housing units(USCB 2011).

2.2.9.2 Public Services

This section presents information regarding public services including water supply, education, and transportation.

Water Supply. There are six major public water suppliers In Rockingham County. The Portsmouth Water Works serves a population of 33,000 with the largest capacity and daily demand served, and smaller systems supply other municipalities in the county (Table 2–10). There are four major public water suppliers In Strafford County—the City of Rochester Water Department has the largest capacity, while the City of Dover Water Department serves a population of 28,000 (Table 2–10).

Table 2–10. Rockingham County and Strafford County Public Water Supply Systems (in mgd)

Water supplier	Primary water source [(a)]	Average daily demand (mgd)	System capacity (mgd)	Population served
		Rockingham County		
Aquarion Water/NH	GW	1.5	5.0	23,000
Derry Water Department	SW	1.5	3.0	15,000
Exeter Water Department	SW	1.1	2.0	11,000
Portsmouth Water Works	SW	4.0	8.0	33,000
Salem Water Department	SW	0.6	2.5	18,000
Seabrook Water Department	GW	0.9	2.5	14,000
		Strafford County		
Dover Water Department	GW	2.5-3.0	4.2	28,000
Rochester Water Department	SW	2.0-2.6	4.6	20,000
Somersworth Water Works	SW	2.0-3.0	3.0	12,000
UNH/Durham Water System	SW	1.0	2.1	16,000

[(a)] Groundwater = GW; Surface Water = SW

Sources: (EPA 2010b; Tetra Tech 2009)

Seabrook obtains water from the Town of Seabrook Water Department, which provided an average of 0.1 mgd to the plant from 2003–2008 (NextEra 2010a). The town's maximum permitted capacity is currently 2.5 mgd, while average daily use is 0.9 mgd, including the amount consumed by Seabrook. Demand for water in the Town of Seabrook is projected to increase from 2010–2020, with additional groundwater wells, surface water sources, and inter-municipal distribution systems all expected to meet water demand (Town of Seabrook 2010).

Education

Primary Education

There are 36 school districts in Rockingham County with 82 schools and an enrollment of 43,852 students from 2008–2009. In Strafford County, there are eight school districts with 30 schools and 14,917 students (NCES 2010). In the Seabrook School District, there is 1 elementary school, which had 462 students from 2008–2009, and 1 middle school, which had 360 students. High school students residing in Seabrook attend Winnacunnet High School, located in Hampton, which had 1,273 students from 2008–2009.

Secondary Education

Within 50 mi (80.5 km) of Seabrook, there are sixty-eight 4-year institutes, the two nearest being Zion Bible College and the University of New Hampshire-Main Campus. Zion Bible College is a privately owned college located in Haverhill, MA, approximately 15 mi (24.1 km) southwest of Seabrook. Fall 2009 enrollment totaled 260 undergraduate students and 45 full-time Faculty. The University of New Hampshire-Main Campus is located approximately 20 mi (32.2 km) north of Seabrook in Durham, NH. Total enrollment in fall of 2009 was 15,253 students, with 3,072 full-time Faculty (IES 2010).

Transportation. U.S. Route (US) 1, located 1 mi (1.6 km) west of Seabrook, is a two-lane highway providing north-south access to local communities between Newburyport and Portsmouth. Interstate 95, the New Hampshire Turnpike, passes 1.6 mi (2 km) west of Seabrook, which also runs in a north-south direction. Four routes traverse the area in an east-west direction. Closest to Seabrook is State Route (SR) 107 that intersects with Interstate 95 to the southwest. SR 84 and SR 87 intersect with US 1 to the northwest of Seabrook. SR 101, the Exeter-Hampton Expressway, also intersects with US 1 in Hampton, to the north of Seabrook. Route US 1A, located 1.7 mi east of the site, provides access to coastal communities.

Table 2–11 lists commuting routes to Seabrook and average annual daily traffic (AADT) volume values. The AADT values represent traffic volumes for a 24-hour period factored by both day of week and month of year.

Table 2–11. Major Commuting Routes in the Vicinity of Seabrook, 2009 Average Annual Daily Traffic Count

Roadway & location	Average annual daily traffic (AADT)[(a)]
Interstate 95 (between Exit 1 & Exit 2)	74,600
US 1 (at East Side Road)	21,000
US 1A (Ocean Boulevard, at Seabrook)	8,900
SR 84 (Kensington Road, west of US 1)	3,400
SR 88 (Exeter Road, west of US 1)	3,600
SR 101 (in Hampton, at Interstate 95)	223,000
SR 107 (New Zealand Road, west of US 1)	24,000[(b)]

[(a)] All AADTs represent traffic volume during the average 24-hour day during 2009

[(b)] 2007 AADT data

Source: (NHDOT 2010)

2.2.9.3 Offsite Land Use

This section focuses on Rockingham County and Strafford County, NH, where 67 percent of the Seabrook workforce currently live. In addition, Seabrook pays property taxes to numerous communities in Rockingham County.

The town of Seabrook has a total area of 9.6 square mi (mi^2) (24.9 square km (km^2)) of which 8.9 mi^2 (23.1 km^2) is land. Although wetlands, open areas and forested areas comprise almost half of the total area in the town, the amount of developed land has increased from 2.7 mi^2 (7.0 km^2) (28 percent) in 1974 to 3.7 mi^2 (9.6 km^2) (40 percent) in 2000, primarily at the expense of forested land and open space (Town of Seabrook 2010).

The Town of Seabrook currently has no formal growth control measures (Town of Seabrook 2010). The Master Plan indicates major concerns for the future to include the compatibility of land uses, natural resource protection, cultural resource protection, affordable housing, pollution prevention, sewage disposal, conservation of agricultural land, open space, forest land, and transportation management. Renovating of the municipal water system enabled the expansion of residential, commercial, and industrial development (FPLE 2009).

Although large tracts of available land are suitable for industrial development in the vicinity of the Seabrook, local planners intend to gradually phase out most of the industrial development east of Interstate 95 (FPLE 2009). The Town of Seabrook Transfer Station and Recycling Center and Hannah Foods, located immediately west of the Seabrook, use the South Access Road and the North Access Road, respectively.

Rockingham County has a total area of 727.8 mi^2 (1885.0 km^2), of which approximately 8 percent is water and wetlands. From 1974–1998, developed land within the county almost doubled, increasing from 83.1 mi^2 (215.2 km^2) (11.4 percent of the total) to 153.8 mi^2 (398.3 km^2) (21.1 percent). In 1998, forested land was the most important land use (64 percent), followed by residential (16 percent) (FPLE 2009). Stafford County has a total area of 384 mi^2 (994.6 km^2), of which 96 percent is land. From 1974–1998, developed land within the county increased from 33.5 mi^2 (86.8 km^2) to 52.5 mi^2 (136.0 km^2) (FPLE 2009).

2.2.9.4 Visual Aesthetics and Noise

Seabrook is located on a promontory of land, approximately 20 ft (6 m) in elevation, rising above the surrounding Hampton Flats salt marsh, whose elevation is approximately 4 ft (1 meter) (AEC 1974; FPLE 2008). Visually, the site is dominated by the 199-ft (61-m) containment structure and the 103-ft (31-m) high and 325-ft (99-m) long turbine and heater bay building north of the containment building. Other structures include the smaller 88-ft (27-m) high and 145-ft (44-m) long grey PAB to the south and a 220-ft (67-m) meteorological tower to the east.

Seabrook is visible from US 1A, which passes 1.7 mi (2.7 km) from the site and from Hampton Harbor to the east. During the winter season, Seabrook is visible from elevated locations, such as Powwow Hill, located approximately 2 mi (3.2 km) southwest in Amesbury, MA. Conservatively colored metal siding was chosen to blend the structures with their natural surroundings. Trees and shrubs surrounding the plant site also screen the many of the lower Seabrook support buildings from major viewing locations and serve to break up the features of the larger structures.

Noise emanating from the single-unit Seabrook is difficult to detect offsite. Given the industrial nature of the site, noise emissions from the site would only be an intermittent minor nuisance in the vicinity (EPA 1974). However, noise levels may sometimes exceed the 55 decibel (dBA) level that the EPA uses as a threshold to protect against excess noise during outdoor activities (EPA 1974). Once a year, the offsite outdoor emergency warning sirens are sounded as a test following a public awareness campaign. To date, no complaints have been received at Seabrook concerning noise from operations heard offsite.

2.2.9.5 Demography

According to the 2000 Census, an estimated 448,637 people lived within 20 mi (32 km) of Seabrook, which equates to a population density of 535 persons per mi^2 (NextEra 2010a). This translates to a Category 4, “least sparse” population density, using the generic environmental impact statement (GEIS) measure of sparseness (greater than or equal to 120 persons per mi^2 within 20 mi). An estimated 4,157,215 people live within 50 mi (80 km) of Seabrook, with a population density of 887 persons per mi^2 (NextEra 2010a). This translates to a Category 4 “in close proximity” population using the GEIS measure of proximity (greater than or equal to

190 persons per mi^2 within 50 mi). Therefore, Seabrook is located in a high population area based on the GEIS sparseness and proximity matrix.

Table 2–12 shows population projections and growth rates from 1970–2030 in Rockingham and Strafford counties in New Hampshire. The growth rate in Rockingham County showed an increase of 12.8 percent from 1990–2000. Strafford County population also shows an increase between 1990–2000 (7.7 percent). Both county populations are expected to continue to increase in the next decades and through 2030, although at lower rates of growth.

Table 2–12. Population and Percent Growth in Rockingham County and Strafford County, From 1970–2000 and Projected for 2010–2050

	Rockingham		Strafford	
Year	**Population**	**Percent growth [(a)]**	**Population**	**Percent growth [(a)]**
1970	138,951	-----	70,431	-----
1980	190,345	37.0	85,408	21.3
1990	245,845	29.1	104,233	22.0
2000	277,359	12.8	112,233	7.7
2009	***299,276***	***7.9***	***123,589***	***10.1***
2010	300,502	8.3	124,095	10.6
2020	317,673	3.1	128,733	3.7
2030	339,448	3.4	137,863	7.1
2040	358,154	5.5	143,988	4.5
2050	377,627	5.4	150,882	4.8

---- = No data available

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

Source: (NHOEP 2010; USCB 2011)

Demographic Profile. The demographic profiles of the two-county ROI population are presented in Table 2–13 and Table 2–14. In 2000, minorities (race and ethnicity combined) comprised 4.1 percent of the total 2-county population. The minority population is largely Hispanic or Latino with a small percentage of Asian residents.

Table 2–13. Demographic Profile of the Population in the Seabrook Two-County Socioeconomic ROI in 2000

	Rockingham	Strafford	ROI
Total population	277,359	112,233	389,592
Race (percent of total population, not-Hispanic or Latino)			
White	96.1	95.7	95.9
Black or African American	0.5	0.6	0.6
American Indian & Alaska Native	0.2	0.2	0.2
Asian	1.1	1.4	1.2
Native Hawaiian & Other Pacific Islander	0.0	0.0	0.0
Some other race	0.1	0.3	0.1
Two or more races	0.8	1.0	0.9
Ethnicity			
Hispanic or Latino	3,314	1,155	4,469
Percent of total population	1.2	1.0	1.1
Minority population (including Hispanic or Latino ethnicity)			
Total minority population	8,873	4,160	15,804
Percent minority	3.9	4.3	4.1

Source: (USCB 2011)

According to American Community Survey 2009 estimates, minority populations in the two-county region (Rockingham and Strafford) increased by approximately 9,500 persons and comprised 6.0 percent of the total two-county population (see Table 2–14). Most of this increase was due to an estimated increase of Hispanic or Latinos (over 4,100 persons), an increase in population of 91.9 percent from 2000. The next largest increase in minority population was Asian, an estimated additional 2,400 persons or an increase of 52.1 percent from 2000, followed by Black or African American, an estimated 1,100 persons or an increase of 49.9 percent from 2000 (USCB 2011).

Table 2–14. Demographic Profile of the Population in the Seabrook Two-County Socioeconomic ROI in 2009, Estimated

	Rockingham	Strafford	ROI
Population	299,276	123,589	422,865
Race (percent of total population, not-Hispanic or Latino)			
White	94.1	93.8	94.0
Black or African American	0.9	0.5	0.8
American Indian & Alaska Native	0.2	0.3	0.2
Asian	1.5	2.0	1.7
Native Hawaiian & Other Pacific Islander	0.0	0.0	0.0
Some other race	0.1	0.1	0.1
Two or more races	1.0	1.7	1.2
Ethnicity			
Hispanic or Latino	6,606	1,968	8,574
Percent of total population	2.2	1.6	2.0
Minority population (including Hispanic or Latino ethnicity)			
Total minority	17,683	7,652	25,335
Percent minority	5.9	6.2	6.0

Source: (USCB 2011)

Transient Population. Within 50 mi (80 km) of Seabrook, colleges and recreational opportunities attract daily and seasonal visitors who create demand for temporary housing and services. In 2010, there were approximately 309,680 students attending colleges and universities within 50 mi (80 km) of Seabrook (IES 2011).

In 2000, 5.3 percent of all housing units are considered temporary housing for seasonal, recreational, or occasional use in Rockingham County. By comparison, seasonal housing accounted for 26.7, 42.8, 1.5, 5.1, and 4.0 percent of total housing units in Belknapp, Carroll, Hillsborough, Merrimack, and Strafford counties in New Hampshire, respectively (USCB 2011). Six counties in the state of Massachusetts are within 50 mi (80 km) of Seabrook; none has seasonal housing units making up more than 5 percent of total housing units in each county. One county in Maine, York County, is located within 50 mi of the plant, where seasonal housing consists of 17.6 of total housing units (USCB 2011). Table 2–15 provides information on seasonal housing for the 13 counties located all, or partly, within 50 mi (80 km) of Seabrook.

Table 2–15. Seasonal Housing in Counties Located Within 50 mi of Seabrook

County[a]	Housing units	Vacant housing units: for seasonal, recreational, or occasional use	Percent
		Maine	
York	94,234	16,597	17.6
		Massachusetts	
Essex	287,144	4,255	1.5
Middlesex	576,681	2,823	0.5
Norfolk	255,154	1,161	0.5
Plymouth	181,524	8,594	4.7
Suffolk	292,520	1,725	0.6
Worcester	298,159	3,063	1.0
County subtotal	1,891,182	21,621	1.1
		New Hampshire	
Belknap	32,121	8,569	26.7
Carroll	34,750	14,887	42.8
Hillsborough	149,961	2,283	1.5
Merrimack	56,244	2,892	5.1
Rockingham	113,023	6,031	5.3
Strafford	45,539	1,823	4.0
County subtotal	431,638	36,485	8.5
Total	2,417	74,703	3.1

[a] Counties within 50 mi (80 km) of Seabrook with at least one block group located within the 50-mi (80 km) radius

Source: (USCB 2011)

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 follow the harvesting of crops, particularly fruit, throughout rural areas of the U.S. Others may be permanent residents near Seabrook 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 a significant amount of 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 2007 Census of Agriculture. Table 2–16 provides information on migrant farm workers and temporary farm labor (less than 150 days) within 50 mi (80 km) of the Seabrook. According to the 2007 Census of Agriculture, approximately 7,104 farm workers were hired to work for less than 150 days and were employed on 1,348 farms within 50 mi (80 km) of the Seabrook. The county with the largest number of temporary farm workers (1,433) on 149 farms was Essex County, MA (USDA 2009).

In the 2002 Census of Agriculture, farm operators were asked for the first time whether or not they hired migrant workers, defined as a farm worker whose employment required travel that prevented the migrant worker from returning to their permanent place of residence the same day. A total of 535 farms in a 50-mi (80-km) radius of the Seabrook reported hiring migrant workers in the 2007 Census of Agriculture. Middlesex County and Plymouth County reported the most farms (82 in both) with hired migrant workers, followed by Worcester County and Essex County, with 81 and 63 farms, respectively (USDA 2009).

Table 2–16. Migrant Farm Workers and Temporary Hired Farm Labor in Counties Located Within 50 mi of Seabrook

County[(a)]	Number of farms with hired farm labor[(b)]	Number of farms hiring workers for less than 150 days[(b)]	Number of farm workers working for less than 150 days[(b)]	Number of farms reporting migrant farm labor[(b)]
		Maine		
York	160	141	555	9
		Massachusetts		
Essex	171	116	463	15
Middlesex	214	149	1,433	20
Norfolk	70	51	219	7
Plymouth	295	240	894	25
Suffolk	3	3	4	0
Worcester	284	216	1,066	49
County subtotal	1,037	775	4,079	116
		New Hampshire		
Belknap	41	28	166	3
Carroll	42	32	147	2
Hillsborough	124	101	495	13
Merrimack	120	95	554	12
Rockingham	150	123	802	14
Strafford	60	53	306	2
County subtotal	537	432	2,470	46
Total	1,734	1,348	7,104	171

(a) Counties within 50 mil (80 km) of Seabrook with at least one block group located within the 50-mi (80 km)radius
(b) Table 7. Hired Farm Labor—Workers and Payroll, 2007

Source: (USDA 2009)

According to the 2007 Census of Agriculture estimates, 802 temporary farm workers (those working fewer than 150 days per year) were employed on 123 farms in Rockingham County, and 306 temporary farm workers were employed on 53 farms in Strafford County (USDA 2009).

2.2.9.6 Economy

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

Employment and Income. From 2000–2009, the civilian labor force in Rockingham County increased 11.8 percent from 155,473 to an estimated 173,847. Strafford County also increased 17.3 percent during that time, from 62,065 to an estimated 72,806 (USCB 2011).

In 2009, educational services, and health care and social services industry (21.8 percent) represented the largest sector of employment (19.9 percent) in Rockingham County, followed by retail trade (14.5 percent). In Strafford County, the educational services, health care, and social services industry represented the largest employment sector (24.3 percent), followed by manufacturing (14.5 percent). A list of major employers in the two-county area is provided in Table 2–17. As shown in the table, the two largest employers in the two-county area are Liberty Mutual Insurance and the University of New Hampshire.

Table 2–17. Major Employers in the Two-County Socioeconomic ROI, in 2009

Employer	Number of employees
Liberty Mutual Insurance	4,337
University of New Hampshire	4,268
Insight Technologies	1,300
Columbia Hospital Corporation of America Hospital	1,150
City of Dover	1,139
City of Rochester	1,119
Wentworth-Douglas Hospital	1,048
Exeter Hospital	1,000
NextEra Energy Seabrook, LLC	1,000
City of Portsmouth	937
U.S. Department of State, National Passport Center	900
Heidelberg-Harris, Inc.	900
Timberlane Regional School District	740
Derry Cooperative School System	690
Rockingham County Home and Jail	690
Frisbie Memorial Hospital	655
Timberland	650
Lonza Biologies	650

Source: (NHELMIB 2010)

Estimated income information for the Seabrook ROI is presented in Table 2–18. According to the American Community Survey 2009 estimates, median household and per capita incomes were above the state average in Rockingham County and lower in Strafford County. An estimated 6.0 and 9.2 percent of individuals in Rockingham County and Strafford County were living below the official poverty level, respectively, while New Hampshire, as a whole, had 8.5 percent. The percentage of families living below the poverty level in Rockingham County and Strafford County was 4.0 and 5.2 percent, respectively. The percentage of families in the New Hampshire as a whole was 5.5 percent (USCB 2011).

Table 2–18. Estimated Income Information for the Seabrook Two-County Socioeconomic ROI in 2009, Estimated

	Rockingham	Strafford	New Hampshire
Median household income (dollars)[(a)]	70,160	56,463	60,567
Per capita income (dollars)[(a)]	34,315	28,160	30,396
Individuals living below the poverty level (percent)	6.0	9.2	8.5
Families living below the poverty level (percent)	4.0	5.2	5.5

[(a)] In 2009 inflation-adjusted dollars

Source: (USCB 2011)

Unemployment. According to the American Community Survey 2009 estimates, unemployment rates in Rockingham and Strafford counties were 8.2 and 6.8 percent, respectively, while the unemployment rate for the State of New Hampshire was 7.8 percent (USCB 2011).

Taxes. NextEra pays annual property taxes to seven local towns and the State of New Hampshire. However, payments to the Town of Seabrook and to the New Hampshire Education Trust Fund are the most significant, with payments in 2009 providing 48.7 percent of net tax commitment in the Town of Seabrook (Table 2–19) and 2 percent of the Education Trust Fund revenues (Table 2–20). Property tax payments made to the Towns of East Kingston, Kingston, Hampton, Hampton Falls, and Newington constituted 1 percent or less of net tax commitment in each jurisdiction in 2008 (NextEra 2010a).

Table 2–19. Net Tax Commitment in Town of Seabrook, 2004–2008; Seabrook Property Tax 2004–2008; and Seabrook Property Tax as a Percentage of Net Tax Commitment in Town of Seabrook

Year	Net tax commitment of Town of Seabrook (in millions of dollars, 2009)	Property tax paid by Seabrook (in millions of dollars, 2009) [(a)]	Seabrook property tax as percentage of net tax commitment in Town of Seabrook[(a)]
2004	23.2	8.8	38.1
2005	25.2	8.4	33.5
2006	27.0	10.5	39.0
2007	28.7	11.2	39.1
2008	32.0	15.6	48.7

[(a)] includes property tax payments made by NextEra and Joint Owners

Source: (NextEra 2010f)

From 2004–2008, property taxes paid by NextEra and the Joint Owners increased from $8.8 million to $15.6 million, while the net tax commitment increased in the Town of Seabrook from $23.2 to $32.0 million (Table 2–19). Each year, the Town of Seabrook collects these taxes, retains a portion for operations, and disburses the remainder to the local school system, Rockingham County, and the state of New Hampshire (NextEra 2010a). Over the same period, property taxes paid by NextEra to the New Hampshire Education Trust Fund increased from $4.0 million to $7.6 million, while total revenues in the Fund increased from $289.1 million to $380.3 million (Table 2–20).

Table 2–20. New Hampshire Education Trust Fund Revenues, 2004–2008; Seabrook Property Tax, 2004–2008; and Seabrook Property Tax as a Percentage of Total New Hampshire Education Trust Fund Revenues

Year	Education Trust Fund revenues (in millions of dollars, 2009)	Property tax paid by Seabrook (in millions of dollars, 2009)	Seabrook property tax as percentage of total Education Trust Fund revenues
2004	289.1	4.0	1.4
2005	304.7	4.0	1.3
2006	360.8	4.3	1.2
2007	383.8	5.8	1.5
2008	380.3	7.6	2.0

Source: (NextEra 2010f)

The State of New Hampshire's electric utility industry is deregulated, and this is not expected to change, meaning that property taxes paid by Seabrook are expected to continue to be primarily based on the market value of the Station property over the license renewal period.

Other Fees and Charitable Contributions. During 2009, Seabrook paid $3.8 million in emergency preparedness fees to the Federal Emergency Management Agency (FEMA) and to the States of Maine, Massachusetts, and New Hampshire. NextEra also made more than $90,000 in charitable donations to various local and regional organizations as well as a $29,000 donation to other various environmental outreach programs (NextEra 2010f).

2.2.10 Historic and Archaeological Resources

This section discusses the cultural background and the known historic and archaeological resources at Seabrook and in the surrounding area.

2.2.10.1 Cultural Background

The earliest evidence of people living in New England dates to the Paleo-Indian Cultural Period (10,000 B.C.–8,000 B.C.). Sites containing artifacts associated with this cultural period are found throughout New England, including several locations in New Hampshire. Paleo-Indian sites are found on elevated landforms and contain fluted projectile points (i.e., Clovis spear points), channel flakes, hide scrapers, hammerstones, anvilstones, and abradingstones (Starbuck 2006). Paleo-Indian peoples came into the region as the last major glacial period was ending. The climate being much colder than it is today. Paleo-Indian lifestyles followed a nomadic subsistence pattern based on hunting large game but also using smaller game (Starbuck 2006). During this period, ocean levels rose and landscapes were saturated due to melting glacial ice.

The transition to modern climatic conditions occurred during the next and longest prehistoric cultural period—the Archaic (8,000 B.C.–1,000 B.C.). The Archaic Period was a time of major climatic shifts and the development of new subsistence strategies. The very long Archaic Period (7,000 years) is often divided into early, middle, and late subperiods. The Archaic Period, in general, appears to have been a time of increasing population that required more intensive subsistence strategies. Hallmarks of archaic cultures are an increased reliance on fish and shellfish, the first evidence of continued reliance on plants as a food source, and use of the atlatl (a throwing stick used to increase the range and effectiveness of spears). Archaic settlement patterns suggest a considerable amount of seasonal resource use. The first evidence for horticulture appears at the end of the Archaic Period. Archaic sites are often found near the falls of major rivers and on the ocean shoreline.

The Archaic Period is followed by the Woodland Cultural Period (1000 B.C.–A.D. 1600). The Woodland Period is often divided into early, middle and late periods. The Woodland Period is marked by the appearance of pottery, smoking pipes, more elaborate funerary practices (i.e., burials mounds, funerary items), semi-sedentary villages, and horticulture. In New Hampshire, there is almost no direct evidence of horticulture (Starbuck 2006). In the Merrimack River Valley of New Hampshire, many sites appear to have gone through cycles of occupation. Some sites were occupied during the early and late Woodland Periods but deserted during the Middle Woodland. In contrast, Woodland Period sites on the Atlantic Coast appear to have been occupied throughout the entire Woodland Period.

The Woodland Period ends with the coming of Europeans around A.D. 1600. This period is often termed the Contact Period. Based on historical sources, the main groups living in New Hampshire prior to the Contact Period were the eastern and western tribes of the Abenaki, the Winnipesaukees, and the Penacooks (Starbuck 2006). The Penacooks lived in the southeastern portion of the state in the vicinity of the future Seabrook. Most of the Native population in the New England region succumbed to European diseases by the early 1600s.

English and French ships had explored and fished the New England coast for many years prior to the establishment of settlements. The first permanent European settlement in New Hampshire was in 1623 at Odiorne Point near modern day Rye, NH. The lands containing Seabrook were settled in 1638 as part of the town of Hampton. In 1726, the Seabrook area separated and became part of Hampton Falls. The community of Seabrook was incorporated in 1768. The city would reach its modern geographical extent in 1822. The economy in Seabrook was based on fishing and hay farming in the salt marshes as feed for cattle, milling, weaving, and shoemaking (Valimont 2010). In 1791, a canal was built linking the Hampton River to the Merrimack River. This helped to start a boat building industry in Seabrook. In 1840, the Eastern Railroad connected Seabrook to other major towns along the Atlantic seacoast. The railroad caused the economy and population to grow. Seabrook also became heavily involved in the shoe industry, although fishing continued to be a major part of the local economy. The population of Seabrook peaked around 1880 (Valimont 2010). The establishment and expansion of the highway system in the 20th century further increased the accessibility of coastal towns like Seabrook. By the late 20th century, tourism had become a major component of the local economy (NHDHR 2010).

2.2.10.2 Historic and Archaeological Resources

A review of the National Register of Historic Places (NRHP) lists 124 properties in Rockingham County, NH, and 480 properties in Essex County, MA (NPS 2010). Two NRHP properties, the Governor Meshech Weare House and the Unitarian Church, are located in Hampton Falls. There are nine NRHP properties or historic districts in Hampton. These include the Capt. Jonathan Currier House, the Highland Road Historic District, the Benjamin James House, the Jewell Town District, the Reuben Lamprey Homestead, the Little Boar's Head District, the Smith's Corner Historic District, the Town Center Historic District, and the Woodman Road Historic District. There are no listed NRHP properties in the town of Seabrook. However, historic and archaeological resources have been found at the Seabrook.

Seven archaeological sites have been identified on Seabrook property, and more sites are likely to be present; however, these are located outside the areas expected to be affected by station operations (Valimont 2010). Archaeological surveys conducted in 1973, prior to the construction of the Seabrook, identified archaeological sites (NRC 1982). Three of the archaeological sites were later combined to form the Rocks Road Site (27RK75). The other two archaeological sites (27RK452 and 27RK453) were determined to be outside the construction footprint. The Rock Roads Site was exhumed, prior to construction, in 1974. The other two sites were not affected by the construction of Seabrook. In 2010, NextEra sponsored additional archaeological investigations to refine the location and extent of existing archaeological sites and resources at the Seabrook.

Table 2–21 lists the historic and archaeological resources found on Seabrook property. Most of the historic and archaeological sites on the Seabrook property are associated with prehistoric cultures. The Rocks Road Site, 27RK75, contained evidence of human use beginning in the Late Archaic Period and continuing on to the Late Woodland Period. Human remains were also found at the site. These remains were given to the Abenaki Nation of Missisquoi in 2002 (73 FR 104; May 29, 2008). The remains of a 19th century habitation site was also found at the site. Site 27RK75 was excavated in 1974–1975 by Charles Bolian of the University of New Hampshire, prior to construction of the station. The location of this site was under the Protected Area. Site 27RK162 is the remains of a prehistoric site of unknown age. This site also contained evidence of use during the 19th century. Site 27RK164 is the remains of a prehistoric era site that was occupied from the Late Archaic Period to the Late Woodland Period. Site 27RK165 is the remains of a Late Archaic campsite. Site 27RK170 is the remains of a prehistoric campsite of unknown age. Pottery fragments were found at this site suggesting the

Late Archaic to Woodland Period. Sites 27RK452 and 27RK453 both appear to be fishing station and habitation sites; however, one dates to the Middle Woodland Period and one dates to the Middle Archaic Period, respectively.

Table 2–21. Historic and Archaeological Resources Found on Seabrook Property

Site number	Type	NRHP eligibility	Status
27RK75 (Rocks Road Site)	Prehistoric/Historic	Eligible	Removed prior to construction
27RK162 (Healey's Island)	Prehistoric/Historic	Unevaluated	Outside power block area
27RK164 (Hunts Island)	Prehistoric/Historic	Unevaluated	Outside power block area
27RK165 (Seabrook Marsh)	Prehistoric	Unevaluated	Outside power block area
27RK170 (South Rock Storage Area)	Prehistoric	Unevaluated	Outside power block area
27RK452 (Bolian 2)	Prehistoric	Unevaluated	Partially under power block perimeter fence
27RK453 (Bolian 5)	Prehistoric	Unevaluated	Within power corridor to plant

In addition to the known sites, a recent study suggests that additional archaeological sites are likely to be found on Seabrook property (Valimont 2010). The recent study identified areas that should be examined for archaeological resources in the event of future activities.

Transmission Lines. Two archaeological sites (27RK168 and 27RK244) have been identified within the transmission line ROW. Both sites contain prehistoric material and have not been assessed for eligibility for listing on the NRHP.

2.3 Related Federal and State Activities

The NRC staff reviewed the possibility that activities of other Federal agencies might impact the renewal of the operating license for Seabrook. 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 Seabrook SEIS.

The NRC has determined that there are no Federal projects that would make it desirable for another Federal agency to become a cooperating agency in the preparation of the SEIS. Federally owned facilities within 50 mi (80 km) of Seabrook are listed below:

- Pease Air National Guard Base (U.S. Department of Defense (USDOD)),
- Portsmouth Naval Shipyard (USDOD),
- Portsmouth Harbor Coast Guard Station (U.S. Department of Homeland Security), and
- Merrimack River Coast Guard Station (U.S. Department of Homeland Security).

The NRC is required, under Section 102(2)(c) of the National Environmental Policy Act of 1969 (NEPA), as amended, 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. The NRC consulted with the NMFS and the FWS. Federal agency consultation correspondence and comments on the SEIS are presented in Appendix D.

In the U.S., coastal areas are managed through the Coastal Zone Management Act of 1972. 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 Hampshire Coastal Management Program was initially approved by NOAA in 1982. The lead agency is the NHDES. The lead agency implements and supervises all the various Coastal Zone Management Programs in the State. Federal consistency requires "[F]ederal 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." NHDES completed its review of the Seabrook consistency certification on November 4, 2010, and found that the applicant complies with the enforceable policies of New Hampshire's Coastal Management Program (NHDES 2010d).

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3.0 ENVIRONMENTAL IMPACTS OF REFURBISHMENT

Environmental issues associated with refurbishment activities are discussed in NUREG-1437, *Generic Environmental Impact Statement (GEIS) for License Renewal of Nuclear Plants*, Volumes 1 and 2 (NRC 1996). The GEIS includes a determination of whether or not the analysis of the environmental issues can be applied to all plants and whether or not additional mitigation measures are warranted. Issues are then 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:

- The environmental impacts associated with the issue have been determined to apply to all plants or, for some issues, apply only to plants having a specific type of cooling system or other specified plant or site characteristics.
- A single significance level (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).
- Mitigation of adverse impacts associated with the issue has been considered in the analysis. 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 supplemental environmental impact statement (SEIS) unless new and significant information is identified.

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

License renewal actions include refurbishment for the extended plant life. These actions may have an impact on the environment that requires evaluation, depending on the type of action and the plant-specific design. Environmental issues associated with refurbishment, which were determined to be Category 1 issues, are listed in Table 3–1.

Table 3–1. Category 1 Issues for Refurbishment Evaluation

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section(s)
Surface Water Quality, Hydrology, & Use (for all plants)	
Impacts of refurbishment on surface water quality	3.4.1
Impacts of refurbishment on surface water use	3.4.1
Aquatic Ecology (for all plants)	
Refurbishment	3.5
Groundwater Use & Quality	
Impacts of refurbishment on groundwater use & quality	3.4.2
Land Use	
Onsite land use	3.2
Human Health	
Radiation exposures to the public during refurbishment	3.8.1
Occupational radiation exposures during refurbishment	3.8.2
Socioeconomics	
Public services: public safety, social services, and tourism & recreation	3.7.4; 3.7.4.3; 3.7.4.4; 3.7.4.6
Aesthetic impacts (refurbishment)	3.7.8

Environmental issues related to refurbishment considered in the GEIS that are inconclusive for all plants, or for specific classes of plants, are Category 2 issues. These are listed, along with other Category 2 issues, in Table 3–2.

Table 3–2. Category 2 Issues for Refurbishment Evaluation

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section(s)	10 CFR 51.53(c)(3)(ii) Subparagraph
Terrestrial Resources		
Refurbishment impacts	3.6	E
Threatened or Endangered Species (for all plants)		
Threatened or endangered species	3.9	E
Air Quality		
Air quality during refurbishment (nonattainment & maintenance areas)	3.3	F
Socioeconomics		
Housing impacts	3.7.2	I
Public services: public utilities	3.7.4.5	I
Public services: education (refurbishment)	3.7.4.1	I
Offsite land use (refurbishment)	3.7.5	I
Public services & transportation	3.7.4.2	J
Historic & archaeological resources	3.7.7	K
Environmental Justice		
Environmental justice [a]	Not addressed	Not addressed

[a] Guidance related to environmental justice was not in place at the time the U.S. Nuclear Regulatory Commission (NRC) prepared the GEIS and the associated revision to 10 CFR Part 51. If an applicant plans to undertake refurbishment activities for license renewal, the applicant's Environmental Report (ER) and the NRC staff's environmental impact statement must address environmental justice.

The potential environmental effects of refurbishment actions are identified, and the analysis will be summarized within this section, if such actions are planned. NextEra Energy Seabrook, LLC (NextEra) indicated that it has performed an evaluation of systems, structures, and components (SSCs) pursuant to Section 54.21 of Title 10 of the *Code of Federal Regulations* (10 CFR 54.21) to identify the need to undertake any major refurbishment activities that are necessary to support continued operation of Seabrook Station (Seabrook) during the requested 20-year period of extended operation. Items that are subject to aging and might require refurbishment to support continued operation during the renewal period are listed in Table B.2 of the GEIS.

The results of NextEra's evaluation of SSCs for Seabrook, as required by 10 CFR 54.21, did not identify the need to undertake any major refurbishment or replacement actions associated with license renewal to support the continued operation of Seabrook beyond the end of the existing operating license (NextEra 2010). Therefore, an assessment of refurbishment activities is not considered in this SEIS.

3.1 References

U.S. Code of Federal Regulations (CFR), "Environmental protection regulations for domestic licensing and related regulatory functions," Part 51, Title 10, "Energy."

CFR, “Requirements for renewal of operating licenses for nuclear power plants,” Part 54, Title 10, “Energy.”

NextEra Energy Seabrook, LLC (NextEra), 2010, “License renewal application, Seabrook Station,” Appendix E, “Applicant’s Environmental Report, Operating License Renewal Stage,” May 25, 2010, Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML101590092 and ML101590089.

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4.0 ENVIRONMENTAL IMPACTS OF OPERATION

This chapter addresses potential environmental impacts related to the period of extended operation of Seabrook Station (Seabrook). These impacts are grouped and presented according to resource. Generic issues (Category 1) rely on the analysis provided in the generic environmental impact statement (GEIS) (NRC 1996, 1999, 2013a) and are discussed briefly. Site-specific issues (Category 2) have been analyzed for Seabrook and assigned a significance level of SMALL, MODERATE, or LARGE, accordingly. Some remaining issues are not applicable to Seabrook because of site characteristics or plant features. For an explanation of the criteria for Category 1 and Category 2 issues, as well as the definitions of SMALL, MODERATE, and LARGE, refer to Section 1.4.

In addition, as also described in Section 1.4, the U.S. Nuclear Regulatory Commission (NRC) has published a final rule (NRC 2013b) revising its environmental protection regulation, Title 10 of the *Code of Federal Regulations* (10 CFR) Part 51, “Environmental protection regulations for domestic licensing and related regulatory functions.” The final rule consolidates similar issues and changes some Category 2 issues into Category 1 issues. The final rule also adds new Category 1 and 2 issues.

4.1 Land Use

Onsite land use issues that could be affected by license renewal are listed in Table 4–1. As discussed in the GEIS, onsite land use and power line right-of-way (ROW) conditions are expected to remain unchanged during the license renewal term at all nuclear plants; thus, impacts would be SMALL. Therefore, these issues were classified as Category 1 issues. Section 2.2.1 of this supplemental environmental impact statement (SEIS) describes the land use conditions at Seabrook.

Table 4–1. Land Use Issues

Issues	GEIS section	Category
Onsite land use	4.5.3	1
Power line ROW	4.5.3	1

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

The Seabrook environmental report (ER) (NextEra 2010), scoping comments, and other available data records on Seabrook were reviewed and evaluated for new and significant information. The review included a data gathering site visit to Seabrook. No new and significant information was identified during this review that would change the conclusions presented in the GEIS. Therefore, for these Category 1 issues, impacts during the renewal term are not expected to exceed those discussed in the GEIS.

4.2 Air Quality

As described in Section 1.4 of this SEIS, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to air quality, the final rule amends Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51 by changing the “Air quality during refurbishment (non-attainment and maintenance areas)” issue from a Category 2 to a Category 1 issue and renamed it “Air quality impacts (all plants).” This Category 1 issue,

"Air quality impacts (all plants)," has an impact level of SMALL. There was no change to the Category 1 "Air quality effects of transmission lines" issue. The NRC staff performed its review, as discussed below, of air quality issues in accordance with the 1996 GEIS (NRC 1996) for this SEIS.

The air quality issue applicable to Seabrook is listed in Table 4–2. There are no applicable Category 2 issues for air quality. The Category 2 issue, "Air quality during refurbishment," is not applicable because NextEra Energy Seabrook, LLC (NextEra) has no plans for refurbishment or other license renewal-related construction activities, as presented in Chapter 3 of this SEIS. Section 2.2.2 of this SEIS describes the meteorological and air quality conditions relative to Seabrook.

Table 4–2. Air Quality Issues

Issue	GEIS section	Category
Air quality effects of transmission lines	4.5.2	1

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

The area around Seabrook is designated nonattainment for the Federal 8-hour ozone National Ambient Air Quality Standards (NAAQS). Air emissions from current Seabrook operations are regulated by the operating permit conditions that would continue in effect during the license renewal period; thus, no increases in emissions from stationary sources would occur. For the Category 1 issue of air quality effects of transmission lines, the NRC staff found that "production of ozone and oxides of nitrogen is insignificant and does not contribute measurably to ambient levels of these gases." NRC staff did not identify any new and significant information based on the review of the ER (NextEra 2010), based on the public scoping process, or as a result of the environmental site audit that would change the conclusions presented in the GEIS. As a result, it is expected that there would be no impacts related to this Category 1 issue during the period of extended operation beyond those discussed in the GEIS. For these issues, the GEIS concluded that the impacts are SMALL.

4.3 Geological Environment

4.3.1 Geology and Soils

As described in Section 1.4 of this SEIS, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to the geologic environment of a plant site, the final rule amends Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51 by adding a new Category 1 issue, "Geology and soils." This new issue has an impact level of SMALL. This new Category 1 issue considers geology and soils from the perspective of those resource conditions or attributes that can be affected by continued operations during the renewal term. An understanding of geologic and soil conditions has been well established at all nuclear power plants and associated transmission lines during the current licensing term, and these conditions are expected to remain unchanged during the 20-year license renewal term for each plant. The impact of these conditions on plant operations and the impact of continued power plant operations and refurbishment activities on geology and soils are SMALL for all nuclear power plants and not expected to change appreciably during the license renewal term. Operating experience shows that any impacts to geologic and soil strata would be limited to soil disturbance from construction activities associated with routine infrastructure renovation and maintenance projects during continued plant operations. Implementing best management practices would reduce soil erosion and subsequent impacts on surface water quality.

Information in plant-specific SEISs prepared to date and GEIS reference documents have not identified these impacts as being significant.

Section 2.2.3 of this SEIS describes the local and regional geologic environment relevant to Seabrook. The NRC staff did not identify any new and significant information with regard to this Category 1 (generic) issue based on review of the ER (NextEra 2010), the public scoping process, or as a result of the environmental site audit. As discussed in Chapter 3 of this SEIS and as identified in the ER (NextEra 2010), NextEra has no plans to conduct refurbishment or construction of new facilities during the license renewal term. Further, it is anticipated that routine plant operation and maintenance activities would continue in areas previously disturbed by construction activities, including existing transmission line ROWs. Based on this information, it is expected that any incremental impacts on geology and soils during the license renewal term would be SMALL.

4.4 Surface Water Resources

The surface water issues applicable to Seabrook are listed in Table 4–3 (also see Table B-1 in Appendix B to Subpart A of 10 CFR 51). Surface water use and water quality relative to Seabrook are described in Sections 2.1.7.1 and 2.2.4 of this SEIS, respectively.

Table 4–3. Surface Water Use and Quality Issues

Issues	GEIS sections	Category
Altered salinity gradient	4.2.1.2.2	1
Scouring caused by discharged cooling water	4.2.1.2.3	1
Discharge of chlorine or other biocides	4.2.1.2.4	1
Discharge of sanitary wastes & minor chemical spills	4.2.1.2.4	1
Discharge of other metals in wastewater	4.2.1.2.4	1
Water use conflicts (plants with once-through cooling systems)	4.2.1.3	1

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

4.4.1 Generic Surface-Water Issues

NRC staff did not identify any new and significant information based on review of the ER (NextEra 2010), the public scoping process, or as a result of the environmental site audit. The NRC staff also reviewed other sources of information such as various permits, assorted applicant files, and data reports. As a result, no information or impacts related to these issues were identified that would change the conclusions presented in the GEIS. Therefore, it is expected that there would be no impacts related to these Category 1 issues during the period of extended operation beyond those discussed in the GEIS. For these surface water issues, the GEIS concluded that the impacts are SMALL.

4.4.2 Surface-Water Use Conflicts

No Category 2 surface water issues were found to be applicable to the continued operation of the station, and no further evaluation was performed for Seabrook.

4.5 Groundwater Resources

The groundwater issues applicable to Seabrook are listed in Table 4–4 (also see Table B-1 of Appendix B of 10 CFR 51). Groundwater use and water quality relative to Seabrook are described in Sections 2.1.7.2 and 2.2.5 of this SEIS, respectively.

Table 4–4. Groundwater Use and Quality Issues

Issues	GEIS sections	Category
Groundwater use conflicts (potable & service water; plants that use <100 gallons per minute (gpm))	4.8.1.1	1
Groundwater quality degradation (saltwater intrusion)	4.8.2.1	1
Radionuclides released to groundwater	4.5.1.2[a]	2

[a] NRC 2013a, 2013b

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

4.5.1 Generic Groundwater Issues

The combined groundwater withdrawal for Unit 2 dewatering and Unit 1 tritium hydraulic control, as discussed in Section 2.1.7.2, is much less than 100 gpm (380 liters per minute (L/min)). NRC staff did not identify any new and significant information—based on review of the ER (NextEra 2010), the public scoping process, or as a result of the environmental site audit—that would change the conclusions presented in the GEIS. Therefore, it is expected that were would be no impacts related to these Category 1 issues during the period of extended operation beyond those discussed in the GEIS. For these groundwater issues, the GEIS concluded that the impacts are SMALL. Additional information on NRC's evaluation of new and significant information relative to groundwater quality at Seabrook is presented in Section 4.11 of this SEIS.

4.5.2 Groundwater Use Conflicts

No Category 2 groundwater use issues were found to be applicable to the continued operation of the station, and no further evaluation was performed for Seabrook.

4.5.3 Radionuclides Released to Groundwater

With respect to groundwater quality, the final rule amends Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51 by adding a new Category 2 issue, "Radionuclides released to groundwater," with an impact level range of SMALL to MODERATE, to evaluate the potential impact of discharges of radionuclides from plant systems into groundwater. This new Category 2 issue has been added to evaluate the potential impact to groundwater quality from the discharge of radionuclides from plant systems, piping, and tanks. This issue was added because, within the past several years, there have been events at nuclear power reactor sites that involved unknown, uncontrolled, and unmonitored releases of radioactive liquids into the groundwater. A discussion of groundwater quality concerns at Seabrook is included in Section 2.2.5 of this SEIS, and an assessment of the significance of groundwater quality degradation due to tritium contamination is presented in Section 4.11 of this SEIS. In evaluating the potential impacts on groundwater quality associated with license renewal, the NRC staff uses as its baseline the

groundwater conditions as described in Section 2.2.5 of this SEIS. These baseline conditions encompass the quality of groundwater potentially affected by continued operations (as compared to relevant state or Environmental Protection Agency (EPA) primary drinking water standards) as well as the current and potential onsite and offsite uses and users of groundwater for drinking and other purposes. The baseline also considers other downgradient or in-aquifer uses and users of groundwater.

As detailed in Section 2.2.5, the NRC staff found that groundwater with elevated tritium activity concentrations was detected in the annular space around the Unit 1 containment structure in September 1999. In response to the elevated tritium concentrations, NextEra initiated a leak investigation, which identified a leak source associated with the cask loading area and transfer canal adjacent to the spent fuel pool (SFP). In addition, NextEra has undertaken leak source elimination efforts and other corrective actions, which ultimately involved installation of a groundwater dewatering and pumping system to mitigate contaminated groundwater. An extensive groundwater monitoring network was also installed to provide surveillance of groundwater quality across the Seabrook site.

NextEra has monitored the dewatering system since 2000, the results of which were reviewed by NRC staff in support of the preparation of the August 2011 draft SEIS. The highest tritium levels (up to 3,500,000 picocuries per liter (pCi/L) in 2003) were found in water removed from around the Unit 1 containment enclosure ventilation area (CEVA). Since monitoring began, NextEra has found that the tritium levels are trending down. Based on the most recent (2011) dewatering system monitoring data available for the site, tritium concentrations in the CEVA have ranged from 2,150 up to 50,000 pCi/L (NextEra 2011a).

NextEra continues to conduct groundwater monitoring as part of its participation in the Nuclear Energy Institute's Groundwater Protection Initiative (NextEra 2010). Monitoring results obtained through the onsite Groundwater Protection Program are reported in NextEra's radioactive effluent release reports, which are submitted to the NRC. Based on monitoring results from Seabrook's network of 27 groundwater monitoring wells through the end of 2011, the highest concentration of tritium detected was 2,850 pCi/L in well SW-1, a shallow aquifer well located near the Unit 1 containment structure. EPA's drinking water standard (or maximum contaminant level) is 20,000 pCi/L. Several other nearby wells had lower tritium levels, while samples from most wells yielded no tritium above analytical detection limits. Monitoring results from a line of perimeter wells located south and downgradient of the tritium leak source have shown no tritium detections. Finally, NextEra reported no unplanned, unanticipated, or abnormal releases of liquid effluents from the site to unrestricted areas during 2010 and 2011 (NextEra 2010a, 2011b, 2012).

As noted above and further discussed in this SEIS, the Unit 1 groundwater dewatering system, in combination with pumping from beneath the incomplete Unit 2 containment building, functions at Seabrook to remove and provide hydraulic containment of the tritium-contaminated groundwater by reversing the hydraulic gradient and flow of groundwater offsite. No offsite migration of tritium in groundwater has been observed to date. Further, the only drinking water wells (Town of Seabrook) are located hydraulically upgradient from the Seabrook site, and there is no drinking water pathway onsite.

While tritium continues to be detected above background levels at several onsite locations, the applicant is actively monitoring and controlling the tritium concentrations on site. The tritium-impacted groundwater is sent to the facility's main outfall to the ocean, where it is released in compliance with National Pollutant Discharge Elimination System (NPDES) and NRC's radiological limits. Tritium concentrations in groundwater as measured in onsite monitoring wells have remained well below EPA's 20,000 pCi/L drinking water standard. Based

on the information presented above and in Sections 2.2.5 and 4.11 of this SEIS , the NRC concludes that inadvertent releases of tritium have not substantially impaired site groundwater quality or affected groundwater use downgradient of the Seabrook site. The NRC staff further concludes that groundwater quality impacts would remain SMALL during the license renewal term.

4.6 Aquatic Resources

Section 2.1.6 of this SEIS describes Seabrook's cooling water system, and Section 2.2.6 describes the aquatic resources. Table 4–5 lists the issues in 10 CFR Part 51, Subpart A, Appendix B, Table B–1 that apply to the operation of Seabrook's cooling water systems during the renewed license term.

This section examines the present and past impacts resulting from plant operation to infer future impacts over the license renewal term (i.e., the remainder of the present term plus an additional 20 years). Two related concepts bound the analysis of direct and indirect impacts: the timeframe and geographic extent. The timeframe defines how far back and how far forward the analysis will extend. The timeframe of analyses for ecological resources centers on the present and extends into the past far enough to understand trends and to determine whether the resource is stable, as required by the NRC definitions of impact levels, and into the future through the license renewal term. For assessing direct and indirect impacts, the geographic boundaries depend on the biology of the species under consideration.

In assessing the level of impact, the staff looks at the projected effects in comparison to a baseline condition. Consistent with NEPA guidance (CEQ 1997a), the baseline of the assessment is the condition of the resource without the action (i.e., under the no-action alternative). Under the no-action alternative, the resource would conceptually be in its present condition without the plant operating, which is not necessarily the condition of the resource before the plant was constructed. The analyses that follow use two representative baseline conditions that have been incorporated into ecological studies conducted at Seabrook: far field conditions chosen as unaffected by plant operation and preoperational conditions.

Table 4–5. Aquatic Resources Issues

Issues	GEIS sections	Category
For all plants		
Accumulation of contaminants in sediments or biota	4.2.1.2.4	1
Entrainment of phytoplankton & zooplankton	4.2.2.1.1	1
Cold shock	4.2.2.1.5	1
Thermal plume barrier to migrating fish	4.2.2.1.6	1
Distribution of aquatic organisms	4.2.2.1.6	1
Premature emergence of aquatic insects	4.2.2.1.7	1
Gas supersaturation (gas bubble disease)	4.2.2.1.8	1
Low dissolved oxygen in the discharge	4.2.2.1.9	1
Losses from predation, parasitism, & disease among organisms exposed to sublethal stresses	4.2.2.1.10	1
Stimulation of nuisance organisms	4.2.2.1.11	1
Exposure of aquatic organisms to radionuclides	4.6.1.2[a]	1
For plants with once-through dissipation systems		
Entrainment of fish & shellfish in early life stages	4.1.2	2
Impingement of fish & shellfish	4.1.3	2
Heat shock	4.1.4	2

[a]NRC 2013a, 2013b

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

4.6.1 Generic Aquatic Ecology Issues

The NRC staff did not identify any new and significant information related to the Category 1 issues listed above during the review of NextEra's ER (NextEra 2010), the site audit, or the scoping process. The staff found no impacts related to these issues beyond those discussed in the GEIS and the final rule (NRC 2013b), which conclude that the impact levels are SMALL.

<u>Exposure of Aquatic Organisms to Radionuclides</u>

As described in Section 1.4 of this SEIS, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to the aquatic organisms, the final rule amends Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51 by adding a new Category 1 issue, "Exposure of aquatic organisms to radionuclides," among other changes. This new Category 1 issue considers the impacts to aquatic organisms from exposure to radioactive effluents discharged from a nuclear power plant during the license renewal term. An understanding of the radiological conditions in the aquatic environment from the discharge of radioactive effluents within NRC regulations has been well established at nuclear power plants during their current licensing term. Based on this information, the NRC concluded that the doses to aquatic organisms are expected to be well below exposure guidelines developed to protect these organisms and assigned an impact level of SMALL.

The NRC staff has not identified any new and significant information related to the exposure of aquatic organisms to radionuclides during its independent review of Seabrook's ER

(NextEra 2010), the site audit, and the scoping process. Section 2.1.2 of this SEIS describes the applicant's Radioactive Waste Management Program to control radioactive effluent discharges to ensure that they comply with NRC regulations in 10 CFR Part 20. Sections 4.9.1.3 and 4.9.1.4 of this SEIS contains the NRC staff's evaluation of Seabrook's Radioactive Effluent and Radiological Environmental Monitoring programs, respectively. Seabrook's Radioactive Effluent and Radiological Environmental Monitoring programs provide further support for the conclusion that the impacts of aquatic organisms from radionuclides are SMALL.

The NRC staff concludes that there would be no impacts to aquatic organisms from radionuclides beyond those impacts contained in Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51 of the final rule; therefore, the impacts to aquatic organisms from radionuclides are SMALL.

4.6.2 Entrainment and Impingement

Entrainment and impingement of aquatic organisms are site-specific (Category 2) issues for assessing impacts of license renewal at plants with once-through cooling systems. Entrainment is the taking in of organisms with the cooling water. The organisms involved are generally of small size, dependent on the screen mesh size, and include phyto- and zooplankton, fish eggs and larvae, shellfish larvae, and many other forms of aquatic life. Impingement is the entrapment of organisms against the cooling water intake screens.

A particular species can be subject to both impingement and entrainment if some individuals are impinged on screens while others pass through and are entrained (EPA 1977). Section 316(b) of the Clean Water Act (CWA) (33 United States Code § 1326(b)) requires the following:

> Any standard established pursuant to section 1311 of this title or section 1316 of this title and applicable to a point source shall require that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact.

The adverse environmental impacts of cooling water intakes occur through both impingement and entrainment. Heat, physical stress, or chemicals used to clean the cooling system may kill or injure the entrained organisms. Exhaustion, starvation, asphyxiation, descaling, and physical stresses may kill or injure impinged organisms. Due to the length and pressure change associated with the intake and discharge tunnels at Seabrook, NextEra assumes a 100 percent mortality rate for all entrained and impingement organisms.

Because impingement and entrainment are fundamentally linked, the NRC staff determined that effects of each should be assessed using an integrated approach. The NRC staff employed a weight-of-evidence (WOE) approach to evaluate the effects of impingement and entrainment on the aquatic resources in the Gulf of Maine and the Hampton-Seabrook Estuary. NRC employed this approach because the EPA recommends a WOE approach for ecological risk assessments (EPA 1998). WOE is a useful tool due to the complex nature of assessing risk (or impact), and NRC has employed this approach in other evaluations of the effects of nuclear power plant cooling systems on aquatic communities (NRC 2010c).

Menzie et al. (1996) defines WOE as "…the process by which multiple measurement endpoints are related to an assessment endpoint to evaluate whether significant risk of harm is posed to the environment." In this modified WOE approach, NRC staff examined four lines of evidence to determine if operation of the Seabrook cooling system has the potential to cause adverse impacts to fish and shellfish in the vicinity of Seabrook. The first line of evidence is entrainment data provided by NextEra from 1990 through 2009 (NAI 2010). The second line of evidence is impingement data provided by NextEra from 1994 through 2009 (NAI 2010). The third line of

evidence includes reviews by other regulatory agencies, such as EPA and the New Hampshire Fish and Game Department (NHFGD). EPA's analysis, a Case Study Analysis for the Proposed Section 316(b) Phase II Existing Facilities Rule (EPA 2002a), includes a comparison of impingement and entrainment data with Pilgrim Nuclear Generating Station (Pilgrim). The fourth line of evidence includes monitoring data of fish and shellfish populations prior to and during operations at a nearfield and farfield site (see Section 4.6.5).

As part of the WOE approach, NRC related the results of the above lines of evidence to NRC's definitions of SMALL, MODERATE, and LARGE, as described in Section 1.4. NRC defined the impingement and entrainment impact as SMALL if Seabrook monitoring data (the fourth line of evidence described above) concluded that no significant difference occurred between the preoperational and operational periods or, if there was a change, that it occurred at both the nearfield and farfield sites. In this situation, NRC staff would conclude that impingement and entrainment does not noticeably alter the aquatic resource. NRC defined the impingement and entrainment impact as MODERATE if Seabrook monitoring data indicated that the abundance of a certain species or biological group increased at sites further from the Seabrook cooling system and remained steady near the cooling system. In addition, the NRC staff looked for a strong connection between the Seabrook cooling system and the biological group or species, such as high entrainment and impingement. In this situation, NRC staff would conclude that impingement and entrainment noticeably altered, but does not destabilize, the aquatic resource. NRC defined the impingement and entrainment impact as LARGE if Seabrook monitoring data indicated that the abundance of a certain species or biological group increased or remained steady at sites further from the Seabrook cooling system and decreased near the cooling system or if the abundance of a species or biological group declined at all sites, but the decline was significantly greater closer to the Seabrook cooling system. In addition, NRC staff looked for a strong connection between the Seabrook cooling system and the biological group or species, such as high entrainment and impingement. In this situation, NRC staff would conclude that impingement and entrainment destabilizes the aquatic resource near Seabrook.

Line of Evidence Number 1: Entrainment Studies at Seabrook

NextEra conducted entrainment studies four times per month (NAI 2010). For bivalve larvae, NextEra collected three replicates per sampling date using a 0.003-in (0.076-mm) mesh. For fish eggs and larvae, prior to 1998, NextEra collected three replicate samples using 0.02-in (0.505-mm) mesh nets. Since 1998, NextEra collected samples using 0.01-in (0.333-mm) mesh sizes throughout a 24-hour period. NextEra estimated entrainment rates by multiplying the density of entrained eggs or larvae within a sample by the volume of water pumped through the plant within the sample period (FPLE 2008b; NAI 2010).

<u>Fish Eggs and Larvae</u>. NextEra collected fish egg entrainment samples from 1990–2009 that belong to 24 taxa of eggs and one group of unidentified eggs (NextEra 2010c; NAI 2010). Total egg entrainment estimates ranged from 4.8 million in 1994 (8 months of sampling) to 2,104 million in 2000. The annual average total fish egg entrainment was 901 million per year (NAI 2010) (Table 4–6). The most commonly entrained egg species was cunner (*Tautogolabrus adspersus*), which was highest in 2009 at 1,451 million eggs or approximately 69 percent of all entrained eggs in 2009. The annual average entrainment for the most common egg taxa entrained were as follows (Table 4–6):

- cunner (387.4 million/year),
- Atlantic mackerel (*Scomber scombrus*) (191.5 million/year),
- silver hake (*Merluccius bilinearis*) (81.1 million/year),
- fourbeard rockling (*Enchelyopus cimbrius*) (51.5 million/year),

- hake (*Urophycis*) (45.7 million/year),
- yellowtail flounder (*Pleuronectes ferruginea*) (42.8 million/year),
- Atlantic cod (*Gadus morhu*) (32.6 million/year),
- windowpane (*Scopthalmus aquosus*) (31.7 million/year), and
- American plaice (*Hippoglossoides platessoides*) (25.9 million/year).

For all other species, NextEra observed less than 6 millions eggs entrained per year on average (NAI 2010). Generally, eggs that are demersal or adhesive are less likely to be entrained since the intake structure is raised above the sea floor. The one exception is lumpfish (*Cyclopterus lumpus*), which have demersal and adhesive eggs. Annual average entrainment of lumpfish eggs from 1990–2009 was 2.6 million eggs per year (NAI 2010).

NextEra collected fish larvae entrainment samples from 1990–2009 that belong to 52 taxa of larvae and one group of unidentified larvae (NextEra 2010c; NAI 2010). Total larval entrainment estimates ranged from 31.2 million in 1994 (8 months of sampling) to 958.5 million in 2004. The annual average fish larvae entrainment was 260.6 million per year (NAI 2010) (Table 4–7). The annual average entrainment for the most common larval taxa entrained were as follows (Table 4–7):

- cunner (78.4 million/year),
- rock gunnel (*Pholis gunnellus*) (33.5 million/year),
- Atlantic seasnail (*Liparis atlanticus*) (32 million/year),
- American sand lance (*Ammodytes americanus*) (27.9 million/year),
- silver hake (8.1 million/year),
- fourbeard rockling (22.7 million/year),
- grubby (*Myoxocephalus aenaeus*) (15.3 million/year),
- Atlantic herring (*Clupea harengus*) (9.6 million/year),
- winter flounder (*Pleuronectes americanus*) (9.2 million/year), and
- American plaice (4.3 million/year).

In 2009, larval entrainment was highest in June, when cunner and Atlantic mackerel were most abundant (NAI 2010).

Table 4–6. Number of Fish Eggs Entrained (in millions) for Most Common Egg Taxa Entrained

Taxon	1990[(a)]	1991[(b)]	1992[(c)]	1993[(c)]	1994[(d)]	1995[(e)]	1996[(e)]	1997[(e)]	1998[(e)]	1999[(e)]	2000[(e)]	2001[(e)]
American plaice	2.6	21.0	52.3	19.5	0.4	14.8	78.2	15.6	13.7	24.8	16.7	26.8
Atlantic cod	20.8	74.5	32.0	50.3	0.2	37.0	22.4	6.4	84.3	48.6	30.7	32.1
Atlantic mackerel	518.8	673.1	456.3	112.9	0.0	74.5	305.1	23.1	39.3	44.6	266.9	330.4
cunner	489.3	147.2	0	58.4	0	18.2	93.9	221.5	63.6	220.3	1,206.7	239.6
hake	50.1	2.6	0	1.6	0.6	29.3	213.2	71.8	7.5	6.2	295.2	4.4
fourbeard rockling	108.8	39.5	51.4	32.7	0.2	27.5	38.7	46.6	33.9	27.4	63.6	47.1
silver hake	11.4	0	0.1	0.4	0.4	22.5	73.6	271.1	18.6	139.9	90.4	48.9
windowpane	36.4	19.9	22.5	29.1	0.1	17.4	44.2	28.5	17.9	43.2	95.1	33.4
yellowtail flounder	1.2	569.2	198.6	0	0	0.6	17.9	0.5	1.9	33.8	2.8	8.4
Total (all taxon)	1,248	1,551	823	316	4.8	256	926	693	287	594	2,104	775

[(a)] NextEra sampled three months, August–October.

[(b)] NextEra sampled eight months, January–July, December.

[(c)] NextEra sampled eight months, January–August.

[(d)] NextEra sampled seven months, January–March, September–December.

[(e)] NextEra sampled 12 months per year.

Notes: Normandeau Associates, Inc. (NAI) (2010), combined certain groups of species if eggs were morphologically similar and spawning periods overlapped during the sampling period. Groups of species include Atlantic cod/haddock, cunner/yellowtail founder, and hake/fourbeard rockling. NextEra (2010c) estimated entrainment rates for each species by applying the ratio of larval species to the egg species groups.

Source: (NextEra 2010c; NAI 2010)

Table 4–6. Number of Fish Eggs Entrained (in millions) for Most Common Egg Taxa Entrained (cont.)

Taxon	2002[e]	2003[e]	2004[e]	2005[e]	2006[e]	2007[e]	2008[e]	2009[e]	Average
American plaice	22.4	37.8	33.4	11.7	5.3	35.8	48.0	36.7	25.9
Atlantic cod	77.8	15.5	9.3	16.0	15.7	15.1	48.0	15.4	32.6
Atlantic mackerel	56.7	26.4	70.1	37.7	475.6	153.6	82.4	83.5	191.5
cunner	1,395.7	143.9	518.1	251.2	489.4	295.0	444.5	1,451.2	387.4
hake	79.7	5.2	5.7	2.8	8.1	15.6	21.7	92.1	45.7
fourbeard rockling	61.4	44.1	38.2	68.8	36.6	78.2	61.7	123.8	51.5
silver hake	341.4	235.6	19.8	30.7	9.4	60.8	50.9	196.2	81.1
windowpane	39.1	15.5	18.2	26.2	24.7	34.7	25.9	61.8	31.7
yellowtail flounder	3.9	0	0.1	5.0	1.1	7.8	0	4.1	42.8
Total (all taxon)	2,087	529	724	454	1075	715	791	2,073	901

(a) NextEra sampled three months, August–October.

(b) NextEra sampled eight months, January–July, December.

(c) NextEra sampled eight months, January–August.

(d) NextEra sampled seven months, January–March, September–December.

(e) NextEra sampled 12 months per year.

Notes: Normandeau Associates, Inc. (NAI) (2010), combined certain groups of species if eggs were morphologically similar and spawning periods overlapped during the sampling period. Groups of species include Atlantic cod/haddock, cunner/yellowtail founder, and hake/fourbeard rockling. NextEra (2010c) estimated entrainment rates for each species by applying the ratio of larval species to the egg species groups.

Source: (NextEra 2010c; NAI 2010)

Table 4–7. Number of Fish Larvae Entrained (in millions) for the Most Common Larval Taxa Entrained

Taxon	1990 [a]	1991 [b]	1992 [c]	1993 [c]	1994[d]	1995 [e]	1996 [e]	1997 [e]	1998 [e]	1999 [e]	2000 [e]	2001 [e]
American plaice	0.4	1.0	0.8	0.7	0	7.9	8.1	7.0	2.9	4.9	1.6	8.7
American sand lance	0	37.3	18.1	12.0	8.3	9.5	14.0	10.1	10.7	7.8	1.0	5.3
Atlantic herring	0.7	0.5	4.9	9.6	0.1	11.2	4.3	2.1	9.5	8.6	0.2	15.2
Atlantic seasnail	11.6	16.0	31.5	64.4	0.0	26.5	60.6	1.2	38.5	76.5	34.3	19.7
cunner	42.7	<0.1	0	4.7	0.1	4.4	9.2	203.8	8.4	4.7	111.0	13.6
fourbeard rockling	37.9	0.5	0.1	2.2	0.0	3.9	11.7	22.4	13.1	21.0	8.2	19.6
grubby	0	22.4	18.9	13.8	4.9	17.4	18.6	12.8	17.3	6.4	2.2	12.4
rock gunnel	0	51.1	45.3	5.7	11.0	15.6	33.8	25.1	16.9	18.2	3.5	4.6
silver hake	7.7	0	0	0.1	0	0.9	16.9	69.0	0.2	0.4	33.2	0.6
winter flounder	3.2	9.0	6.2	2.9	0	8.0	10.3	2.2	4.7	7.4	14.3	14.3
Total (all taxon)	121.5	153.8	133.1	126.1	31.2	145.3	215.7	373.4	134.1	171.8	261.2	124.3

[a] NextEra sampled three months, August–October.

[b] NextEra sampled eight months, January–July, December.

[c] NextEra sampled eight months, January–August.

[d] NextEra sampled seven months, January–March, September–December.

[e] NextEra sampled 12 months per year.

Source: (NAI 2010)

Table 4–7. Number of Fish Larvae Entrained (in millions) for the Most Common Larval Taxa Entrained (cont.)

Taxon	2002 [e]	2003 [e]	2004 [e]	2005[e]	2006 [e]	2007 [e]	2008 [e]	2009 [e]	Average
American plaice	11.3	9.1	2.6	1.4	0.6	2.6	3.5	11.5	4.3
American sand lance	10.5	27.1	107.1	28.3	14.1	36.6	71.2	128.6	27.9
Atlantic herring	11.7	15.3	8.8	9.7	12.8	11.5	28.2	27.7	9.6
Atlantic seasnail	29.0	43.2	64.2	37.5	20.2	0.0	27.4	37.8	32.0
cunner	391.1	22.5	451.2	2.5	8.8	97.7	86.2	105.7	78.4
fourbeard rockling	176.4	19.3	61.4	2.0	4.9	16.4	11.9	20.3	22.7
grubby	6.6	27.5	51.8	7.8	9.3	15.4	8.3	31.6	15.3
rock gunnel	12.3	56.0	109.0	54.2	30.3	46.7	48.2	82.9	33.5
silver hake	5.9	0.5	0.2	0.0	0.1	0.0	17.9	8.2	8.1
winter flounder	4.5	20.0	34.8	4.9	7.2	15.8	0.1	15.2	9.2
Total (all taxon)	724.4	268.5	958.5	167	123.2	297.2	333.7	523.2	269.4

[a] NextEra sampled seven months, August–October.
[b] NextEra sampled eight months, January–July, December.
[c] NextEra sampled eight months, January–August.
[d] NextEra sampled eight months, January–March, September–December.
[e] NextEra sampled 12 months per year.

Source: (NAI 2010)

Entrainment rates for essential fish habitat (EFH) species and their prey are discussed in more detail in Appendix D-1.

Bivalve Larvae. NextEra collected bivalve larvae entrainment samples from 1990–2009 (NAI 2010). Total larval entrainment estimates ranged from 6,624 x 10^9 in 2004 (among sampling years with at least 6 months of data) to 67,415 x 10^9 in 1999 (Table 4–8). The annual average total bivalve larvae was 17,595 x 10^9 per year (NAI, 2010) (Table 4–8). On average, prickly jingle (*Heteranomia squamula*) larvae comprised 43 percent of annual bivalve larvae entrainment. Blue mussel (*Mytilus edulis*) larvae comprised 33.5 percent, and the rock borer comprised 12.7 percent of annual bivalve larvae entrainment (NAI 2010). All other taxa comprised less than 7 percent of annual bivalve larvae entrainment (Table 4–8) (NAI, 2010). In 2009, larvae entrainment was highest in August (73 percent) when NAI (2010) detected unusually high numbers of prickly jingle larvae in the nearshore waters. Throughout all years, NAI (2010) detected the highest entrainment rates in summer, which is indicative of when the seasonal depth distribution of bivalve larvae is most likely to be near the depth of the intake structure.

Line of Evidence Number 2: Impingement Studies at Seabrook

NextEra conducted impingement monitoring once or twice per week by cleaning traveling screens and sorting fish and other debris (NAI 2010). Prior to 1998, NextEra did not sort some collections, and impingement estimates are based on the volume of debris (NAI 2010). Beginning in 1998, Seabrook staff sorted all collections and identified all impinged fish by species. Beginning in April 2002, NextEra collected two standardized 24-hour samples per week and multiplied by seven to estimate weekly impingement.

The results for 1995–2009 are presented in Table 4–9. Prior to October 1994, NextEra determined that some small, impinged fish had been overlooked during separation procedures. NextEra enhanced the impingement monitoring program in the end of 1994 to remedy this issue (NextEra 2010c).

NextEra collected fish and American lobster (*Homarus americanus*) impingement samples from 1995–2009 that belong to 84 taxa and one group of unidentified fish (NAI 2010). Total fish and lobster impingement estimates ranged from 7,281 in 2000 to 71,946 million in 2003. The annual average impingement was 20,876 fish and lobster. On average, the most commonly impinged species included Atlantic silverside (*Menidia menidia*) (11.5 percent), rock gunnel (10.5 percent), and winter flounder (10 percent) (Table 4–9). Rainbow smelt (*Osmerus mordax*), a National Marine Fisheries Service (NMFS) species of concern, was the sixth most impinged species at Seabrook, with an annual average impingement rate of 1,093 fish per year. The majority of impingement occurred during spring and fall, especially with young-of-the-year (YOY), demersal fish (NAI 2010).

Table 4–8. Number of Bivalve Larvae Entrained (x 10^9) for the Most Common Larval Taxa Entrained

Taxon	1990[a]	1991[b]	1992[c]	1993[d]	1995	1996	1997	1998	1999	2000
prickly jingle	1,691	250.8	6.9	3,923	8,906	23,522	2,883	3,827	36,495	7,542
Bivalvia mussels	181.7	38.1	14.5	334.5	797.1	671.4	71.1	64.5	651.3	228.6
rock borer	876.6	421.3	189.8	2,406	2,598	4,670	923.7	609.7	4,417	1,921
northern horsemussel	909.7	160.2	0.3	1,284	546.4	5145	614.7	241.7	2,376	2,521
soft shell clam	8.1	0.6	0.2	22.5	4.3	33.2	53.7	11.4	45.7	23.9
truncate softshell clam	249.2	6.5	1.1	2.1	27.6	123	0.8	8.3	66	34.9
blue mussels	3,991	1,688	121.9	10,051	13,231	17,932	1,745	1,493	22,374	10,255
sea scallop	0.7	0.7	0.1	16.9	6.2	31	0.8	0.8	11.5	9.9
Solenidae clams	61.1	0	75.7	102.5	1,092	241.9	49.5	20.9	773.2	150.4
surf clam	69	4.4	0	48.5	112.5	171.1	22.5	14.8	175.5	33.6
shipworm	0.01	15.9	0	0	4.8	7.4	1.7	0.8	29.9	1.5
Total (all taxon)	8,039	2,586	410	18,190	27,327	52,547	6,366	6,293	67,415	22,721

(a) NextEra sampled June–October.

(b) NextEra sampled the last week in April through the first week in August.

(c) NextEra sampled the third week in April through the third week in June.

(d) Number of months that entrainment sampling occurred varied by year. Except as noted, NextEra sampled the third week in April through the fourth week in October. In 1994, NextEra did not conduct bivalve larvae entrainment studies.

(e) NextEra sampled the fourth week in April through the fourth week in October.

(f) NextEra sampled the fourth week in April through the fourth week in September.

Source: (NAI 2010)

Table 4–8. Number of Bivalve Larvae Entrained (x 10^9) for the Most Common Larval Taxa Entrained (cont.)

Taxon	2001	2002	2003	2004	2005[e]	2006[f]	2007	2008	2009	Average
prickly jingle	4,129	8,204	3,218.1	2,595	1,217	3,966	3,950	18,452	27,733	8,553.2
Bivalvia mussels	483	1,94.2	73.7	89.6	40.4	73.9	46.2	411.8	74.3	238.94
rock borer	1,575	567.3	1,203.9	1,024	352.9	604.6	650.7	3,137	2,548	1,615.5
northern horsemussel	251.6	776.4	240.8	843.2	292.9	715.1	172.5	2,270	1421	1,093.8
soft shell clam	26.4	60.2	5.1	15.1	9.2	11.1	4.7	45.8	31.8	21.737
truncate softshell clam	26.3	1.9	13.8	5.2	2.3	0.6	3	6.4	4.8	30.726
blue mussels	9,621	3,318	2,199	1,526	921.5	1,351	834.4	2,700	3,974	5,754
sea scallop	8.5	0.8	0	0.7	0.1	0	0.1	0.3	1.2	4.7526
Solenidae clams	922.9	150.8	85.5	113.4	57.9	65.2	156.1	85.1	162.4	229.83
surf clam	50.8	44.2	3.1	10	14.5	20	2.8	100.7	31.5	48.921
shipworm	0.3	2.3	0.1	0.6	0.3	0.8	0	1.8	2.3	3.7111
Total (all taxon)	17,095	13,320	7,043	6,223	2,909	6,809	5,820	27,211	35,983	17,595

(a) NextEra sampled June–October.

(b) NextEra sampled the last week in April through the first week in August.

(c) NextEra sampled the third week in April through the third week in June.

(d) Number of months that entrainment sampling occurred varied by year. Except as noted, NextEra sampled the third week in April through the fourth week in October. In 1994, NextEra did not conduct bivalve larvae entrainment studies.

(e) NextEra sampled the fourth week in April through the fourth week in October.

(f) NextEra sampled the fourth week in April through the fourth week in September.

Source: (NAI 2010)

Table 4–9. Number of Impinged Fish and Lobsters at Seabrook From 1994–2009 for Commonly Impinged Species

Species	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
alewife	0	8	1,753	2,797	14	16	4	35	1	9
American sand lance	1,215	1,324	823	182	708	234	423	114	245	3,396
Atlantic menhaden	0	7	97	0	1	957	142	19	1,022	7
Atlantic silverside	5,348	1,621	1,119	210	834	1,335	31	282	1,410	20,507
Atlantic cod	58	119	94	69	38	66	29	30	199	3,091
cunner	32	342	1,121	233	309	255	324	341	291	554
grubby	2,678	2,415	1,457	430	3,269	3,953	1,174	549	1,089	2,523
hakes	2,822	2,188	156	122	4	68	113	523	1,813	166
northern pipefish	188	579	1,200	243	268	748	370	714	936	2,716
pollock	1,681	899	1,835	379	536	11,392	534	405	719	499
rainbow smelt	545	213	4,489	365	535	100	8	65	323	3,531
red hake	1	16	1,478	371	903	1,120	112	155	52	271
rock gunnel	494	1,298	1,122	459	2,929	2,308	1,514	2,251	2,066	6,274
sea raven	78	125	1,015	223	137	132	206	271	166	217
shorthorn sculpin	14	156	282	123	190	296	923	621	642	7,450
snailfishes	180	165	1,013	351	856	2,356	690	334	616	451
threespine stickleback	67	155	320	174	773	506	10	280	34	1,549
windowpane	980	943	1,164	1,688	772	692	251	161	2,242	4,749
winter flounder	1,435	1,171	3,231	468	1,143	3,642	102	777	897	10,491
Total (all taxa)	19,212	15,940	26,825	10,648	15,198	31,241	7,281	8,577	18,413	71,946

Source: (NAI 2010)

Table 4–9. Number of Impinged Fish and Lobsters at Seabrook From 1994–2009 for Commonly Impinged Species (cont.)

Species	2004	2005	2006	2007	2008	2009	Total	Percent of Total	Annual Average
alewife	212	87	255	244	41	0	5,476	1.6	342
American sand lance	665	1,029	213	2,073	758	796	14,198	4.3	887
Atlantic menhaden	361	7,226	94	160	67	39	10,199	3.1	637
Atlantic silverside	877	2,717	788	639	247	525	38,490	11.5	2,406
Atlantic cod	467	454	113	178	73	147	5,225	1.6	327
cunner	625	893	687	922	731	837	8,497	2.5	531
grubby	676	531	235	869	3,919	521	26,288	7.9	1,643
hakes	35	11	6	1,184	3,216	1,427	13,854	4.1	866
northern pipefish	1,413	1,724	1,288	2,374	1,082	698	16,541	5.0	1,034
pollock	80	218	73	340	123	657	20,370	6.1	1,273
rainbow smelt	2,085	3,314	878	572	421	43	17,487	5.2	1,093
red hake	892	821	546	1,389	14	0	8,141	2.4	509
rock gunnel	4,137	1,752	3,782	3,174	937	701	35,198	10.5	2,200
sea raven	129	221	138	164	138	79	3,439	1.0	215
shorthorn sculpin	876	2,214	1,258	465	1,515	266	17,291	5.2	1,081
snailfishes	185	442	330	76	233	85	8,363	2.5	523
threespine stickleback	130	307	139	193	80	118	4,835	1.4	302
windowpane	936	2,034	572	1,502	1,640	427	20,753	6.2	1,297
winter flounder	783	1,875	767	3,949	1,920	655	33,306	10.0	2,082
Total (all taxa)	16,696	29,368	12,955	22,472	17,935	9,304	334,011	100.0	20,876

Source: (NAI 2010)

Impingement rates for EFH species and their prey are discussed in more detail in Appendix D-1.

Line of Evidence Number 3: Related Regulatory Reviews

316(b) Regulations. Section 316(b) of the CWA requires that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available (BTA) for minimizing adverse environmental impacts. In its evaluation of the NPDES permit, EPA (2002) determined that the following:

> [T]he Cooling Water Intake System, as presently designed, employs the best technology available for minimizing adverse environmental impact. Therefore, no change in the location, design or capacity of the present system can be made without prior approval of the Regional Administrator and the Director. The present design shall be reviewed for conformity to regulations pursuant to Section 316(b) when such are promulgated.

In March 2011, EPA promulgated new draft regulations pursuant to Section 316(b). As described in Section 2.2.4, Seabrook is currently operating under the NPDES permit from 2002.

EPA Case Study Analysis for the Proposed Section 316(b) Phase II Existing Facilities Rule. In 2002, EPA conducted a case study analysis for a proposed Section 316(b) Phase II existing facilities rule. In the case study, EPA evaluated the economic losses associated with impingement and entrainment at Seabrook and Pilgrim. Pilgrim is located south of Seabrook, in Cape Cod Bay.

EPA (2002a) evaluated entrainment and impingement based on data reported by NextEra in monitoring reports and using the methods outlined in EPA (2002a) to estimate the total number of organisms, age 1 equivalents, yield loss to fisheries, and production foregone due to entrainment and impingement. EPA (2002a) determined that 69 percent of all entrained and impinged species at Seabrook are valued commercially or recreationally. The mostly frequently entrained fishery species were Atlantic mackerel, winter flounder, and red hake. Entrainment of forage fish, species that are prey for fishery species and are important components of the Gulf of Maine food web, was high at Seabrook and Pilgrim and included species such as fourbeard rockling, lumpfish, and rock gunnel at Seabrook. The most frequently impinged fishery species at Seabrook were winter flounder, red hake, and Atlantic silverside (EPA 2002a).

EPA (2002a) determined that entrainment and impingement for certain species was higher at Pilgrim, whereas entrainment for other species was higher at Seabrook (Table 4–10 and Table 4–11). For example, entrainment of the winter flounder category was nearly an order of magnitude higher at Seabrook (annual mean of 244 million per year) compared to Pilgrim (30.9 million per year). These differences are likely due to differences in the relative abundance of the various species at the two sites and the location of the intake structures (i.e., the Seabrook intake structure is offshore whereas the Pilgrim intake structure is nearshore).

Table 4–10. Comparison of Annual Mean Entrainment (in millions of organisms) for Selected Species at Seabrook and Pilgrim Nuclear Station

Species	Seabrook	Pilgrim
American plaice	27.4	11.3
American sand lance	13.3	138.0
Atlantic cod	10.0	6.3
Atlantic mackerel	245.4	1,035.0
Atlantic menhaden	0.3	81.9
blue mussel	6,281,453.8	8,073,966.7
cunner	35.4	2,714.6
fourbeard rockling	58.5	94.3
lumpfish	31.9	6.5
pollock	0.7	42.8
radiated shanny	1.7	19.3
rainbow smelt	0.07	10.1
red hake	93.2	31.1
rock gunnel	22.7	34.3
sculpin spp.	1.6	40.8
windowpane	25.7	83.5
winter flounder	244.0	30.9

Notes: Seabrook entrainment data is from 1990–1998. Pilgrim entrainment data is generally from 1990–1999, although for some species selected years from 1974–1990 were included, as described in EPA (2002a) Table G3-14.

Source: (EPA 2002a), Tables G3-6 and G3-14

As described in EPA (2004), certain species were aggregated in order to limit the number of species groups. Aggregated groups include the following:

- Atlantic cod includes Atlantic cod and haddock.
- Atlantic herring includes Atlantic herring, hickory shad, and round herring.
- Lumpfish includes lumpfish and lumpsucker.
- Red hake includes red hake, white hake, and spotted hake.
- Sculpin spp. includes longhorn sculpin, moustache sculpin, sea raven, and shorthorn sculpin.
- Windowpane includes American fourspot flounder, smallmouth flounder, summer flounder, and windowpane.
- Winter flounder includes fourspot flounder, lefteye flounder, righteye flounder, smooth flounder, winter flounder, witch flounder, and yellowtail flounder.

Table 4–11. Comparison of Annual Mean Impingement for Selected Species at Seabrook and Pilgrim Nuclear Station

Species	Seabrook	Pilgrim
alewife	508	3,250
American sand lance	476	19
Atlantic cod	99	252
Atlantic herring	287	7,593
Atlantic silverside	1,040	11,587
blueback herring	50	612
butterfish	28	297
grubby	1,156	717
lumpfish	391	198
pollock	643	30
rainbow smelt	701	5,118
red hake	1,041	178
sculpin spp.	401	11
scup	3	97
tautog	7	183
windowpane	664	236
winter flounder	1,032	1,039

Notes: Seabrook impingement data is from 1990–1998. Pilgrim impingement data is generally from 1990–1999, although for some species a few years prior to 1990 were included, as described in EPA (2002a) Table G3-10.

Source: (EPA 2002a), Tables G3-2 and G3-10

The mean impingement and entrainment rate for Seabrook is not necessarily the same for the data provided in NextEra's 2009 monitoring report (NAI, 2010) (Table 4–6, Table 4–7, and Table 4–9) and estimates in EPA (2002a) (Table 4–10 and Table 4–11). This is due to several reasons. For example, NextEra's 2009 monitoring report provides data from 1990–2009 for entrainment and 1994–2009 for impingement, whereas EPA (2002a) is an earlier document that includes data from 1990–1998. In addition, EPA (2002a) included multiple species within a single species category in order to limit the number of species groups. EPA (2002a) aggregated species for the purpose of conducting benefit transfer analyses that require specific life history data. As requested in NRC's request for additional information (RAIs), NextEra estimated entrainment data per species (NextEra 2010c). Lastly, EPA (2002a) provides the total entrainment for eggs and larvae, whereas NextEra's entrainment data are separated for eggs and larvae (NAI 2010).

To estimate economic losses, EPA (2002a) used a variety of benefit transfer methods. For recreational fisheries, EPA used the results from nonmarket valuation studies, whereby recreational fisherman stated the amount they would be willing-to-pay for higher densities of fish. EPA (2002a) evaluated commercial fishery impacts based on commodity prices for the individual species. EPA (2002a) determined the economic value of forage species losses by estimating the replacement cost if fish were restocked with hatchery fish and by considering the foregone biomass production resulting from impingement and entrainment losses.

At Seabrook, EPA valued average entrainment losses at between $139,000–$309,000 per year and average impingement losses at between $3,000–$5,000 per year (in year 2000 dollars).

For comparison purposes, EPA determined higher entrainment losses ($513,000 and $744,000 in year 2000 dollars) at Seabrook compared to Pilgrim, but a similar value for impingement losses (EPA 2002a).

Lastly, EPA (2002a) estimated the benefits of reducing impingement and entrainment at Seabrook. EPA (2002a) determined that the annual benefits for a 70 percent reduction in entrainment at Seabrook range from $97,000–$216,000 and that the annual benefits for a 60 percent reduction in impingement at Seabrook range from $2,000–$3,000.

In the Pilgrim SEIS, NRC staff determined that entrainment at Pilgrim Station was SMALL to MODERATE, depending on the species (NRC 2007). The NRC staff determined that continued operations would have a MODERATE impact on winter flounder and rainbow smelt—both species were regionally declining in population. In addition, the NRC staff determined that the continued operation of the Pilgrim cooling water system would have MODERATE impacts on the local winter flounder population and the Jones River population of rainbow smelt (NRC, 2007) and SMALL to MODERATE impacts for other species of fish.

New Hampshire Fish and Game. In 2010, NextEra provided NHFGD a copy of "Seabrook Station, 2010 Environmental Monitoring Program Mid-Year Report." In reviewing this report, NHFGD noted that the cooling system impinged over 20,000 fish during the first 6 months of 2010, which was a large increase from the previous year (NextEra 2010c). NHFGD requested additional data on the fish species impinged and when the impingement occurred (NextEra 2010c).

In response to this request, NextEra provided additional data on the species impinged broken down by month (NextEra 2010c). Approximately 77 percent of the impingement occurred in March, and 58 percent of the monthly total occurred during the week of March 14–20, 2010 (NextEra 2010c). The most commonly impinged species during March included American sand lance (2,294), hake (2,645), and grubby (2,537) (NextEra 2010c).

NextEra noted that high impingement is often correlated with high wave action. NextEra compared wave height data from a nearby buoy with impingement data and found that the greatest number of fish (1,551) was impinged on March 14–15, when wave heights were highest 19 feet (ft) (5.9 meters (m)) (NextEra 2010c). Likewise, during a period of low wave height (March 10–11), few fish (45) were impinged (NextEra 2010c). Based on this data and experience conducting monitoring studies at Seabrook, NextEra (2010c) concluded that the high impingement in March was likely due to high wave action.

Line of Evidence Number 4: Seabrook Monitoring Data

The fourth line of evidence includes monitoring data of fish and shellfish populations prior to and during operations at a nearfield and farfield site. As described in Section 2.2.6, NextEra has conducted monitoring studies for fish and invertebrates since the 1970s. NextEra used a before-after control-impact (BACI) design to test for potential impacts from operation of Seabrook. This monitoring design can be used to test the statistical significance of differences in community structure and abundance between the pre-operation and operational period at nearfield and farfield sites. Section 4.6.4 provides the results of these monitoring studies. For the purposes of this WOE approach, a summary of the results is provided below.

NextEra compared the abundance of demersal fish species prior to and during operation at nearfield and farfield sites using an analysis of variance (ANOVA) on a BACI design. As described in Section 2.2.6, at the nearfield sampling station (T2) and at one of the farfield stations (T1), the abundance of fish was significantly higher in the 1970s–1980s (prior to operations) when compared to more recent years that include plant operations (NAI 2010). In 2009, the combined abundance for all fish species were similar to that found in the mid-1980s

at the farfield stations but below preoperational levels at the nearfield station (NAI 2010). Sosebee et al. (2006) analyzed separate trawl survey data from over 40 years and found similar trends as NAI (2010) at the two farfield stations.

The abundances of the majority of fish species were higher during preoperational monitoring than during operations, although the abundance of some species increased with time (Table 4–13). NAI (2010) used a mixed model analysis of variance to determine if there were statistically significant differences between the pre-operational and operational monitoring periods, nearfield and farfield sampling stations, and in the interaction of these terms. The abundance of yellowtail flounder, Atlantic cod, and rainbow smelt were significantly higher prior to operations at the nearfield and farfield sampling sites. The decrease in rainbow smelt was significantly greater at the nearfield station compared to the farfield station (see Table 4–13). However, NAI (2010) observed a different trend for winter flounder and silver hake. At the nearfield site (T2), the abundance of winter flounder significantly decreased over time from a mean catch per unit effort (CPUE) of 5.5 prior to operations to 2.3 during operations, whereas at both farfield sampling sites (T1 and T3), the mean CPUE significantly increased from 2.8 and 1.4 prior to operations, respectively, to 4.0 and 3.6 during operations. Silver hake abundance also increased at farfield sampling sites and decreased at the nearfield sampling site. NAI (2010) did not test whether the trends for silver hake were statistically significant.

For most fish, changes in species abundance and community structure prior to and during operations occurred at both the nearfield and farfield sampling sites (NAI 2010). These results suggest that Seabrook operations have not noticeably altered fish populations near Seabrook for most fish species. However, the abundance of winter flounder and rainbow smelt has decreased to a greater and observable extent near Seabrook’s intake and discharge structures compared to 3–4 miles (mi) (5–8 kilometers (km)) away. The local decrease suggests that to the extent local subpopulations exist within 3–4 mi (5–8 km) of Seabrook, they have been destabilized through operation of Seabrook’s cooling water system. There is insufficient data for NRC to make a conclusion for silver hake.

Summary of Entrainment and Impingement Impacts

NRC staff examined four lines of evidence to determine if impingement and entrainment have the potential to cause adverse impacts to fish and shellfish in the vicinity of Seabrook. The first line of evidence is entrainment data provided by NextEra. The second line of evidence is impingement data provided by NextEra. The third line of evidence includes reviews by other regulatory agencies, such as EPA and NHFGD. EPA's (2002a) review also included a comparison of impingement and entrainment data with Pilgrim. The fourth line of evidence includes monitoring data of fish and shellfish populations prior to and during operations at a nearfield and farfield site. Based on this assessment, the NRC concludes that the impacts to the majority of species due to entrainment and impingement would be SMALL, because the NRC staff found that operations of Seabrook have not noticeably altered most fish and shellfish populations. However, the NRC concludes that the impact on winter flounder due to entrainment and impingement is LARGE since winter flounder is regularly entrained and impinged at Seabrook and since monitoring data indicates that the abundance of winter flounder has decreased to a greater and observable extent near Seabrook’s intake and discharge structures compared to 3-4 mi (5-8 km) away. The local decrease suggests that to the extent local subpopulations exist within 3-4 mi (5-8 km) of Seabrook, they have been destabilized through operation of Seabrook’s cooling water system.

Winter flounder was the eighth most commonly entrained fish larvae species, with an annual average of 9.2 million entrained larvae per year (NAI 2010). Winter flounder was the third most commonly impinged species, comprising 10 percent of all impinged fish (NAI 2010). On

average, the Seabrook cooling system impinged 2,083 winter flounder per year (NAI 2010). Seabrook trawling data indicated that winter flounder significantly decreased at the nearfield sampling site, which is located closest to the intake and discharge structures, but increased or stayed the same at sites 3-4 mi (5-8 km) from the intake and discharge structures. These results suggest that to the extent a local subpopulation of winter flounder exists within 3-4 mi (5-8 km), it has been destabilized through operation of Seabrook's cooling system.

4.6.3 Thermal Shock

For plants with once-through cooling systems and cooling pond heat dissipation systems, NRC's GEIS (1996) lists the effects of heat shock as an issue requiring plant-specific evaluation before license renewal (Category 2). The NRC (1996) made impacts on fish and shellfish resources resulting from heat shock a site-specific issue because of continuing concerns about thermal discharge effects and the possible need to modify thermal discharges in the future in response to changing environmental conditions.

Information considered in this analysis includes the type of cooling system (once-through in this case), Seabrook's NDPES permit, evidence of a CWA Section 316(a) variance documentation, modeling of the thermal plume, Seabrook monitoring of cold-water and warm-water algae species, and other information. To perform this evaluation, the NRC staff reviewed the NextEra's ER (NextEra 2010) and monitoring data (NAI 2010), visited the Seabrook site, and reviewed the applicant's NPDES and EPA 316(a) determination.

As described in Section 2.2.4, Seabrook's discharge to the Gulf of Maine is permitted under its NPDES permit (EPA 2002), which was issued April 1, 2002. The permit allows discharge of 720 mgd (2.7 million m^3/day) on both an average monthly and maximum daily basis. The permit also limits the rise in monthly mean temperature to 5 degrees Fahrenheit in the "near field jet mixing region," or within waters less than 3.3 ft (1 m) from the surface. An EPA online database indicated that Seabrook has had no CWA formal enforcement actions or violations related to discharge temperature in the last 5 years (EPA 2010a). EPA's Regional Administer determined that NextEra's NPDES permit provides a Section 316(a) variance that satisfies thermal requirements and that "will ensure the protection and propagation of a balanced indigenous community of fish, shellfish, and wildlife in and on Hampton Harbor and the near shore Atlantic Ocean" (EPA 2002).

The thermal effluent from Seabrook is discharged through 11 riser shafts, spaced approximately 100 ft (30.5 m) apart for a total diffuser length of 1,000 ft (305 m) (NAI 2001). Each riser shaft terminates in a pair of nozzles that are pointed up at an angle of about 22.5 degrees (NAI 2001). The nozzles are located about 6.5–10 ft (2–3 m) above the seafloor in depths of approximately 49–59 ft (15–18 m) of water (NAI 2001).

Padmanabhan and Hecker (1991) conducted a thermal plume modeling and field verification study. This study estimated a temperature rise of approximately 36 to 39 degrees Fahrenheit (20 to 22 degrees Celsius) at the diffusers (Padmanabhan and Hecker 1991). Field and modeling data indicated that the water rose relatively straight to the surface and spread out within 10–16 ft (3–5 m) of the ocean surface. At the surface, Padmanabhan and Hecker (1991) observed a temperature rise of 3 degrees Fahrenheit (1.7 degrees Celsius) or more within 32 acres (ac) (12.9 hectares (ha)) of the discharge. Padmanabhan and Hecker (1991) did not observe significant increases in surface temperature 1,640 ft (500 m) to the northwest of the discharge structure.

NextEra has conducted monitoring of water temperature at bottom and surface waters near the discharge structure during operations (NAI 2001; NAI 2010). NextEra monitored bottom water temperature at a site 656 ft (200 m) from the discharge and at a site 3–4 nautical mi (5–8 km)

from the discharge from 1989–1999 (NAI 2001). NextEra observed a significant difference in the monthly mean bottom water temperature between the two sites. The mean difference was less than 0.9 degrees Fahrenheit (0.5 degrees Celsius) (NAI 2001). As required by Seabrook's NPDES permit, NextEra conducts continuous surface water monitoring. The mean difference in temperature between a sampling station within 328 ft (100 m) of the discharge and a sampling station 1.5 mi (2.5 km) to the north has not exceeded 5 degrees Fahrenheit (2.8 degrees Celsius), which is the limit identified in the NPDES permit (EPA 2002; NAI 2001). For the majority of months between August 1990 and December 2009, the monthly mean increase in surface water temperature was less than 3.6 degrees Fahrenheit (2.0 degrees Celsius).

Based on Seabrook's water quality monitoring and the Padmanabhan and Hecker (1991) study, the habitat most likely affected by the thermal plume would be the upper water column (10–16 ft (3–5 m) of the ocean surface) in the immediate vicinity of the discharge (less than 328 ft (100 m)). Fish may avoid this area; however, the thermal plume would not likely block fish movement since fish could swim around the thermal plume. EFH species likely to avoid this area are discussed in Appendix D-1. Benthic species may also avoid the immediate area surrounding the discharge structures due to higher temperature, velocities, and turbulence. This area is expected to be considerably smaller than the area of increased temperature at the surface.

To examine the potential thermal impacts from plant operations, NAI (2010) compared the abundance of cold water and warm water macroalgae species prior to and during operations at nearfield and farfield sites, as described in Section 2.2.6. Benthic perennial algae are sensitive to changes in water temperature since they are immobile and live more than 2 years. Prior to operations, NAI (2010) collected six uncommon species that were not collected during operations, including the brown macroalgae *Petalonia fascia,* which is associated with cold-water habitat. During operations, NAI (2010) collected some typically warm-water taxa for the first time (e.g., the red macroalga *Neosiphonia harveyi*), collected other warm-water taxa less frequently, and collected some cold-water taxa more frequently. NAI (2010) observed 10 species that only occurred during operations, and NAI (2010) reported that these species were within their geographic ranges (NAI 2010). NAI (2010) concluded that the changes in community composition among cold and warm water species were relatively small, although NAI (2010) did not report the results of any statistical tests to examine the significance in such changes. Since there were no clear patterns of emergent warm-water species, or changes in the abundance of cold-water species, NRC concludes that thermal impacts from Seabrook operations have not noticeably altered aquatic communities near Seabrook.

After reviewing the status of Seabrook's NPDES permit, 316(a) compliance, modeling of the thermal plume, and monitoring of cold water and warm water algae, the NRC concludes that the level of thermal impacts to the aquatic community due to renewing Seabrook's operating license is SMALL.

4.6.4 Mitigation

NextEra prepared a proposal for information collection as a first step to comply with EPA's 2008 proposed Phase II rule of Section 316(b) of CWA (ARCADIS 2008). In this document, NextEra identified several mitigation measures that currently reduce entrainment and impingement at Seabrook (ARCADIS 2008). For example, the location of the intake structures is offshore in an area of reduced biological activity as compared to an inshore location. The offshore location also reduces cooling system impacts because the deep offshore location of the intake withdraws cooler water than a more shallow, inshore location. The cooler temperature reduces the amount of water required to cool Seabrook. In addition, during cooler months, NextEra recirculates cooling water prior to discharge (ARCADIS 2008).

The Seabrook intake structures also have behavioral and structural deterrents to minimize impingement and entrainment. For example, the intake structure design includes velocity caps, which fish tend to avoid due to the changes in horizontal flow of water created by the velocity cap. In addition, NextEra installed a seal deterrent system by adding vertical bars on intake structures to prevent seals from getting trapped and drowning (NextEra 2010c).

Additional Mitigation Measures

Additional intake technologies that might mitigate cooling water intake effects and other efforts that could mitigate impacts to aquatic resources are described in the following sections. The first three potential mitigation measures, including wedgewire screens, grey water, and variable frequency drives (VFDs) were included in NextEra's assessment of additional potential mitigation options when responding to EPA in support of its Phase II 316(b) Program (ARCADIS 2008). The other potential mitigation measures were suggested in comments on the draft SEIS. In addition, in their comments on the draft SEIS, EPA, NMFS, and New Hampshire Department of Environmental Services (NHDES) recommended that NRC staff evaluate the environmental impacts of a cooling system alternative. In response to these comments, NRC evaluated a closed-cycle cooling system alternative in Chapter 8. Therefore, closed-cycle cooling is not addressed further in this chapter.

Wedgewire Screens

In some cases, the use of wedgewire screens has shown potential for decreasing entrainment and impingement at once-through power plants. Wedgewire screens may reduce entrainment and impingement by physical exclusion and exploiting hydrodynamic patterns (EPA 2004). Fish and other aquatic resources are physically excluded from the intake if the screen's mesh is smaller than the size of the organism. Hydrodynamic exclusion occurs because the screen's cylindrical configuration helps to create a low through-slot velocity that is quickly dissipated. In this situation, organisms can escape the flow field by swimming faster than the through-slot velocity and as the ambient currents assist organisms in bypassing the intake. Factors influencing the use and effectiveness of this technology include the screen size, the location, the configuration of the system relative to the intake, the intake flow rates, the presence and magnitude of a "sweeping" current that can move organisms past the screen into safe water, and the size of the organism present near the intake.

NextEra considered wedgewire screens to potentially reduce impingement and entrainment at Seabrook (ARCADIS 2008). The proposed screens would be located at offshore intakes, which would require modification of the velocity caps currently installed. Three screens would be installed on each of the three velocity caps for a total of nine screens. The screens would have 0.25 in (6.4 mm) openings. With this configuration, the anticipated through screen velocity would be 0.5 feet per second (fps). In addition to the screens and velocity cap modifications, NextEra would need to install an air burst system for cleaning the screens (ARCADIS 2008). All construction activities would occur underwater at approximately 60 ft (18 m) depth.

EPA (2004) describes three conditions for wedgewire screens to be effective: 1) the screen size is small enough to physically exclude organisms, 2) the through screen velocity is low, typically 0.5 fps or less, and 3) there is sufficient ambient currents to aid organisms in bypassing the intake structure and to remove other debris from the screen face. ARCADIS (2008) determined that the second condition could be meet at Seabrook. The third condition may not be met because the ambient currents near the intakes do not always parallel the longitudinal axis of the screens (ARCADIS 2008). The first condition cannot be met at Seabrook because the possibility of significant biofouling prevents the use of a screen size small enough (1 m [0.04 in]) to physically exclude eggs and larvae (ARCADIS 2008). At the deep underwater location of the Seabrook intakes (60 ft (18 m) depth), ARCADIS (2008) anticipated heavy

biofouling that would not likely be completely cleared by the use of an air burst system. To prevent biofouling on wedgewire screens at a facility in Boston Harbor, the screens are manually cleaned once a month by physically removing the screens and pressure washing them out of the water. At Seabrook, manual cleaning would require divers, which would be costly and timely (ARCADIS 2008). In addition to organisms growing on the screens, kelp could also block the screens, which “has the potential to quickly cover the screens causing a rapid loss of cooling water and the air burst system may not be effective in removing the kelp from the screen (ARCADIS 2008).” This situation could cause an operational risk.

In conclusion, ARCADIS (2008) determined that wedgewire screens are not a suitable intake technology because of the “significant increase in operational risk of failure and potential maintenance efforts.”

Grey Water

The use of grey water, or treated wastewater, would reduce impacts from impingement and entrainment because the grey water would be used in place of withdrawing water from the Gulf of Maine. No impingement or entrainment would be associated with the use of grey water because the cooling water would come from water pollution control plants (WPCPs).

NextEra considered using grey water to reduce impingement and entrainment at Seabrook (ARCADIS 2008). The three WPCP within 15 mi (24 km) of Seabrook include the Seabrook WPCP, and Portsmouth WPCP, and the Hampton WPCP (ARCADIS 2008). ARCADIS (2008) estimated that these three WPCPs could provide approximately 5 to 6 mgd, which is less than 1 percent of Seabrook’s daily cooling water requirements (682 mgd).

ARCADIS (2008) estimated that the reduction in impingement and entrainment would be approximately less than 1 percent. In addition, a variety of environmental impacts would result from construction and operation of pipelines to transport the grey water from the WPCPs to Seabrook. These impacts would likely be greatest in wetlands and salt marsh areas, which provide high quality habitat for terrestrial and aquatic resources. Given the location of Seabrook and the WPCPs, wetlands and salt marshes would be difficult to avoid. In addition, NextEra would need to acquire ROWs, which could be on or adjacent to private land, recreational areas, or high quality terrestrial and aquatic habitats.

NextEra concluded that the use of grey water was not a suitable option for reducing impingement and entrainment because the reduction in impingement and entrainment would be “essentially imperceptible” (ARCADIS 2008). Further, the permitting, engineering, and construction of the pipelines would be difficult and would result in a variety of environmental impacts, as described above.

Variable Frequency Drives

Variable frequency drives (VFDs) can reduce impingement and entrainment by reducing the amount of water withdrawn for cooling water. VFDs on the circulating water pump motors reduce the pump speed, which in turn reduces the pump flow. Harish et al. (2010) created a theoretical model that demonstrated that VFD would reduce withdrawal rates, but the discharge temperature would increase. This research suggests that VFDs may decrease impingement and entrainment because less water and organisms would be pulled through the cooling system, although VFDs may increase thermal impacts because the discharge would be released at a higher temperature.

NextEra considered VFDs to reduce the withdrawal requirements at Seabrook (ARCADIS 2008). ARCADIS (2008) determined that a VFD could be installed on each of the

three circulating water pump motors. Each VFD enclosure would be over 20 ft (6.1 m) long and, therefore, installed on the outside of the turbine building (ARCADIS 2008).

ARCADIS (2008) determined that the three VFDs would reduce the minimum flow achievable to 250,000 gpm (360 mgd). This would result in an approximate 8 to 30 percent decrease in cooling water withdrawal, depending on the season and water temperature. The greatest reductions would occur in the winter and spring when the water is coolest. ARCADIS (2008) estimated that the use of VFDs would reduce entrainment by 4 percent. However, the use of VFDs would also increase the discharge temperature from 39 °F (3.9 °C) to 45 °F (7.2 °C), thereby increasing potential thermal impacts and exceeding the limits of Seabrook's NPDES discharge.

NextEra concluded that installing and operating three VFDs is feasible in terms of operation. However, it would require Seabrook to obtain a new NPDES permit that would increase the allowable temperature of the discharge water.

Other Potential Mitigation

In its comments on the draft SEIS, NMFS suggested that NextEra conduct additional studies to understand the causative agent for the decline in macroalgae near Seabrook. For example, various studies could be conducted to better understand whether the decline was due to Seabrook’s thermal discharge or other activities. Similarly, NMFS suggested that NextEra conduct studies that test whether changes in benthic fish communities near the Seabrook discharge (NMFS 2011a):

> “are the result of thermal effects from the discharge plume, such as avoidance of the thermal plume by juvenile and adult life stages or from mortality reduced fitness of egg and larval stages that may settle to the bottom in this area, or a result of eggs and larvae that are lost to the general area from impingement and entrainment in the cooling water system.”

In its comments on the draft SEIS, NHFGD identified two potential mitigation projects that would mitigate potential impacts to winter flounder and rainbow smelt, which are important commercial and recreational fish. As described in Appendix A, NHFGD suggested that NextEra fund projects that would reduce the point and nonpoint sources of nitrogen loading in the Great Bay Estuary System watershed to potentially improve habitat for juvenile winter flounder and rainbow smelt. NHFGD also suggested that NextEra could compensate businesses that rely on winter flounder catch for income.

4.6.5 Combined Impacts

As described in Section 2.2.6, NextEra has conducted monitoring studies for plankton, fish, invertebrates, and macroalgae since the 1970s. NextEra used a BACI design to test for potential impacts from operation of Seabrook. This monitoring design can be used to test the statistical significance of differences in community structure and abundance between the preoperation and operational period at nearfield and farfield sites. If a significant difference occurs in the geographical distribution of a population, it could be due to entrainment, impingement, heat shock, or a combination of the cumulative effects from Seabrook operations.

When appropriate, NextEra has tested the significance of the changes in species or biological group abundance, density, or biomass using various statistical tests. A multivariate ANOVA on a BACI design compares preoperational and operational data at the nearfield and farfield sites to test if a significant difference occurred between the preoperational and operational periods and to test if this change was restricted to the nearfield site. When data were inappropriate for an ANOVA test, NextEra used an analysis of similarities (ANOSIM). Using this statistical test,

NextEra first tested whether there was a significant difference between sites during the preoperational period. If there was no significant difference, then NextEra separately tested whether each station experienced significant differences prior to and during operations. If there was a significant difference between sites prior to operations, NextEra relied upon hierarchical clustering and nonmetric multi-dimensional scaling (MDS), as described below, to look for changes in species abundance after operations began.

NextEra examined the change in community composition, or relative abundance of various taxa, over time for the biological groups discussed below. NextEra calculated the Bray-Curtis Similarity Index (Boesch 1977 in NAI 2010; Clifford and Stephenson 1975 in NAI 2010) for all combinations of stations and years by using the mean annual abundance, density, or biomass for each taxon. NextEra evaluated temporal and spatial changes in the similarity indices by using hierarchical clustering and MDS plots. MDS plots resulted in a dendrogram that showed the most similar groups of monitoring sites and years. NextEra then evaluated whether groups were consistent separately by site and monitoring period. For example, an effect on aquatic communities from Seabrook operation could be concluded if MDS plots indicated that the nearfield and farfield sites were similar prior to operations but less similar during operations.

NRC staff related NextEra's monitoring results to NRC's definitions of SMALL, MODERATE, and LARGE, as described in Section 1.4. NRC defined the Seabrook cooling system impact as SMALL, if Seabrook monitoring data concluded that no significant difference occurred between the preoperational and operational periods or, if there was a change, that it occurred at both the nearfield and farfield sites. In this situation, NRC staff would conclude that operations of the Seabrook cooling system do not noticeably alter the aquatic resource. NRC defined the Seabrook cooling system impact as MODERATE if Seabrook monitoring data indicated that the abundance of a certain species or biological group increased at farfield sites and remained steady at nearfield sites during operations. In this situation, NRC staff would conclude that operations of the Seabrook cooling system noticeably altered, but does not destabilize, the aquatic resource. NRC defined the Seabrook cooling system impact as LARGE if Seabrook monitoring data indicated that the abundance of a certain species or biological group increased or remained steady at farfield sites and decreased at nearfield sites or if the abundance of a species or biological group declined at all sites, but the decline was significantly greater at nearfield sites. In this situation, NRC staff would conclude that operations of the Seabrook cooling system destabilizes the aquatic resources within 3–4 mi (5–8 km) of Seabrook.

Phytoplankton

As described in Section 2.2.6.3, NextEra examined differences in phytoplankton abundance and chlorophyll *a* concentrations prior to and during operation at nearfield and farfield sites using an ANOVA on a BACI design. NAI (1998) found no significant differences in phytoplankton abundance or chlorophyll *a* concentrations between the nearfield and farfield sites, nor was there any significant difference prior to and during operations. NAI (1998) observed minimal changes in species composition prior to and during operations. These results suggest that Seabrook operations have not noticeably altered phytoplankton abundance near Seabrook.

Zooplankton

<u>Holoplankton, Meroplankton, and Hyperbenthos</u>. NextEra compared the density of holoplankton, meroplankton, hyperbenthos taxa prior to and during operation at nearfield and farfield sites using an ANOSIM. NAI (2010) did not find a significant difference in the density of holoplankton or meroplankton taxa prior to and during operations or between the nearfield and farfield sampling sites. These results suggest that Seabrook operations have not noticeably altered holoplankton or meroplankton density near Seabrook.

Since hyperbenthos live closest to the intake structure, this assemblage of species would be most likely to be entrained. NAI (2010) found a significant difference in the density of hyperbenthos taxa between the nearfield and farfield sites. The average density of all hyperbenthos species at the nearfield site was generally an order of magnitude larger than the abundances found at the farfield site both prior to and during operations (NAI, 2010). For *Neomysis American*, a mysid shrimp and the most common species in the hyperbenthos assemblage, NAI (2010) reported significantly higher density at the nearfield site compared to the farfield site. NextEra used MDS plots to examine how the density of hyperbenthos taxa changed over time. NAI (2010) reported relatively consistent density of hyperbenthos taxa at the nearfield site both prior to and during operations. At the farfield site, NAI (2010) reported changes in the density of hyperbenthos taxa after 1996, when the sampling methods were modified in an effort to sample both sites at similar times. Since the density of hyperbenthos taxa generally remained consistent at the nearfield site, these results suggest that Seabrook operations have not noticeably altered hyperbenthos density near Seabrook.

<u>Bivalve Larvae</u>. NextEra compared the density of bivalve larval taxa prior to and during operations at nearfield and farfield sites by using an ANOSIM and MDS plots. NAI (2010) reported three main groups of typical bivalve larvae assemblages in MDS plots, as described in Section 2.2.6. These groups were primarily divided by year, and NAI (2010) reported similar patterns at both the farfield and nearfield sampling sites. At both sampling sites, blue mussels and the rock borer dominated community assemblages of bivalve larvae prior to operations, whereas prickly jingle and blue mussels dominated monitoring samples after 1996. NAI (2010) did not find a significant difference between sampling sites prior to and during operations, when examining total bivalve larvae using an ANOSIM. Since the change in community structure occurred at nearfield and farfield sampling sites, these results suggest that Seabrook operations have not noticeably altered bivalve larval density near Seabrook.

<u>Fish Eggs and Larvae</u>. NextEra compared the density of fish eggs and larvae prior to and during operation at nearfield and farfield sites using an ANOSIM. While there was no significant difference between sampling sites, NAI (2010) reported a significant difference prior to and during operations in the density of fish eggs and larval species. These significant changes over time occurred at both sampling sites. For example, NAI (2010) reported higher average egg density in 1983, 1984, 1986, and 1987 when compared to 1998–2008 for hake, Atlantic cod/haddock (*Melanogrammus aeglefinus*), and fourbeard rockling. NAI (2010) reported the opposite trend for the average egg density of Atlantic mackerel, cunner/yellowtail flounder, hake/fourbeard rockling, windowpane, and silver hake, as shown in Table 4–12. NAI (2010) reported higher average larval densities prior to operations when compared to more recent years for Atlantic mackerel, Atlantic herring, winter flounder, and witch flounder (*Glyptocephalus cynoglossus*) and the opposite trend for cunner, American sand lance, fourbeard rockling, rock gunnel, silver hake, and radiated shanny (*Ulvaria subbifurcata*), as shown in Table 4–12. Since changes in density prior to and during operations occurred at both the nearfield and farfield sampling sites, these results suggest that Seabrook operations have not noticeably altered fish egg and larval density near Seabrook.

Table 4–12. Mean Density (No./1,000 m^3) and Upper and Lower 95% Confidence Limits (CL) of the Most Common Fish Eggs and Larvae From 1982–2009 Monitoring Data at Seabrook

Taxon	Group 1[a]			Group 2[a]		
	Lower 95% CL	Mean	Upper 95% CL	Lower 95% CL	Mean	Upper 95% CL
Eggs[b]						
Atlantic mackerel	650	1,009	1,369	1,344	1,941	2,538
cunner/yellowtail flounder	2,764	5,003	7,243	6,577	7,239	8,081
hakes	235	1,226	2,217	332	488	643
hake/fourbeard rockling	45	215	386	503	626	749
Atlantic cod/haddock	79	153	226	63	92	120
windowpane	73	147	221	160	232	304
fourbeard rockling	168	248	328	34	49	65
silver hake	45	77	109	149	322	494
Larvae[c]						
cunner	143	425	707	828	1,386	1,945
American sand lance	57	182	307	160	234	308
Atlantic mackerel	28	179	330	65	121	176
fourbeard rockling	40	68	96	56	78	99
Atlantic herring	37	68	99	23	29	35
rock gunnel	14	31	49	32	42	52
winter flounder	18	44	70	8	11	14
silver hake	14	23	32	35	67	100
radiated shanny	15	26	36	3	27	50
witch flounder	9	18	28	3	5	6

[a] NAI (2010) determined groups using a cluster analysis (numerical classification) and non-metric MDS of the annual means (log (x+1)) of each taxon at each station.

[b] Egg Group 1 years = 1983, 1984, 1986, 1987; Group 2 years = 1988–2008

[c] Larvae Group 2 years = 1982–1984, 1986–1989; Group 2 years = 1989–1991, 1993–2009

Source: (NAI 2010)

Juvenile and Adult Fish

Demersal Fish. NextEra compared the abundance of demersal fish prior to and during operation at nearfield and farfield sites using an ANOVA on a BACI design. As described in Section 2.2.6, at the nearfield sampling station (T2) and at one of the farfield stations (T1), the abundance of fish was significantly higher in the 1970s–1980s (prior to operations) when compared to more recent years that include plant operations (NAI 2010). In 2009, the combined abundance for all fish species was similar to that found in the mid-1980s at the farfield stations but below preoperational levels at the nearfield station (NAI 2010). Sosebee, et al. (2006) analyzed separate trawl survey data from over 40 years and found similar trends as NAI (2010) at the 2 farfield stations.

NAI (2010) compared abundance by taxon prior to and during operations at the nearfield and farfield sites. The abundances of the majority of species were higher during preoperational monitoring than during operations, although the abundance of some species increased with time (Table 4–13). NAI (2010) used a mixed model analysis of variance to determine if there were statistically significant differences between the preoperational and operational monitoring periods, nearfield and farfield sampling stations, and in the interaction of these terms. The abundance of yellowtail flounder, Atlantic cod, and rainbow smelt were significantly higher prior to operations at the nearfield and farfield sampling sites. The decrease in rainbow smelt was significantly greater at the nearfield station compared to the farfield station (see Table 4–13). However, NAI (2010) observed a different trend for winter flounder and silver hake. At the nearfield site (T2), the abundance of winter flounder significantly decreased over time from a mean CPUE of 5.5 prior to operations to 2.3 during operations. However, at both farfield sampling sites (T1 and T3), the mean CPUE increased from 2.8 and 1.4 prior to operations, respectively, to 4.0 and 3.6 during operations. This increase was statistically significant at one of the farfield sites (T3). Silver hake abundance also increased at farfield sampling sites and decreased at the nearfield sampling site. NAI (2010) did not test if these trends were statistically significant.

Table 4–13. Geometric Mean CPUE (No. per 10-minute tow) and Upper and Lower 95% CL During Preoperational and Operational Monitoring Years for the Most Abundant Species

Species	Sample site	Preoperational monitoring			Operational monitoring		
		Lower 95% CL	Mean	Upper 95% CL	Lower 95% CL	Mean	Upper 95% CL
yellowtail flounder	Nearfield (T2)	2.7	3.7	5.0	0.1	0.2	0.3
	Farfield (T1)	15.7	20.6	26.9	1.8	2.4	3.1
	Farfield (T3)	6.6	9.2	12.8	1.4	2.1	3.0
longhorn sculpin	Nearfield (T2)	0.6	1.0	1.5	0.4	0.6	0.8
	Farfield (T1)	2.3	3.2	4.5	2.3	3.1	4.1
	Farfield (T3)	4.2	6.1	8.5	4.8	6.4	8.4
winter flounder	Nearfield (T2)	3.7	5.5	8.0	1.6	2.3	3.1
	Farfield (T1)	2.1	2.8	3.6	3.0	4.0	5.4
	Farfield (T3)	1.1	1.4	1.9	2.7	3.6	4.8
hake	Nearfield (T2)	0.6	0.9	1.2	0.3	0.4	0.5
	Farfield (T1)	1.3	1.7	2.0	0.4	0.6	0.8
	Farfield (T3)	0.8	1.1	1.4	0.4	0.9	1.4
Atlantic cod	Nearfield (T2)	0.5	0.8	1.2	0.1	0.2	0.4
	Farfield (T1)	1.7	2.6	3.7	0.2	0.3	0.5
	Farfield (T3)	2.6	4.1	6.2	0.8	1.1	1.5
Raja sp.	Nearfield (T2)	0.4	0.6	0.7	0.4	0.7	0.9
	Farfield (T1)	0.8	1.4	2.3	1.6	2.2	2.9
	Farfield (T3)	2.0	2.6	3.2	2.6	3.5	4.7
windowpane	Nearfield (T2)	0.8	1.2	1.6	0.7	1.0	1.3
	Farfield (T1)	1.1	1.6	2.3	1.4	1.8	2.2
	Farfield (T3)	0.6	0.9	1.4	1.0	1.7	2.6
rainbow smelt	Nearfield (T2)	2.2	3.2	4.3	0.3	0.5	0.8
	Farfield (T1)	1.6	2.3	3.1	0.4	0.6	0.9
	Farfield (T3)	0.9	1.6	2.5	0.4	0.6	0.8
ocean pout	Nearfield (T2)	0.6	0.8	1.0	0.2	0.2	0.3
	Farfield (T1)	0.6	0.7	1.0	0.1	0.1	0.2
	Farfield (T3)	1.4	1.8	2.3	0.1	0.2	0.3
silver hake	Nearfield (T2)	0.0	0.1	0.1	0.0	0.0	0.1
	Farfield (T1)	0.1	0.2	0.4	0.3	0.6	0.9
	Farfield (T3)	0.1	0.2	0.3	0.1	0.3	0.6

Source: (NAI 2010)

In addition to the decrease in abundance of species over time, NAI (2010) also reported changes in community composition, or the relative abundance of the most common species, over time. Prior to operations, yellowtail flounder was the most abundance species, followed by longhorn sculpin (*Myoxocephalus octodecimspinosus*) and winter flounder (Table 4–13). During operations, winter flounder has been the most abundant species, followed by longhorn sculpin,

Raja spp., windowpane, and yellowtail flounder. NAI (2010) observed similar changes in community composition at all three sampling sites. Sosebee (2006) classifies yellowtail flounder as overfished.

Except for rainbow smelt, winter flounder, and silver hake, changes in species abundance and community structure, prior to and during operations, occurred at both the nearfield and farfield sampling sites. Therefore, for most species, these results suggest that Seabrook operations have not noticeably altered demersal fish populations near Seabrook. However, the abundance of winter flounder and rainbow smelt has decreased to a greater and observable extent near Seabrook's intake and discharge structures compared to 3–4 mi (5–8 km) away. The local decrease suggests that, to the extent local subpopulations exist within 3–4 mi (5–8 km) of the intake and discharge structures, they have been destabilized through operation of Seabrook's cooling water system. Regarding silver hake, specifically, the NRC does not have sufficient information to make a conclusion for this species because NAI (2010) did not test whether the differences in silver hake abundance at the sampling sites were statistically significant; therefore, the NRC cannot make a species-specific conclusion on silver hake.

Pelagic Fish. As described in Section 2.2.6, the geometric mean CPUE for all pelagic fish species peaked in 1977 and has been declining ever since. NAI (1998) observed this trend at nearfield and farfield sampling sites. The National Oceanic and Atmospheric Administration (NOAA) (2006) reported a different trend for principal pelagic species, which included Atlantic herring and Atlantic mackerel, two of the dominant fish in NAI monitoring surveys. NOAA (2006) reported record low biomass for principal pelagic from 1975–1979, an increase in biomass from the mid-1980s–1990s, and slightly declining biomass since 2000.

NAI (1998) reported a change in the community composition, or the relative abundance of the most common species, in the preoperational monitoring compared to monitoring during operations (Table 4–14). Prior to operations, the most abundant species were Atlantic herring (1.1 CPUE), blueback herring (*Alosa aestivalis*) (0.3 CPUE), silver hake (0.3 CPUE), pollock (*Pollachius virens*) (0.3 CPUE), and Atlantic mackerel (0.2 CPUE). During operations, the most common fish species were Atlantic herring (0.3 CPUE), Atlantic mackerel (0.3 CPUE), pollock (0.2 CPUE), and blueback herring (0.2 CPUE) (NAI 1998). Changes in community composition were similar at nearfield and farfield sampling sites.

Table 4–14. Geometric Mean CPUE (No. per 24-hr surface and bottom net set) and Coefficient of Variation (CV) During Preoperational (1976–1989) and Operational Monitoring Years (1990–1996)

Species	Sample site	Preoperational monitoring		Operational monitoring	
		Mean	CV	Mean	CV
Atlantic herring	Nearfield (G2)	1.1	20	0.2	33
	Farfield (G1)	1.0	18	0.3	22
	Farfield (G3)	1.2	21	0.4	25
Atlantic mackerel	Nearfield (G2)	0.2	15	0.3	29
	Farfield (G1)	0.2	16	0.3	17
	Farfield (G3)	0.3	16	0.3	15
pollock	Nearfield (G2)	0.3	10	0.3	16
	Farfield (G1)	0.2	17	0.2	18
	Farfield (G3)	0.3	13	0.2	13
spiny dogfish	Nearfield (G2)	<0.1	35	0.1	41
	Farfield (G1)	<0.1	45	0.1	69
	Farfield (G3)	<0.1	27	0.2	47
silver hake	Nearfield (G2)	0.2	35	0.1	60
	Farfield (G1)	0.2	34	0.1	40
	Farfield (G3)	0.3	31	0.1	31
blueback herring	Nearfield (G2)	0.3	18	0.2	26
	Farfield (G1)	0.2	17	0.2	50
	Farfield (G3)	0.3	24	0.2	32
alewife	Nearfield (G2)	0.1	14	0.1	21
	Farfield (G1)	0.1	17	0.1	34
	Farfield (G3)	0.1	21	0.1	35
rainbow smelt	Nearfield (G2)	0.1	21	0.1	29
	Farfield (G1)	<0.1	26	0.1	40
	Farfield (G3)	0.1	21	0.1	39
Atlantic cod	Nearfield (G2)	<0.1	22	<0.1	63
	Farfield (G1)	0.1	18	<0.1	53
	Farfield (G3)	0.1	13	<0.1	63

Source: (NAI 1998)

The abundance of Atlantic herring decreased the most dramatically at nearfield and farfield sampling sites, with a peak geometric mean CPUE of 6.0 in 1978 and remaining below 1.0 since 1980. Using an ANOVA on a BACI design, NAI (1998) determined that this decrease was statistically significant. NOAA (1995) also reported a precipitous decline in the biomass of Atlantic herring in 1978, which was associated with the collapse of the Georges Bank fishery. In the 1980s, fishing by distant-fleet stopped due to new fishery management regulations. From 1982–1994, the stock continued to increase, so much so that the 1994 stock biomass was larger than the pre-collapse biomass levels in the 1960s (NOAA 1995). NAI (1998) did not observe a similar recovery of Atlantic herring in its monitoring studies.

The abundance of spiny dogfish (*Squalus acanthias*) increased during operations at the nearfield and farfield sampling sites from a geometric mean CPUE of fewer than 0.1 prior to operations to a CPUE of 0.1 during operations. Using an ANOVA on a BACI design, NAI (1998) determined that this increase was statistically significant. NOAA (1995) also reported an increase in spiny dogfish from 1968–1994, with biomass peaking in 1989. Link and Garrison (2002) attributed the increase in spiny dogfish abundance to the lower populations of other piscivores species that were heavily targeted by commercial fishery operations, such as Atlantic cod and haddock. Currently, spiny dogfish are one of the dominant fish predators in Georges Bank (Link and Garrison 2002).

Since changes in species abundance, prior to and during operations, occurred at both the nearfield and farfield sampling sites, these results suggest that Seabrook operations have not noticeably altered pelagic fish populations near Seabrook.

<u>Estuarine (Juvenile) Fish</u>. NextEra compared the abundance of estuarine fish in Hampton-Seabrook Harbor prior and during operation at nearfield and farfield sites using an ANOVA on a BACI design. The abundance of the total number of fish was significantly higher prior to operations when compared to more recent years at the nearfield and farfield sampling stations (NAI 2010).

NAI (2010) determined that the abundance of the majority of species was higher during preoperational monitoring than during operations (Table 4–15). However, NAI (2010) observed a different trend for American sand lance. At the nearfield sampling station (S2), the abundance of American sand lance decreased over time from a mean CPUE of 0.2 prior to operations to 0.1 during operations. At both farfield sampling sites (S1 and S3), the mean CPUE increased from 0.1 prior to operations, to 0.2 and 0.6, respectively, during operations. NAI (2010) did not test if these trends were statistically significant. NHFGD (2010) conducted seine hauls at four sampling sites within the Hampton-Seabrook Estuary and reported the geometric mean CPUE for juvenile American sand lance to range between 1.49–0.0. At sampling sites in estuaries near the Hampton-Seabrook Estuary, the geometric mean CPUE ranged from 2.0–0.0 (NHFGD 2010).

Table 4–15. Geometric Mean CPUE (No. per seine haul) and Upper and Lower 95% CL During Preoperational and Operational Monitoring Years

Species	Sample site	Preoperational monitoring			Operational monitoring		
		Lower 95% CL	Mean	Upper 95% CL	Lower 95% CL	Mean	Upper 95% CL
Atlantic silverside	Nearfield (S2)	5.1	6.8	9.1	2.4	3.1	4.1
	Farfield (S1)	5.1	7.2	10.2	3.6	4.8	6.2
	Farfield (S3)	4.0	6.7	10.7	2.1	2.9	3.9
winter flounder	Nearfield (S2)	0.6	1.0	1.5	0.1	0.2	0.3
	Farfield (S1)	0.6	0.9	1.2	0.2	0.4	0.5
	Farfield (S3)	2.2	3.2	4.4	0.3	0.5	0.7
killifishes	Nearfield (S2)	0.6	1.2	2.0	0.1	0.2	0.3
	Farfield (S1)	0.8	1.1	1.5	0.5	0.9	1.3
	Farfield (S3)	<0.1	<0.1	0.1	0.1	<0.1	0.1
ninespine stickleback	Nearfield (S2)	0.3	0.8	1.6	<0.1	0.1	0.1
	Farfield (S1)	0.4	0.7	1.2	0.1	0.2	0.3
	Farfield (S3)	0.3	0.8	1.4	0.1	0.2	0.3
rainbow smelt	Nearfield (S2)	<0.1	0.2	0.3	0.1	0.1	0.2
	Farfield (S1)	<0.1	0.1	0.2	<0.1	0.1	0.2
	Farfield (S3)	0.3	0.7	1.2	0.1	0.2	0.4
American sand lance	Nearfield (S2)	0.0	0.2	0.5	0.0	0.1	0.1
	Farfield (S1)	<0.1	0.1	0.2	0.1	0.2	0.3
	Farfield (S3)	<0.1	0.1	0.2	0.3	0.6	0.9
pollock	Nearfield (S2)	<0.1	0.2	0.3	0.0	<0.1	<0.1
	Farfield (S1)	<0.1	0.1	0.2	<0.1	<0.1	<0.1
	Farfield (S3)	0.1	0.4	0.8	<0.1	0.1	0.1
blueback herring	Nearfield (S2)	<0.1	0.1	0.1	<0.1	0.1	0.1
	Farfield (S1)	0.1	0.2	0.3	0.1	0.3	0.4
	Farfield (S3)	<0.1	0.1	0.3	<0.1	<0.1	0.1
Atlantic herring	Nearfield (S2)	0.1	0.3	0.5	<0.1	<0.1	0.1
	Farfield (S1)	0.0	0.1	0.5	0.1	0.2	0.3
	Farfield (S3)	0.1	0.1	0.2	<0.1	0.1	0.2
alewife	Nearfield (S2)	0.0	0.1	0.2	<0.1	<0.1	<0.1
	Farfield (S1)	<0.1	0.1	0.2	0.1	0.2	0.4
	Farfield (S3)	<0.1	0.1	0.1	0.0	0.1	0.2

Source: (NAI 2010)

Since changes in community composition and the abundance for most species, prior to and during operations, occurred at both the nearfield and farfield sampling sites, these results suggest that Seabrook operations have not noticeably altered estuarine fish populations near Seabrook. Regarding the American sand lance, specifically, the NRC does not have sufficient information to make a conclusion for this species because NAI (2010) did not test whether the differences in American sand lance abundance at the sampling sites were statistically

significant; therefore, the NRC cannot make a species-specific conclusion on American sand lance.

Invertebrates

NextEra compared the number of taxa and total density of invertebrates prior and during operation at nearfield and farfield sites using an ANOVA on a BACI design (NAI 2010). NextEra examined patterns of species richness as an indicator of community stability and total density as an indicator of fluctuations in the abundance of dominant organisms (NAI 2010). NAI (2010) observed significantly more taxa prior to than during operations at both sampling sites. Species richness was 12–20 percent lower during operational monitoring. NAI (2010) did not observe significant changes in total invertebrate density prior to and during operations or between the nearfield and farfield shallow subtidal sampling sites. At the mid-depth sampling sites, NAI (2010) did not observe significant changes in total number of taxa or invertebrate density prior to and during operations or between the nearfield and farfield shallow subtidal sampling sites.

NAI (2010) used multivariate community analysis techniques, such as MDS plots, to examine changes in community composition, or the relative density of common species, prior to and during operations at the nearfield and farfield sites. MDS plots at the shallow subtidal sampling stations suggest that species composition was relatively similar between the two sites, especially when samples were grouped by date—before or after 1995. Prior to 1995, the herbivorous snail, *Lacuna vincta*, was the most common species, followed by Mytillid spat (the larval stage of mussels) and the isopod *Idotea phosphorea*. After 1995, *L. vincta* was still the most common species, but *I. phosphorea* was more common than Mytilidae spat. NAI (2010) observed this trend at both the nearfield and farfield shallow subtidal sampling stations.

Noncolonial macroinvertebrate community composition was slightly less similar at the mid-depth subtidal samplings stations. NAI (2010) classified monitoring samples into three groups of similar community composition—prior to 1994 at both sampling stations, after 1995 at the nearfield sampling station, and after 1995 at the farfield station (NAI 2010). In all groups, Mytillid spat was the most common biological group, but the relative abundance of other taxa varied among the three groups. The change in community composition after 1995 may be related to the change in macroalgae biomass over time (NAI 2010).

NextEra compared the density of selected invertebrate species prior to and during operation at nearfield and farfield sites using an ANOVA on a BACI design (NAI 2010). NAI (2010) did not observe significant differences prior to and during operations or between the nearfield and farfield sampling sites for mytillid spat, northern horse mussels, sea stars, and the green sea urchin.

<u>Crabs</u>. NextEra compared the abundance of rock crab (*Cancer irroratus*) and Jonah crab (*Cancer borealis*) larvae, juveniles, and adults prior to and during operation at nearfield and farfield sites using an ANOVA on a BACI design (NAI 2010). NAI (2010) did not observe significant differences in the abundance of crab larvae or juvenile and adult Jonah crab prior to and during operations or between sampling sites.

<u>Lobsters</u>. NextEra compared the abundance of lobster larvae, juveniles, and adults prior to and during operation at nearfield and farfield sites using an ANOVA on a BACI design (NAI 2010). The geometric mean abundance of lobster larvae, and all lobsters found in traps, was significantly higher during operations compared to prior to operations at all sites. Incze, et al. (2000) also observed an increase in lobster larval in the Gulf of Maine. Fogarty (1988) conjectured that this regional increase might be related to higher water temperatures. Zhang and Chen (2007) built a conceptual model that indicated that increases in

the juvenile and adult lobster population might be related to lobster bait as a supplemental food source. In addition, the recent decline in many groundfish species has influenced the increases in crustaceans, such as lobsters and crabs, due to less predation and less competition for prey (Zhang and Chen 2007).

However, NAI (2010) found that the geometric mean abundance of lobsters of legal-size for commercial harvesting was significantly higher prior to operations. During operations, legal-sized lobsters comprised approximately 3–4 percent of total lobsters caught, whereas prior to operations, legal-sized lobsters comprised approximately 7–8 percent of the total lobsters caught. The legal-size limit for commercial lobsters has changed several times since monitoring began near Seabrook. In 1984, the legal-size carapace length increased from $3\ ^{1}/_{8}$ inches (in.) (79 millimeters (mm)) to $3\ ^{3}/_{16}$ in. (81 mm). In 1989, it increased to $3\ ^{7}/_{32}$ in. (82 mm), and in 1990 (when Seabrook started operations), it increased to $3\ ^{1}/_{4}$ in. (83 mm). The change in the legal-size to commercially harvest lobsters may, in part, explain the decline in legal-sized lobsters during the operational period. Females comprised between 53–55 percent of the total catch, which remained relatively constant at all sampling stations over time.

NextEra conducted impingement studies for lobsters, as described in Section 4.5.2. Lobster impingement ranged from 0 in 2000 to 77 in 2005 (NAI 2010). The average annual lobster impingement from 1990–2009 was 15.9 per year (NAI 2010).

<u>Soft Shell Clams</u>. NextEra compared the abundance of soft shell clam (*Mya arenaria*) larvae; YOY, 1-25 mm; seed clams, 1-12 mm; yearlings, 26-50 mm; and adults, greater than 50 mm (generally at least 2 years of age (Brousseau 1978)) prior to and during operation using an ANOVA (NAI 2010). NAI (2010) did not observe significant differences in the abundance of larvae, YOY, or adults prior to and during operations. In the Hampton-Seabrook Estuary, the geometric mean clam density was significantly lower during operations than prior to operations for yearlings (1.0 vs. 3.9) (NAI 2010).

NAI (2010) compared the density of seed clams in the Hampton-Seabrook Estuary and Plum Island Sound from 1987–2009. NAI (2010) reported no significant difference between site or time periods.

Green crabs, which are an introduced species, are a major source of clam predation (Glude 1955; Ropes 1969). NAI (2010) examined the relationship between green crab density and clam density and found that green crab density explained 17 percent of the variation in clam density at one clam flat but did not explain the variation at two other clam flats.

Macroalgae

NextEra compared the number of taxa and total biomass of macroalgae prior to and during operation at nearfield and farfield sites using an ANOVA on a BACI design (NAI 2010). NAI (2010) observed significantly more taxa at the farfield shallow subtidal site (B35) compared to the nearfield shallow subtidal site (B17). However, there was no significant difference prior to and during operations. NAI (2010) did not observe significant changes in biomass prior to and during operations or between the nearfield and farfield shallow subtidal sampling sites.

At the mid-depth sampling sites, NAI (2010) observed significantly more taxa at the farfield site (B31) during operations than prior to operations, whereas there was no significant change at the nearfield site (B19). Algal biomass was significantly greater prior to operations than during operations, but NAI (2010) did not observe a significant difference between the nearfield and farfield sampling sites.

NAI (2010) used multivariate community analysis techniques, such as MDS plots, to determine changes in community composition prior to and during operations at the nearfield and farfield

sites. MDS plots indicated high levels of similarity (approximately 75 percent) over time at nearfield and farfield shallow subtidal sampling sites, except for 2 sampling years. MDS plots indicated that samples with the most similar taxa were not consistently grouped by sampling site or year (NAI 2010). At the mid-depth sampling sites, MDS plots indicated lower levels of similarity (approximately 70 percent). MDS plots indicated that samples with the most similar taxa were grouped by sampling site, although no clear pattern was obvious with preoperational and operational samples (NAI 2010). This suggests that the community structure differed by site, but, at each site, there was no clear pattern of changing community structure prior to and during operations.

NextEra compared the biomass of selected macroalgae species prior to and during operation at nearfield and farfield sites using an ANOVA on a BACI design (NAI 2010). Irish moss is one of the most common understory, red algae in the vicinity of Seabrook, and it comprised at least half of the biomass in Seabrook monitoring samples in the shallow subtidal. NAI (2010) did not observe significant differences in Irish moss biomass prior to and during operations or between sampling sites.

NAI (2010) observed significant changes in kelp density prior to and during operations (Table 4–16). NAI (2010) reported significantly higher *Laminaria digitata* density prior to than during operations. In the shallow and the mid-depth subtidal, the decline at the nearfield sampling site was significantly greater than the decline at the farfield station. In the nearfield mid-depth sampling site (B19), NAI (2010) did not identify *L. digitata* in 2008 or 2009. The density of *Agarum clathratum*, which competes with *L. digitata*, significantly increased over time in the mid-depth sampling stations, and density was significantly higher at the nearfield site (NAI 2010).

Table 4–16. Kelp Density (No. per 100 m^2) and Upper and Lower 95% CL During Preoperational and Operational Monitoring Years

Kelp	Sample site	Preoperational monitoring			Operational monitoring		
		Lower 95% CL	Mean	Upper 95% CL	Lower 95% CL	Mean	Upper 95% CL
L. digitata	Nearfield shallow (B17)	140.6	213.9	287.3	5.3	15.2	25.2
	Farfield shallow (B35)	96.5	155.8	215.1	52.3	73.9	95.6
	Nearfield mid-depth (B19)	81.5	139.9	198.3	3.1	7.5	11.9
	Farfield mid-depth (B31)	401.6	500.2	598.7	106.0	157.7	209.5
sea belt	Nearfield shallow (B17)	270.7	415.1	559.4	66.1	137.9	209.7
	Farfield shallow (B35)	210.9	325.7	440.5	247.8	326.0	404.2
	Nearfield mid-depth (B19)	2.0	59.1	116.3	1.5	10.1	18.7
	Farfield mid-depth (B31)	59.6	95.5	131.5	29.3	48.2	68.2
A. esculenta	Nearfield mid-depth (B19)	0.0	2.4	7.2	0.3	2.3	4.2
	Farfield mid-depth (B31)	19.9	75.2	130.5	20.3	40.0	59.6
A. clathratum	Nearfield mid-depth (B19)	613.5	786.6	959.6	792.2	955.2	1,118.1
	Farfield mid-depth (B31)	280.2	366.4	452.6	407.3	503.6	599.9

Source: (NAI 2010)

In the shallow subtidal, sea belt (*Saccharina latissima*) density was significantly lower during operations at the nearfield site, but there was no significant change at the farfield site

(NAI 2010). In the mid-depth subtidal, sea belt density significantly decreased at both sampling sites (NAI 2010). In the mid-depth subtidal, *Alaria esulenta* significantly declined during operations at the farfield site and remained at a low density at the nearfield site prior to and during operations (NAI 2010). NAI (2010) did not identify *A. esulenta* at the nearfield sampling station over the past 4 years.

Since the decrease in *L. digitata* density was significantly greater at the nearfield sites, and since sea belt density was lower during operations at the nearfield site but not at the farfield site in the shallow subtidal, these results suggest that the local population of *L. digitata* and sea belt has been destabilized through operation of Seabrook's cooling water system.

Summary of Combined Effects

The NRC staff reviewed Seabrook monitoring data to evaluate the impacts from Seabrook cooling water system on aquatic resources. NRC concludes that the impact from operation of the Seabrook cooling water system on phytoplankton, zooplankton, invertebrates, and most fish species is SMALL since monitoring data suggest that operations has not noticeably altered these aquatic communities near Seabrook.

For winter flounder and rainbow smelt, specifically, the NRC staff concludes that the impact is LARGE since the abundance of winter flounder and rainbow smelt has decreased to a greater and observable extent near Seabrook's intake and discharge structures compared to 3–4 mi (5–8 km) away. The local decrease suggests that, to the extent local subpopulations exist within 3–4 mi (5–8 km), they have been destabilized through operation of Seabrook's cooling water system.

For macroalgae, specifically, the NRC staff concludes that the impact from operation of the Seabrook cooling system is LARGE for *L. digitata* and sea belt since the abundance of these species has decreased to a greater and observable extent near Seabrook's intake and discharge structures compared to 3–4 mi (5–8 km) away. The local decrease suggests that, to the extent local subpopulations exist within 3–4 mi (5–8 km), they have been destabilized through operation of Seabrook's cooling water system.

4.7 Terrestrial Resources

The Category 1 (generic) and Category 2 (site-specific) terrestrial resources issues applicable to Seabrook are listed in Table 4–17.

Table 4–17. Terrestrial Resources Issues

Section 2.2.7 provides a description of the terrestrial resources at Seabrook and in the surrounding area.

Issues	GEIS section	Category
Cooling tower impacts on crops & ornamental vegetation	4.3.4	1
Cooling town impacts on native plants	4.3.5.1	1
Bird collisions with cooling towers	4.3.5.2	1
Power line ROW management (cutting herbicide application)	4.5.6.1	1
Bird collisions with power lines	4.5.6.1	1
Impacts of electromagnetic fields on flora and fauna (plants, agricultural crops, honeybees, wildlife, livestock)	4.5.6.3	1
Floodplains & wetland on power line ROW	4.5.7	1
Exposure of terrestrial organisms to radionuclides	4.6.1.1[a]	1
Effects on terrestrial resources (non-cooling system impacts)	4.6.1.1[a]	2

[a] NRC 2013a, 2013b

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

4.7.1 Generic Terrestrial Resource Issues

For the Category 1 terrestrial resources issues listed in Table 4–17, the NRC staff did not identify any new and significant information during the review of the ER (NextEra 2010), the NRC staff's site audit, the scoping process, or the evaluation of other available information. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS and the final rule (NRC 2013b). For these issues, the GEIS and the final rule concluded that the impacts are SMALL.

4.7.1.1 Exposure of Terrestrial Organisms to Radionuclides

As described in Section 1.4 of this SEIS, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to the terrestrial organisms, the final rule amends Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51 by adding a new Category 1 issue, "Exposure of terrestrial organisms to radionuclides," among other changes. This new issue has an impact level of SMALL. This new Category 1 issue considers the impacts to terrestrial organisms from exposure to radioactive effluents discharged from a nuclear power plant during the license renewal term. An understanding of the radiological conditions in the terrestrial environment from the discharge of radioactive effluents within NRC regulations has been well established at nuclear power plants during their current licensing term. Based on the revision to the environmental protection guidance and the staff's understanding of radiological conditions, the NRC concluded that the doses to terrestrial organisms are expected to be well below exposure guidelines developed to protect these organisms and assigned an impact level of SMALL.

The NRC staff has not identified any new and significant information related to the exposure of terrestrial organisms to radionuclides during its independent review of Seabrook's ER (NextEra 2010), the site audit, and the scoping process. Section 2.1.2 of this SEIS describes the applicant's Radioactive Waste Management Program to control radioactive effluent discharges to ensure that they comply with NRC regulations in 10 CFR Part 20. Section 4.9.1.4

of this SEIS contains the NRC staff's evaluation of Seabrook's Radioactive Effluent and Radiological Environmental Monitoring programs. Seabrook's Radioactive Effluent and Radiological Environmental Monitoring programs provide further support for the conclusion that the impacts from radioactive effluents are SMALL.

Therefore, the NRC staff concludes that there would be no impact to terrestrial organisms to radionuclides beyond those impacts contained in Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51 of the revised rule; therefore, the impacts to terrestrial organisms from radionuclides are SMALL.

4.7.2 Effects on Terrestrial Resources (Non-cooling System Impacts)

As described in Section 1.4 of this SEIS, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to the terrestrial organisms, the final rule amends Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51 by expanding the Category 2 issue, "Refurbishment impacts," among others, to include normal operations, refurbishment, and other supporting activities during the license renewal term. This issue remains a Category 2 issue with an impact level range of SMALL to LARGE; however, the final rule renames this issue "Effects on terrestrial resources (non-cooling system impacts)."

Section 2.2.7 of this SEIS describes the terrestrial resources on and in the vicinity of the Seabrook site, and Section 2.2.8 describes protected species and habitats. During the construction of Seabrook, approximately 22 percent of the plant site (194 ac (79 ha)) was cleared for buildings, parking lots, roads, and other infrastructure. By 2014, NextEra plans to have returned approximately 32 ac (13 ha), which are currently occupied by excavation spoil, to its natural state. The remaining terrestrial habitats have not changed significantly since construction. As discussed in Chapter 3 of this SEIS and according to the applicant's ER (NextEra 2010), NextEra has no plans for refurbishment or other license renewal-related construction activities. Further, it is anticipated that routine plant operation and maintenance activities would continue in areas previously disturbed by construction activities, including existing transmission line ROWs. Based on the staff's independent review, the staff concurs that operation and maintenance activities that NextEra might undertake during the renewal term, such as maintenance and repair of plant infrastructure (e.g., roadways, piping installations, onsite transmission lines, fencing and other security infrastructure), would likely be confined to previously-disturbed areas of the plant site or along the in-scope transmission line corridors. Therefore, the staff expects non-cooling system impacts on terrestrial resources during the license renewal term to be SMALL.

4.8 Protected Species and Habitats

This site-specific, or Category 2 issue, requires consultation with the appropriate agencies to determine if threatened or endangered species are present and if they would be adversely affected by continued operation of Seabrook during the license renewal term. The characteristics and habitats of threatened and endangered species (Table 4–18) in the vicinity of the Seabrook site are discussed in Section 2.2.8 of this SEIS.

Protected aquatic species and protected terrestrial species are discussed separately in the following sections.

Table 4–18. Threatened or Endangered Species

Section 2.2.8 describes the threatened or endangered species on or near Seabrook.

Issue	GEIS section	Category
Threatened or endangered species	4.1	2

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

4.8.1 Protected Aquatic Species

Section 2.2.8 of this document describes the threatened or endangered species on or near Seabrook. The impact to threatened and endangered species is a Category 2 issue, and it is discussed below.

The sections below describe potential impacts to Endangered Species Act (ESA)-listed and proposed species, species protected under the Marine Mammal Protection Act (MMPA), NMFS species of concern, and species of concern for the States of New Hampshire and Massachusetts that may occur along transmission corridors. An assessment of impacts to EFH is provided in Appendix D-1.

ESA-listed and Proposed Species

Three whale species, three sea turtle species, and two fish species, that are protected under the ESA or proposed for listing under the ESA, could occur within the vicinity of Seabrook.

Whales. Northern right whales (*Eubalaena glacialis*), humpback whales (*Megatera novaeangliae*), and fin whales (*Balaenoptera physalus*) are Federally endangered species that inhabit waters off the coast of New Hampshire (NMFS 2010). These species are not likely to occur in the vicinity of the Seabrook facility or the facility's intake or discharge structures since these species generally inhabit deeper waters (NMFS 2010). There are no known occurrences of Seabrook operations affecting whales.

Turtles. Three species of sea turtles—loggerhead (*Caretta caretta*), Kemp's ridley (*Lepidochelys kempii*), and leatherback (*Dermochelys coriacea*)—regularly occur in the Gulf of Maine (Thompson 2010). Under ESA, the leatherback and Kemp's ridley sea turtles are listed as endangered species, and the loggerhead sea turtle is listed as threatened. Leatherback turtles and loggerhead turtles would be most likely to be seasonally present off the coast of New Hampshire and occasionally within the vicinity of Seabrook, including the intake and discharge structures (NMFS 2010). It is less likely for Kemp's ridley sea turtle to be present in the vicinity of Seabrook (NMFS 2010). NextEra has not documented any known occurrences of Seabrook operations affecting turtles. In addition, the installment of additional vertical bars on the intake structure as part of the seal deterrent barrier should also help prevent any future incidental takes (NextEra 2010c).

Fish. NMFS (2010) proposed listing the population of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) in the Gulf of Maine as a threatened species. Atlantic sturgeon currently occurs in coastal waters off the coast of New Hampshire and is likely to occur within the vicinity of Seabrook (NMFS 2010). Seabrook monitoring data indicate that operation of the cooling system is not likely to affect Atlantic sturgeon. For example, Seabrook captured a single Atlantic sturgeon during gill-net monitoring studies from 1976–1997 (NextEra 2010c). Seabrook did not report impingement or entrainment of any Atlantic sturgeon since operations began in 1990 (NextEra 2010c; NAI 2010).

The shortnose sturgeon (*Acipenser brevirostrum*) is Federally listed as endangered throughout its range (NMFS 1998). The shortnose sturgeon has not been observed in New Hampshire since 1971 (NHFGD 2005). Seabrook has not captured any shortnose sturgeon within monitoring, entrainment, or impingement studies since studies began in 1975 (NextEra 2010c).

<u>Conclusion for ESA Species</u>. The NRC staff has evaluated the eight Federally listed or proposed species by examining the known distributions and habitat ranges of those species, the potential ecological impacts of the operation of Seabrook on the species, and the studies and mitigation measures that Seabrook employs to protect the species. Seabrook has ongoing ecological studies and monitoring systems in place to evaluate the impact of the facility on Federally listed aquatic organisms, and it has not observed any takes of any Federally endangered or threatened species. The NRC staff concludes that continued operation of Seabrook during the license renewal term is not likely to adversely affect any Federally listed marine aquatic species. Therefore, NRC did not prepare a biological assessment for any of these species.

Marine Mammal Protection Act

All marine mammals are protected under the MMPA of 1972, as amended. As described above, and in Section 2.2.8, most whales and dolphins are not likely to occur near Seabrook. In addition, there are no known occurrences of Seabrook affecting whales or dolphins (NextEra 2010).

Seals are likely to occur within the vicinity of Seabrook (NextEra 2010). From 1993–1998, approximately 55 seals drowned in the intake tunnels. Although NextEra did not observe the drowning, the applicant conjectured that the seals likely swam into the intake structure and became trapped inside (NextEra 2010c). The downward flow of the water likely transported the seals to the forebay over a period of approximately 80 minutes (NOAA 2004). Drowned seals were primarily harbor seals (*Phoca vitulina*), although NextEra also discovered the remains of gray seals (*Halichoerus grypus*), harp seals (*P. groenlandica*), and hooded seals (*Cystophora cristata*) (NextEra 2010).

After NextEra discovered the seal remains, NOAA Fisheries issued an incidental take statement for marine mammals at Seabrook in June 1999 (NOAA 2004). In August 1999, Seabrook installed a seal deterrent barrier, which included additional vertical barriers on each of the three intake structures. The additional vertical bars reduced the space between bars to less than 5 in. (13 cm) (NOAA 2004). Since the installment of the seal deterrent barrier, no seals have been trapped at Seabrook (NextEra 2010).

In May 2004, NOAA Fisheries reviewed Seabrook's application for renewal of NOAA Fisheries regulations governing incidental takes of marine mammals and determined that the cause of the earlier incidental takes had been eliminated and that the potential for injury or mortality had been significantly reduced. Therefore, NOAA Fisheries determined that an incidental take authorization was no longer necessary under the improved operating conditions at Seabrook (NOAA 2004).

Since the installment of the seal deterrent barrier, there are no known occurrences of Seabrook operations affecting any marine mammals.

NMFS Species of Concern

<u>Rainbow Smelt</u>. NextEra compared the abundance of rainbow smelt prior to and during operation at nearfield and farfield sites using an ANOVA on a BACI design (see Section 4.5.5). NAI (2010) reported a significant decrease over time in the abundance of rainbow smelt at all trawling stations in the Gulf of Maine; however, the decrease was significantly greater at the

nearfield trawling station in the Gulf of Maine (T2) (see Table 4–13). Rainbow smelt is a cold-water species; therefore, the decrease near the intake and discharge structures could be a combination of impingement and avoidance of thermal effluent.

In the Hampton-Seabrook Estuary, the mean geometric abundance prior to (0.3 CPUE) and during (0.2 CPUE) operations was not significantly different (Table 4–15) (NAI 2010). NHFGD (2010) conducted similar monitoring for juvenile rainbow smelt within the Hampton-Seabrook Estuary and reported a geometric mean CPUE in 2009 of 2.12 at 1 sampling station and 0.0 at 3 other sampling stations. NHFGD (2010) reported similar abundances, between 2.04–0.0 geometric mean CPUE, at 3 other nearby estuaries. From 1997–2009, the abundance of rainbow smelt at the 4 New Hampshire estuaries peaked in 2000 at 1.5 geometric mean CPUE and has been declining ever since (NHFGD 2010).

NAI (2010) reported entrainment of about 100,000 rainbow smelt eggs in 1996. NextEra did not observe entrainment during any other years. Rainbow smelt spawn in freshwater and eggs are adhesive, which means it is unlikely eggs would travel offshore to the intake structures. The cooling system entrained rainbow smelt larvae during most years, which averaged 460,000 entrained larvae per year.

Rainbow smelt was the sixth most impinged species at Seabrook. On average over years 1990 to 2009, the cooling water system impinged 1,093 rainbow smelt per year (NAI 2010).

Blueback Herring. NAI (2010) observed relatively stable blueback herring abundance prior to and during operations from pelagic monitoring data in the Gulf of Maine and monitoring data in the Hampton-Seabrook Harbor. NHFGD (2010) conducted similar monitoring for juvenile blueback herring within the Hampton-Seabrook Estuary and did not find any blueback herring in 2009. NHFGD (2010) reported slightly higher abundances, between 2.43–0.0 geometric mean CPUE, at 3 other nearby estuaries. From 1997–2009, the abundance of blueback herring at the four New Hampshire estuaries peaked in 1999 at 0.97 geometric mean CPUE and has been declining ever since (NHFGD 2010).

NAI (2010) did not observe entrainment of blueback herring eggs or larvae. Blueback herring spawn in freshwater; therefore, eggs and larvae are most likely to occur in fresh or estuarine waters. On average from years 1990 to 2009, the cooling system impinged 129 blueback herring per year.

Alewife. When comparing the abundance of alewife (*Pomolobus pseudoharengus*) prior to and during operations, NAI (2010) reported a slight decrease at the nearfield site (0.1–less than 0.1 CPUE), a slight increase at one of the farfield sites (0.1–0.2 CPUE), and constant levels at the other farfield site (0.1 CPUE). NAI (2010) did not report the significance of these trends. NHFGD (2010) conducted similar monitoring for juvenile alewife within the Hampton-Seabrook Estuary and did not find any alewife in 2009. NHFGD (2010) reported higher abundances, between 0.62–0.0 geometric mean CPUE, at 3 other nearby estuaries. From 1997–2009, the abundance of alewife at the 4 New Hampshire estuaries have varied annually between 0.04–0.34 CPUE (NHFGD 2010).

NAI (2010) did not observe entrainment of alewife eggs or larvae. Alewife spawn in freshwater; therefore, eggs and larvae are most likely to occur in fresh or estuarine waters. On average, the cooling system impinged 342 alewife per year.

Aquatic Species of Special Concern along Transmission Lines. Along the transmission lines, the banded sunfish (*Enneacanthus obesus*) and redfin pickerel (*Esox americanus americanus*), two species of fish listed as species of special concern by the State of New Hampshire, may occur in Rockingham and Hillsborough Counties, NH (NHNHB 2009; NHNHB 2010; NHNHB 2011). The eastern pond mussel (*Ligumia nasuta*), which is listed as a species of

special concern by the States of New Hampshire and Massachusetts, may occur in the vicinity of the transmission lines in Hillsborough and Rockingham Counties, NH, and Amesbury County, MA (MDFW 2009; MFGD 2010; NHNHB 2010, 2011).

As described in Section 2.1.3, within wetlands, Public Service Company of New Hampshire (PSNH) follows the New Hampshire Department of Resources and Economic Development (NHDRED)'s *Best Management Practices Manual for Utility Maintenance In and Adjacent to Wetlands and Waterbodies in New Hampshire* (NHDRED 2010). Because PSNH does not use herbicides within New Hampshire ROWs or any mechanized vehicles within designated wetlands and wet areas, and because PSNH workers are trained to recognized Federally or State-protected species (see Section 2.1.3), species within the New Hampshire ROWs are not expected to be adversely affected during the proposed license renewal term.

Because National Grid is prohibited from using herbicides within State-designated priority habitat without prior written approval within the Commonwealth of Massachusetts per 321 *Code of Massachusetts Regulations* (CMR) 10.14(12), the Massachusetts Department of Fish and Game (MDFG) approves National Grid's yearly operation plan to ensure that vegetative maintenance practices are not adversely affecting sensitive species or wetlands. Additionally, National Grid workers are trained to recognize and avoid impacts to Federally or State-listed species (See Section 2.1.3). NRC staff expects no adverse impacts to species within Massachusetts ROWs during the proposed license renewal term.

Conclusion for Aquatic Species

The NRC staff has evaluated the eight Federally listed or proposed species and six additional species of special concern that could be present in the vicinity of Seabrook or associated transmission lines. In its evaluation, NRC staff examined the known distributions and habitat ranges of those species, the ecological impacts of the operation of Seabrook on the species, and the studies and mitigation measures that NextEra employs to protect the species. NextEra has ongoing ecological studies and monitoring systems in place to evaluate the impact of the facility on aquatic organisms and has not observed any interactions with any Federally endangered or threatened species or species of concern along transmission lines. Since the installment of the seal deterrent barrier, there are no known occurrences of Seabrook operations affecting any marine mammals. Monitoring data for alewife and blueback herring indicate that the operation of Seabrook is not likely to adversely affect these species. Thus, the staff concludes that the impact on protected marine aquatic species from an additional 20 years of operation would be SMALL for most species.

As explained in Section 4.6.2, the NRC staff concludes that the impact on rainbow smelt for an additional 20 years of operations is LARGE due to the relatively high impingement rates and since the abundance of rainbow smelt has decreased to a greater and observable extent near Seabrook's intake and discharge structures compared to further away. The local decrease suggests that, to the extent a local subpopulation exists, it has been destabilized through operation of Seabrook's cooling water system.

4.8.2 Terrestrial Species

In order to identify impacts to terrestrial protected species, the NRC staff contacted applicable Federal and State agencies to gather information, reviewed ecological studies and records of endangered species occurrences near the Seabrook site, and reviewed information provided in the applicant's ER (NextEra 2010).

Federally Listed Species

The NRC contacted the U.S. Fish and Wildlife Service (FWS) on July 16, 2010, to request a list of threatened and endangered species that may occur on, or in the vicinity of, the Seabrook site that would have the potential to be affected by the proposed license renewal (NRC 2010). In response to this request, on September 1, 2010, the FWS noted that the Federally listed piping plover (*Charadrius melodus*) and roseate tern (*Sterna dougallii*) are known to occur along the Atlantic coast beaches east of the Seabrook site, but their presence on, or in the immediate vicinity of, the Seabrook site is unlikely (USFWS 2010). These species are described in detail in Section 2.2.8.2. The FWS concluded that the proposed license renewal of Seabrook is not likely to adversely affect any Federally listed species subject to the FWS's jurisdiction (USFWS 2010).

Because no Federally listed threatened or endangered terrestrial species are known to occur on the Seabrook site, operation of Seabrook and its associated transmission lines is not expected to adversely affect any Federally threatened or endangered terrestrial species during the license renewal term.

New Hampshire-Listed Species

Section 2.2.8.2 describes 13 State-listed plant species that are known to occur on the Seabrook site or within the surrounding area. Because no major construction activities or changes to maintenance procedures would occur during the proposed license renewal term, these species would continue to be unaffected by Seabrook operation.

Four bird species—the willet (*Tringa semipalmata*), horned lark (*Eremophila alpestris*), osprey (*Pandion haliaetus*), and common tern (*Sterna hirundo*)—are known to occur on, or in the vicinity of, the Seabrook site (see Section 2.2.8.2). The willet may use the Seabrook site as marginal foraging habitat, but is likely to restrict its use to the mussel beds and mud flats within the salt marshes along the eastern border of the Seabrook site, which would be unaffected by the proposed license renewal. The horned lark and osprey may occasionally pass through the Seabrook site but are not known to nest or winter on the site and are, therefore, unlikely to be affected by the proposed license renewal. The common tern may use the Seabrook site for marginal foraging and breeding habitat, but is more likely to be found along the Atlantic coastline where it would have access to open, bare ground or beach. Like the willet, its use of the Seabrook site would be restricted to the salt marshes along the eastern border of the Seabrook site and would be unaffected by the proposed license renewal.

Concerning State-listed species along the in-scope transmission lines within New Hampshire, because PSNH does not use herbicides within New Hampshire ROWs or any mechanized vehicles within designated wetlands; and wet areas and PSNH workers are trained to recognized Federally or State-protected species, species within the New Hampshire ROWs are not expected to be impacted during the proposed license renewal term.

Massachusetts-Listed Species

Section 2.2.8.2 notes the existence of priority or estimated habitat for bald eagle (*Haliaeetus leucocephalus*), Blanding's turtle (*Emydoidea blandingii*), wood turtle (*Glyptemys insculpta*), blue-spotted salamander (*Ambrystoma laterale*), and five species of dragonflies along the Massachusetts portion of the in-scope transmission line ROWs. Because herbicides are prohibited within State-designated priority habitat without prior written approval within the Commonwealth of Massachusetts per 321 CMR 10.14(12), National Grid's yearly operation plan is approved by the MDFG's Division of Fish and Wildlife to ensure that vegetative maintenance practices are not adversely affecting sensitive species or wetlands; and National Grid workers

are trained to recognize and avoid impacts to Federally or State-listed species, no impacts to Massachusetts-listed species are expected during the proposed license renewal term.

Conclusion

The NRC staff concludes that the adverse impacts to threatened and endangered species during the license renewal term would be SMALL. A potential mitigation measure that could further reduce this SMALL impact would be for PSNH or National Grid, who own and operate the transmission lines associated with Seabrook, to report existence of any Federally or State-listed endangered or threatened species within or near the transmission line ROWs to the New Hampshire Natural Heritage Bureau (NHNHB), NHFGD, MDFG, or FWS (or all of the above), as applicable, if any such species are identified during the renewal term. In particular, if any evidence of injury or mortality of migratory birds, State-listed species, or Federally listed threatened or endangered species is observed within the corridor during the renewal period, coordination with the appropriate State or Federal agency would minimize impacts to the species and, in the case of Federally listed species, ensure compliance with the ESA.

4.9 Human Health

The human health issues applicable to Seabrook are discussed below and listed in Table 4–19 for Category 1, Category 2, and uncategorized issues.

Table 4–19. Human Health Issues

Table B-1 of Appendix B to Subpart A of 10 CFR Part 51 contains more information on these issues.

Issues	GEIS section	Category
Radiation exposures to the public during refurbishment	3.8.1[(a)]	1
Occupational radiation exposures during refurbishment	3.8.2[(a)]	1
Microbiological organisms (occupational health)	4.3.6	1
Microbiological organisms (public health, for plants using lakes or canals or discharging small rivers)	4.3.6[(b)]	2
Noise	4.3.7	1
Radiation exposures to public (license renewal term)	4.6.2	1
Occupation radiation exposures (license renewal term)	4.6.3	1
Electromagnetic fields—acute effects (electric shock)	4.5.4.1	2
Electromagnetic fields—chronic effects	4.5.4.2	Uncategorized
Human health impact from chemicals	4.9.1.1.2[(c)]	1
Physical occupational hazards	4.9.1.1.5[(c)]	1

[(a)] Issues apply to refurbishment, an activity that Seabrook does not plan to undertake.

[(b)] Issue applies to plant features such as cooling lakes or cooling towers that discharge to small rivers. The issue does not apply to Seabrook.

[(c)] NRC 2013a, 2013b

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51; [(c)] NRC 2013a, 2013b

4.9.1 Generic Human Health Issues

Human health issues in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, applicable to Seabrook, are listed in Table 4–19. NextEra stated in its ER (NextEra 2010) that it was aware of one new radiological issue associated with the renewal of the Seabrook operating license—elevated tritium concentrations in groundwater adjacent to Unit 1. The NRC staff determined that the issue, while new, is not significant. Section 4.11 contains the discussion of this issue. The groundwater monitoring for tritium is discussed in the Groundwater Resources section in Chapter 2, Section 2.2.5, and in Chapter 4, Section 4.5.3. The NRC staff has not identified any new and significant information, beyond this issue identified by the applicant, during its independent review of NextEra's ER (NextEra 2010), the site visit, the scoping process, or its evaluation of other available information. Therefore, there are no impacts related to Category 1 human health issues beyond those discussed in the GEIS. For these issues, the GEIS concluded that the impacts are SMALL.

4.9.1.1 New Category 1 Human Health issues

As described in Section 1.4 of this SEIS, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to the human health, the final rule amends Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51 by adding two new Category 1 issues, "Human health impact from chemicals" and "Physical occupational hazards." The first issue considers the impacts from chemicals to plant workers and members of the public. The second issue only considers the nonradiological occupational hazards of working at a nuclear power plant. An understanding of these non-radiological hazards to nuclear power plant workers and members of the public have been well established at nuclear power plants during the current licensing term. The impacts from chemical hazards are expected to be minimized through the applicant's use of good industrial hygiene practices, as required by permits and Federal and state regulations. Also, the impacts from physical hazards to plant workers will be of small significance if workers adhere to safety standards and use protective equipment as required by Federal and state regulations. The impacts to human health for each of these new issues from continued plant operations are SMALL.

The NRC staff has not identified any new and significant information related to these nonradiological issues during its independent review of NextEra's ER (NextEra 2010), the site audit, and the scoping process. Therefore, the NRC staff concludes that there would be no impact to human health from chemicals or physical hazards beyond those impacts described in Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51 of the final rule; therefore, the impacts are SMALL.

4.9.1.2 Radiological Impacts of Normal Operations

The NRC staff has not identified any new and significant information related to the radiological impacts of normal operations during its independent review of NextEra's ER (NextEra 2010), the site audit, the scoping process, or its evaluation of other available information. Therefore, the NRC staff concludes that there would be no impact from radiation exposures to the public or to workers during the renewal term beyond those discussed in the GEIS.

Radiation exposures to public (license renewal term). Radiation doses to the public would continue at current levels associated with normal operations.

Occupational exposures (license renewal term). Occupational doses during the license renewal term are within the range of doses experienced during normal operations and normal maintenance outages and would be well below regulatory limits.

There are no Category 2 issues related to radiological impacts of routine operations. The information presented below is a discussion of selected radiological programs conducted at Seabrook.

4.9.1.3 Seabrook Radiological Environmental Monitoring Program

Seabrook conducts a Radiological Environmental Monitoring Program (REMP) to assess the radiological impact, if any, to its employees, the public, and the environment around the plant site. An annual radiological environmental operating report is issued with a discussion of the results of the REMP. The report contains data on the monitoring performed for the most recent years and graphs, which show data trends from prior years and, in some cases, provides a comparison to pre-plant operation baseline data. The REMP provides measurements of radiation and of radioactive materials for the exposure pathways and the radionuclides, which lead to the highest potential radiation exposures to the public. The REMP supplements the Radioactive Effluent Monitoring Program by verifying that any measurable concentrations of radioactive materials and levels of radiation in the environment are not higher than those calculated using the radioactive effluent release measurements and transport models.

The objectives of the REMP are as follows:

- to provide an indication of the appearance or accumulation of any radioactive material in the environment caused by the operation of the nuclear power station,
- to provide assurance to regulatory agencies and the public that the station's environmental impact is known and within anticipated limits,
- to verify the adequacy and proper functioning of station effluent controls and monitoring systems, and
- to provide standby monitoring capability for rapid assessment of risk to the general public in the event of unanticipated or accidental releases of radioactive material.

The REMP provides an independent mechanism for determining the levels of radioactivity in the environment to ensure that any accumulation of radionuclides released into the environment will not become significant as a result of station operations. While in-plant radiation monitoring programs are used to ensure that the dose to members of the public from radioactive effluents are within the dose limits in 10 CFR Part 20 and the As Low As Is Reasonably Achievable (ALARA) design criteria in Appendix I to 10 CFR Part 50 and EPA's 40 CFR Part 190, the REMP provides direct verification of any environmental impact that may result from plant effluents.

An annual radiological environmental operating report is issued, which contains numerical data and a discussion of the results of the monitoring program for the past year. The REMP collects samples of environmental media in order to measure the radioactivity levels that may be present. The locations of most monitoring stations have been selected based on an exposure pathway analysis. The exposure pathway analysis considers factors such as weather patterns, anticipated radioactive emissions, likely receptors, and land use in the surrounding areas. Samples collected from monitoring stations located in areas that are likely to be influenced by Seabrook operation are used as indicators. Samples collected from locations that are not likely to be influenced by Seabrook operation serve as controls. Results from indicator monitoring stations are compared to the results from control monitoring stations and results obtained during the previous operational and preoperational years of the program in order to assess the impact Seabrook operation may be having on the environment. The media samples are representative

of the radiation exposure pathways that may affect the public. The REMP measures the aquatic, terrestrial, and atmospheric environment for radioactivity, as well as the ambient radiation. Ambient radiation pathways include radiation from radioactive material inside buildings and plant structures and airborne material that may be released from the plant. In addition, the REMP measures background radiation (i.e., cosmic sources, global fallout, and naturally-occurring radioactive material, including radon). Thermoluminescent dosimeters are used to measure ambient radiation. The atmospheric environmental monitoring consists of sampling and analyzing the air for particulates and radioiodine. Terrestrial environmental monitoring consists of analyzing samples of local vegetable crop, groundwater, plant discharge water, storm drain water, sanitary waste water, sediment, vegetation, and milk. The aquatic environmental monitoring consists of analyzing samples of seawater, Irish moss, fish, lobsters, and shellfish. An annual land use census is conducted to determine if the REMP needs to be revised to reflect changes in the environment or population that might alter the radiation exposure pathways. Seabrook has an onsite Groundwater Protection Program designed to monitor the onsite plant environment near the reactor building for early detection of leaks from plant systems and pipes containing radioactive liquid (NextEra 2010). Information on the Groundwater Protection Program is contained in the Groundwater Resources section in Chapter 2, Section 2.2.5, and in Chapter 4, Section 4.5.3, of this document.

For this SEIS, the NRC staff reviewed Seabrook's annual radiological environmental operating reports for 2005–2009 to look for any significant impacts to the environment or any unusual trends in the data (FPLE 2006a, 2007a, 2008a; NextEra 2009b, 2010b). A 5-year period provides a representative data set that covers a broad range of activities that occur at a nuclear power plant such as refueling outages, non-refueling outage years, routine operation, and years where there may be significant maintenance activities. Subsequent to publishing the draft SEIS, and prior to publishing this final report, the NRC staff reviewed the more recent annual radiological environmental operating reports for 2010 and 2011 (NextEra 2011b, 2012b).

Below is a summary of the results reported by NextEra in Seabrook's 2009 annual radiological environmental operating report, followed by a comparison of the 2010 and 2011 results.

Direct Radiation. Offsite direct radiation monitoring results are consistent with previous years. The 2009 results indicate no measurable dose contribution due to plant operations at locations outside the Seabrook controlled area or any detectable onsite exposures where members of the public are permitted.

For the 2010 and 2011 data, the NRC staff found it to be similar to historical data.

Airborne Particulate and Iodine. The Air Particulate Sampling Program observed no offsite dose to the public or impact to the environment from this pathway as a result of plant operations. Results for these locations are within the range observed in previous years and closely follow the trend observed for the control location. Based on these results, there is no evidence of any measurable environmental radiological air quality impact that can be attributed to Seabrook plant operation during 2009.

For the 2010 and 2011 data, the NRC staff found it to be similar to historical data, with the exception of a March through April 2011, spike due to radioactive fallout from the March 11, 2011 Fukushima Dai-ichi accident in Japan. During the March through April time period, detectable levels of cesium-137 (^{137}Cs) and cesium-134 (^{134}Cs) were observed.

Surface Water. The quarterly composites and samples showed no indication of tritium. Tritium results for all surface water samples were so low as to be below the detection capability of the analysis method (i.e., less than the lower limit of detection of 3,000 pCi/kg for seawater). These results are consistent with preoperational tritium data.

The analysis for gamma radiation emitting material in all surface water samples showed no indication of any gamma-emitting radionuclides related to Seabrook plant operation.

The only radionuclide detected in 2009 was naturally-occurring Potassium-40 (^{40}K). No plant-related nuclides were detected. The present data for gamma emitters in seawater do not indicate any measurable impact from Seabrook plant operation.

For the 2010 and 2011 data, the NRC staff found it to be similar to historical data.

Groundwater. Drinking water quality groundwater samples were collected from three offsite locations; the drinking water line supplied by the Town of Seabrook to the Seabrook plant site, an inactive well located approximately 1 km (0.6 mi) north of the plant, and a private well 1.3 km (0.8 mi) north, northwest. This REMP Groundwater Sampling Program is separate from the onsite Groundwater Monitoring Program, which monitors radioactivity from leaks and spills from buried piping and plant systems. The onsite Groundwater Monitoring Program is described in Section 2.2.5, Groundwater Resources, of this SEIS.

In 2009, a total of 12 REMP groundwater samples were collected. All samples were analyzed for gross-beta activity, gamma-emitters, and tritium. Gross beta activity was detected in 10 of the 12 samples due to naturally-occurring radium and its daughter products. The gross beta activity seen at all three locations are similar to what was seen in the pre-operational program and is consistent with results from previous years of commercial operations. No tritium or gamma emitters were detected in any of the groundwater samples collected during the year. The groundwater sample results do not indicate any measurable impact from Seabrook plant operation.

For the 2010 and 2011 data, the NRC staff found it to be similar to historical data.

Milk. Iodine-131 (^{131}I) was not detected in any of the 55 milk samples collected in 2009. Analysis of milk samples did not identify any plant-related gamma-emitting radionuclides above the detection limits of the analysis method. Naturally-occurring ^{40}K was identified in all milk samples. The milk sample results do not indicate any measurable impact from Seabrook plant operation.

For the 2010 and 2011 data, the NRC staff found it to be generally similar to the historical data for ^{131}I. However, as reported in airborne particulate samples, fallout from the March 11, 2011, Fukushima Dai-ichi accident in Japan may have been the source of detectable levels of ^{137}Cs in some milk samples. NextEra states that past atmospheric weapons testing has been the major contributor of cesium detected in past milk samples. To support its position that the cesium is not from Seabrook, NextEra stated that there was no detectable ^{137}Cs reported in gaseous effluents released during 2011.

Sediment. Analysis of sediment samples for gamma-emitting radionuclides showed the presence of naturally-occurring radionuclides ^{40}K and Thorium-232 (^{232}Th). No plant-related radionuclides were detected. The sediment sample results do not indicate any measurable impact from Seabrook plant operation.

For the 2010 and 2011 data, the NRC staff found it to be similar to historical data.

Fish. Bottom dwelling fish species (winter and yellow tail flounder) and fish species that reside in the upper water column (cunner fish) were collected for analysis. Analysis of fish samples collected at both the indicator location and the control location identified the presence of only naturally-occurring radionuclides (^{40}K). The fish sample results do not indicate any measurable impact from Seabrook plant operation.

For the 2010 and 2011 data, the NRC staff found it to be similar to historical data.

Lobsters. Analysis of lobster samples collected at both the indicator location near the discharge and the control location within Ipswich Bay identified the presence of only naturally occurring radionuclides (^{40}K). The lobster sample results do not indicate any measurable impact from Seabrook plant operation.

For the 2010 and 2011 data, the NRC staff found it to be similar to historical data.

Shellfish. Analysis of mussel samples collected at both the indicator station near the discharge outfall and the control station in Ipswich Bay identified only naturally-occurring radionuclides (^{40}K). The mussel shells were tested for Strontium-90 (^{90}Sr) but no indication of any ^{90}Sr incorporation into the shell was found. The shellfish sample results do not indicate any measurable impact from Seabrook plant operation.

For the 2010 and 2011 data, the NRC staff found it to be similar to historical data.

Irish Moss. Analysis of Irish moss (algae) samples, collected at both the indicator station near the plant discharge and a control location in Ipswich Bay, identified only naturally-occurring radionuclides ^{40}K and Beryllium-7 (^{7}Be). One sample taken from the control location detected ^{131}I (31.1 pCi/kg), but a review of effluent discharge records from Seabrook showed no detectable liquid waste release of ^{131}I. It is unlikely that the ^{131}I found in the sample could have originated from Seabrook due to the control station's distance of 10.8 mi (17.4 km) from the plant. The medical industry uses ^{131}I for patient treatment, and it is likely that the ^{131}I detected in the control sample is medically related. The Irish moss sample results do not indicate any measurable impact from Seabrook plant operation.

For the 2010 and 2011 data, the NRC staff found it to be similar to historical data.

Vegetable Crop. Analysis for gamma-emitting radionuclides was performed on six vegetable crop samples (green beans and tomatoes) in 2009. Naturally-occurring radionuclide ^{40}K was identified in all samples. The vegetable crop sample results do not indicate any measurable impact from Seabrook plant operation.

For the 2010 and 2011 data, the NRC staff found it to be similar to historical data.

Vegetation. Analysis for gamma-emitting radionuclides was performed on five broad leaf vegetation samples from three sites. Naturally-occurring radionuclides—^{40}K, ^{7}Be and ^{232}Th—were detected. The vegetation sample results do not indicate any measurable impact from Seabrook plant operation.

For the 2010 and 2011 data, the NRC staff found the data to be similar to the 2009 data. However, as observed in other sample media, ^{137}Cs was also detected. The evaluation performed by NextEra concluded that the cesium was due to radioactive fallout from the March 11, 2011, Fukushima Dai-ichi accident in Japan.

NRC Staff Summary. Based on the review of the radiological environmental monitoring data, the staff found that there were no unusual and adverse trends, and there was no measurable impact to the offsite environment from operations at Seabrook. Unrelated to the operation of Seabrook, the REMP observed detectable levels of cesium in several types of environmental media. The evaluation performed by the applicant concluded that the cesium was due to radioactive fallout from the March 11, 2011, Fukushima Dai-ichi accident in Japan.

4.9.1.4 Seabrook Radioactive Effluent Release Program

All nuclear plants were licensed with the expectation that they would release radioactive material to both the air and water during normal operation. However, NRC regulations require that radioactive gaseous and liquid releases from nuclear power plants must meet radiation dose-based limits, specified in 10 CFR Part 20, and ALARA criteria, defined in Appendix I to

10 CFR Part 50. Regulatory limits are placed on the radiation dose that members of the public can receive from radioactive material released by a nuclear power plant. In addition, nuclear power plants are required to file an annual report to the NRC, which lists the types and quantities of radioactive effluents released into the environment. The radioactive effluent release reports are available for review by the public through the Agencywide Documents Access and Management System (ADAMS) electronic reading room, available through the NRC website.

The NRC staff reviewed the annual radioactive effluent release reports for 2005–2009 (FPLE 2006; FPLE 2007; FPLE 2008; NextEra 2009a; NextEra 2010a). The review focused on the calculated doses to a member of the public from radioactive effluents released from Seabrook. The doses were compared to the radiation protection standards in 10 CFR 20.1301 and the ALARA dose design objectives in Appendix I to 10 CFR Part 50.

Dose estimates for members of the public are calculated based on radioactive gaseous and liquid effluent release data and atmospheric and aquatic transport models. The 2009 annual radioactive effluent release report (NextEra 2010a) contains a detailed presentation of the radioactive discharges and the resultant calculated doses. The following bullets summarize the calculated hypothetical maximum dose to a member of the public located outside the Seabrook site boundary from radioactive gaseous and liquid effluents released during 2009:

- The maximum whole body dose to an offsite member of the public from radioactive liquid effluents was 8.17×10^{-4} millirem (mrem) (8.17×10^{-6} millisievert (mSv)), which is well below the 3 mrem (0.03 mSv) dose criterion in Appendix I to 10 CFR Part 50.
- The maximum organ dose to an offsite member of the public from radioactive liquid effluents was 1.11×10^{-3} mrem (1.11×10^{-5} mSv), which is well below the 10 mrem (0.1 mSv) dose criterion in Appendix I to 10 CFR Part 50.
- The maximum air dose at the site boundary from gamma radiation in gaseous effluents was 6.24×10^{-5} millirad (mrad) (6.24×10^{-7} milligray (mGy)), which is well below the 10 mrad (0.1 mGy) dose criterion in Appendix I to 10 CFR Part 50.
- The maximum air dose at the site boundary from beta radiation in gaseous effluents was 2.47×10^{-5} mrad (2.47×10^{-7} mGy), which is well below the 20 mrad (0.2 mGy) dose criterion in Appendix I to 10 CFR Part 50.
- The maximum organ (thyroid in any age group) dose to an offsite member of the public at the site boundary from radioactive iodine and radioactive material in particulate form was 2.51×10^{-2} mrem (2.51×10^{-4} mSv), which is well below the 15 mrem (0.15 mSv) dose criterion in Appendix I to 10 CFR Part 50.
- The maximum whole body dose to an offsite member of the public from the combined radioactive releases (i.e., gaseous, liquid, and direct radiation) was 2.58×10^{-2} mrem (2.58×10^{-4} mSv), which is well below the 25 mrem (0.25 mSv) dose standard in 40 CFR Part 190.

For this final SEIS, the NRC staff reviewed the more recent annual radioactive effluent release reports for 2010 and 2011 (NextEra 2011a, 2012a). The results of the 2011 report are presented below:

- The maximum whole body dose to an offsite member of the public from radioactive liquid effluents was 2.56×10^{-3} mrem (2.56×10^{-5} mSv), which is

well below the 3 mrem (0.03 mSv) dose criterion in Appendix I to 10 CFR Part 50.

- The maximum organ dose to an offsite member of the public from radioactive liquid effluents was 3.58×10^{-3} mrem (3.58×10^{-5} mSv), which is well below the 10 mrem (0.1 mSv) dose criterion in Appendix I to 10 CFR Part 50.
- The maximum air dose at the site boundary from gamma radiation in gaseous effluents was 1.11×10^{-3} mrad (1.11×10^{-5} mGy), which is well below the 10 mrad (0.1 mGy) dose criterion in Appendix I to 10 CFR Part 50.
- The maximum air dose at the site boundary from beta radiation in gaseous effluents was 7.56 x 10-4 mrad (7.56×10^{-6} mGy), which is well below the 20 mrad (0.2 mGy) dose criterion in Appendix I to 10 CFR Part 50.
- The maximum organ dose to an offsite member of the public at the site boundary from radioactive iodine, carbon-14, and radioactive material in particulate form was 2.70×10^{-1} mrem (2.70×10^{-3} mSv), which is well below the 15 mrem (0.15 mSv) dose criterion in Appendix I to 10 CFR Part 50.
- The maximum whole body dose to an offsite member of the public from the combined radioactive releases (i.e., gaseous, liquid, and direct radiation) was 7.80×10^{-2} mrem (7.80×10^{-4} mSv), which is well below the 25 mrem (0.25 mSv) dose standard in 40 CFR Part 190.

The NRC staff's review of the Seabrook radioactive waste system performance in controlling radioactive effluents found that the radiological doses to members of the public for the years 2005 through 2011 comply with Federal radiation protection standards, contained in Appendix I to 10 CFR Part 50, 10 CFR Part 20, and 40 CFR Part 190.

Routine plant operational and maintenance activities currently performed will continue during the license renewal term. Based on the past performance of the radioactive waste system to maintain the dose from radioactive effluents to be ALARA, similar performance is expected during the license renewal term.

The radiological impacts from the current operation of Seabrook are not expected to change significantly. Continued compliance with regulatory requirements is expected during the license renewal term; therefore, the impacts from radioactive effluents would be SMALL.

4.9.2 Microbiological Organisms

Table B-1 of Appendix B to Subpart A of 10 CFR Part 51 lists the effects of thermophilic microbiological organisms on public health as a Category 2 issue that applies to nuclear plants that discharge to cooling ponds, lakes, canals, or small rivers (those with an annual average flow rate of less than 3.15×10^{12} ft^3/year). This issue does not apply to Seabrook because Seabrook withdraws from and discharges to the Atlantic Ocean.

4.9.3 Electromagnetic Fields—Acute Shock

Based on the GEIS, the NRC found that electric shock resulting from direct access to energized conductors or from induced charges in metallic structures has not been found to be a problem at most operating plants and, generally, is not expected to be a problem during the license renewal term. However, site-specific review is required to determine the significance of the electric

shock potential along the portions of the transmission lines that are within the scope of this SEIS.

The GEIS states that it is not possible to determine the significance of the electric shock potential without a review of the conformance of each nuclear plant's transmission lines with National Electrical Safety Code (NESC) (IEEE 2007). An evaluation of individual plant transmission lines is necessary because the issue of electric shock safety was not addressed in the licensing process for some plants. For other plants, land use in the vicinity of transmission lines may have changed or power distribution companies may have chosen to upgrade line voltage. To comply with 10 CFR 51.53(c)(3)(ii)(H), the applicant must provide an assessment of the impact of the proposed action on the potential shock hazard from the transmission lines if the transmission lines that were constructed for the specific purpose of connecting the plant to the transmission system do not meet the recommendations of the NESC for preventing electric shock from induced currents. The NRC uses the NESC criteria as its baseline to assess the potential human health impact of the induced current from an applicant's transmission lines. As discussed in the GEIS, the issue of electric shock is of small significance for transmission lines that are operated in adherence with the NESC criteria.

Seabrook electrical output is delivered to the New England electric grid via three transmission lines. The Scobie Pond Substation, located near Derry, NH, is connected to Seabrook via the 345 kilovolt (kV) Scobie Pond Line, which runs approximately 30 mi (48 km). For the first 5 mi, the Scobie Pond Line shares an approximately 250-ft (76-m) corridor with the Tewksbury Line before splitting off into a smaller 170-ft (52-m) wide corridor. The 345 kV Tewksbury Line connects Seabrook first to Ward Hill Substation in Ward Hill, MA, approximately 25 mi (40 km) from the plant, and terminates 15 mi (24 km) past the Ward Hill Substation at Tewksbury Substation. The 345 kV Newington Line connects Seabrook first to the Timber Swamp Substation in Hampton, NH, approximately 4.5 mi (7.2 km) from the plant, and terminates about 13.5 mi (21.7 km) past Timber Swamp Substation at the Newington Generating Station. All three lines are owned and operated by PSNH, while the Massachusetts portion of the Tewksbury Line is owned and operated by National Grid (NextEra 2010). These three lines connect the plant to the New England electric grid.

As concluded by the NRC staff in Seabrook's final environmental statement for operations, all transmission lines associated with Seabrook were constructed in accordance with NESC and industry guidance in effect at that time (NRC 1982). Because this conclusion was based on design rather than as-built information, the applicant analyzed the current as-built data on each line in its ER (NextEra 2010) to verify NRC's conclusion that the lines conform to NESC's electric shock provisions. The applicant's analysis determined that there are no locations within the ROW under the transmission lines that have the capacity to induce more than 5 milliamperes (mA) in a vehicle parked beneath the lines. Therefore, the lines meet the NESC 5 mA criterion. The maximum induced current calculated for the power lines was 3.6 mA (NextEra 2010). Transmission lines and facilities are maintained to ensure continued compliance with current standards. Transmission line procedures include routine ground inspections to identify any ground clearance problems and ensure integrity of the transmission line structures.

The NRC staff has reviewed the available information, including the applicant's evaluation and computational results. Based on this information, the NRC staff concludes that the potential impacts from electric shock during the renewal period would be SMALL.

4.9.4 Electromagnetic Fields—Chronic Effects

In the GEIS, the effects of chronic exposure to 60-Hz electromagnetic fields from power lines were not designated as Category 1 or 2 and will not be until a scientific consensus is reached on the health implications of these fields.

The potential effects of chronic exposure from these fields continue to be studied and are not known at this time. The National Institute of Environmental Health Sciences (NIEHS) directs related research through the U.S. Department of Energy.

The report by NIEHS (NIEHS 1999) contains the following conclusion:

> The NIEHS concludes that ELF-EMF (extremely low frequency-electromagnetic field) exposure cannot be recognized as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard. In our opinion, this finding is insufficient to warrant aggressive regulatory concern. However, because virtually everyone in the United States uses electricity and therefore is routinely exposed to ELF-EMF, passive regulatory action is warranted such as continued emphasis on educating both the public and the regulated community on means aimed at reducing exposures. The NIEHS does not believe that other cancers or non-cancer health outcomes provide sufficient evidence of a risk to currently warrant concern.

This statement is not sufficient to cause the NRC staff to change its position with respect to the chronic effects of electromagnetic fields, as described below (10 CFR 51 Footnote 5 to Table B-1):

> If in the future, the Commission finds that, contrary to current indications, a consensus has been reached by appropriate Federal health agencies that there are adverse health effects from electromagnetic fields, the Commission will require applicants to submit plant-specific reviews of these health effects as part of their license renewal applications. Until such time, applicants for license renewal are not required to submit information on this issue.

The NRC staff considers the GEIS finding of "uncertain" still appropriate and will continue to follow developments on this issue.

4.10 Socioeconomics

The socioeconomic issues applicable to Seabrook are shown in Table 4–20 for Category 1 and Category 2 issues. Section 2.2.9 of this SEIS describes the socioeconomic conditions near Seabrook.

Table 4–20. Socioeconomics During the Renewal Term

Issues	GEIS section(s)	Category
Housing impacts	4.7.1	2
Public services: public safety, social services, & tourism & recreation	4.7.3; 4.7.3.3; 4.7.3.4; 4.7.3.6	1
Public services: public utilities	4.7.3.5	2
Public services: education (license renewal term)	4.7.3.1	1
Offsite land use (license renewal term)	4.7.4	2
Public services: transportation	4.7.3.2	2
Historic & archaeological resources	4.7.7	2
Aesthetic impacts (license renewal term)	4.7.6	1
Aesthetic impacts of transmission lines (license renewal term)	4.5.8	1
Environmental justice (minority & low-income populations)	4.10[a]	2[a]

[a] NRC 2013a, 2013b

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

4.10.1 Generic Socioeconomic Issues

The Seabrook ER (NextEra 2010), scoping comments, and other available data records for Seabrook were reviewed and evaluated for new and significant information. The review included a data-gathering site visit to Seabrook. No new and significant information was identified during this review that would change the conclusions presented in the GEIS. Therefore, for these Category 1 issues, impacts during the renewal term are not expected to exceed those discussed in the GEIS. For Seabrook, the NRC incorporates the GEIS conclusions by reference. Impacts for Category 2 issues are discussed in Sections 4.10.2–4.10.7.

4.10.2 Housing Impacts

Appendix C of the GEIS presents a population characterization method based on two factors, sparseness and proximity (GEIS, Section C.1.4). Sparseness measures population density within 20 mi (32 km) of the site, and proximity measures population density and city size within 50 mi (80 km). Each factor has categories of density and size (GEIS, Table C.1). A matrix is used to rank the population category as low, medium, or high (GEIS, Figure C.1).

According to the 2000 Census, an estimated 448,637 people lived within 20 mi (32 km) of Seabrook, which equates to a population density of 535 persons per square mile (mi^2) (NextEra 2010). This translates to a Category 4, "least sparse," population density using the GEIS measure of sparseness (greater than or equal to 120 persons per mi^2 within 20 mi). An estimated 4,157,215 people live within 50 mi (80 km) of Seabrook, with a population density of 887 persons per mi^2 (NextEra 2010). Applying the GEIS proximity measures, Seabrook is classified as proximity Category 4 (greater than or equal to 190 persons per mi^2 within 50 mi). Therefore, according to the sparseness and proximity matrix presented in the GEIS, rankings of sparseness Category 4 and proximity Category 4 result in the conclusion that Seabrook is located in a high-population area.

Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, states that impacts on housing availability are expected to be of small significance in a medium or high-density population area where growth-control measures are not in effect. Since Seabrook is located in a high-population area, and Rockingham County and Strafford County are not subject to growth-control measures that would limit housing development, any changes in employment at Seabrook would have little noticeable effect on housing availability in these counties. Since NextEra has no plans to add non-outage employees during the license renewal period, employment levels at Seabrook would remain relatively constant with no additional demand for permanent housing during the license renewal term. Based on this information, there would be no additional impact on housing during the license renewal term beyond what has already been experienced.

4.10.3 Public Services—Public Utility Impacts

Impacts on public utility services (e.g., water, sewer) are considered SMALL if the public utility has the ability to respond to changes in demand and would have no need to add or modify facilities. Impacts are considered MODERATE if service capabilities are overtaxed during periods of peak demand. Impacts are considered LARGE if additional system capacity is needed to meet ongoing demand.

Analysis of impacts on the public water systems considered both plant demand and plant-related population growth. Section 2.1.7 describes the permitted withdrawal rate and actual use of water for reactor cooling at Seabrook.

Since NextEra has no plans to add non-outage employees during the license renewal period, employment levels at Seabrook would remain relatively unchanged with no additional demand for public water services. Public water systems in the region are adequate to meet the demands of residential and industrial customers in the area. Therefore, there would be no additional impact to public water services during the license renewal term beyond what is currently being experienced.

4.10.4 Offsite Land Use—License Renewal Period

Offsite land use during the license renewal term is a Category 2 issue (10 CFR Part 51, Subpart A, Appendix B, Table B-1). Table B-1 notes that “significant changes in land use may be associated with population and tax revenue changes resulting from license renewal.” Section 4.7.4 of the GEIS defines the magnitude of land-use changes as a result of plant operation during the license renewal term as SMALL when there will be little new development and minimal changes to an area's land-use pattern. It is defined as MODERATE when there will be considerable new development and some changes to the land-use pattern. It is defined as LARGE when there will be large-scale new development and major changes in the land-use pattern.

Tax revenue can affect land use because it enables local jurisdictions to provide the public services (e.g., transportation and utilities) necessary to support development. Section 4.7.4.1 of the GEIS states that the assessment of tax-driven land-use impacts during the license renewal term should consider the size of the plant's tax payments relative to the community's total revenues, the nature of the community's existing land-use pattern, and the extent to which the community already has public services in place to support and guide development. If the plant's tax payments are projected to be small relative to the community's total revenue, tax driven land-use changes during the plant's license renewal term would be SMALL, especially where the community has pre-established patterns of development and has provided public services to support and guide development. Section 4.7.2.1 of the GEIS states that if tax payments by the plant owner are less than 10 percent of the taxing jurisdiction's revenue, the significance level

would be SMALL. If tax payments are 10–20 percent of the community's total revenue, new tax-driven land-use changes would be MODERATE. If tax payments are greater than 20 percent of the community's total revenue, new tax-driven land-use changes would be LARGE. This would be especially true where the community has no pre-established pattern of development or has not provided adequate public services to support and guide development.

4.10.4.1 Population-Related Impacts

Since NextEra has no plans to add non-outage employees during the license renewal period, there would be no plant operations-driven population increase in the vicinity of Seabrook. Therefore, there would be no additional population-related offsite land use impacts during the license renewal term beyond those already being experienced.

4.10.4.2 Tax Revenue-Related Impacts

As discussed in Chapter 2, NextEra pays annual real estate taxes to six towns and the State of New Hampshire, including the Town of Seabrook and the New Hampshire Education Trust Fund. Since NextEra started making payments to local jurisdictions, population levels and land use conditions in both Rockingham County and Strafford County have changed, although there is no evidence that these tax revenues have had any effect on land use activities within the two counties. For the 5-year period from 2004–2008, tax payments to the Town of Seabrook represented between 34–49 percent of the net tax commitment, while payments to the New Hampshire Education Trust Fund were between 1.2–2.0 percent of revenues.

Since NextEra has no plans to add non-outage employees during the license renewal period, employment levels at Seabrook would remain relatively unchanged. There would be no increase in the assessed value of Seabrook, and annual property tax payments would also remain relatively unchanged throughout the license renewal period. Based on this information, there would be no additional tax-revenue-related offsite land use impacts during the license renewal term beyond those already being experienced.

4.10.5 Public Services—Transportation Impacts

Table B-1 of Appendix B to Subpart A of 10 CFR Part 51 states the following:

> Transportation impacts (level of service) of highway traffic generated...during the term of the renewed license are generally expected to be of SMALL significance. However, the increase in traffic associated with additional workers and the local road and traffic control conditions may lead to impacts of MODERATE or LARGE significance at some sites.

The regulation in 10 CFR 51.53(c)(3)(ii)(J) requires all applicants to assess the impacts of highway traffic generated by the proposed project on the level of service (LOS) of local highways during the term of the renewed license. Since NextEra has no plans to add non-outage employees during the license renewal period, traffic volume and LOS on roadways in the vicinity of Seabrook would not change. Therefore, there would be no transportation impacts during the license renewal term beyond those already being experienced.

4.10.6 Historic and Archaeological Resources

The National Historic Preservation Act (NHPA) requires Federal agencies to take into account the potential effects of their undertakings on historic properties. Historic properties are defined as resources that are eligible for listing on the National Register of Historic Places. The criteria for eligibility include the following (ACHP 2010):

- association with significant events in history;
- association with the lives of persons significant in the past embodiment of distinctive characteristics of type, period, or construction; and
- association with or potential to yield important information on history or prehistory.

The historic preservation review process, mandated by Section 106 of the NHPA, is outlined in regulations issued by the Advisory Council on Historic Preservation in 36 CFR Part 800. The issuance of a renewed operating license for a nuclear power plant is a Federal undertaking that could possibly affect either known or potential historic properties located on or near the plant and its associated transmission lines. In accordance with the provisions of the NHPA, the NRC is required to make a reasonable effort to identify historic properties in the area of potential effect. If no historic properties are present or affected, the NRC is required to notify the State Historic Preservation Officer (SHPO) before proceeding. If it is determined that historic properties are present, the NRC is required to assess and resolve possible adverse effects of the undertaking.

The NRC contacted the New Hampshire SHPO concerning the proposed action (license renewal of Seabrook) (NRC 2010b). The NRC also sent letters to the Wampanoag Tribe of Gay Head-Aquinnah, the Abenaki Nation of New Hampshire, the Abenaki Nation of Missisquoi St. Franci/Sokoki Band, and the Cowasuck Band of Pennacook-Abenaki People notifying them of the proposed action and requesting comments and concerns (NRC 2010a). In a letter dated July 27, 2010, the New Hampshire SHPO acknowledged the NRC staff's letter (NHDHR 2010). To date, the tribes have not responded.

The area of potential effect for the Seabrook license renewal review is the property owned by NextEra for Seabrook. The protected area is the area of greatest activity that could potentially affect historic and archaeological resources. As discussed in Section 2.2.10, there are seven known historic and archaeological resources on the Seabrook property. No resources are known to exist within the area of potential effect. Most resources are located well away from the protected area. However, two archaeological sites, 27RK452 and 27RK453, are in the general vicinity of the protected area. Both of these sites contain prehistoric era resources, including the remains of fishing stations and habitation sites. The protected area perimeter fence runs through a portion of 27RK453, and 27RK452 is close by. A recent archaeological survey study conducted on the Seabrook property found there is a very high potential for additional resources to be found on the property (Valimont 2010). The archaeological study identified additional areas that would need to be surveyed prior to any ground-disturbing activity. Currently, NextEra has no planned activities in or near these areas (NextEra 2010).

Given the high potential for additional historic archaeological resources to be discovered, NextEra has developed plant procedures that take these resources into consideration. NextEra maintains an Environmental Compliance Manual, which identifies the procedures for considering environmental factors during plant maintenance and operations activities. A component of the manual is a dig safe procedure, which controls any ground disturbing activities. These activities represent the greatest risk to historic and archaeological resources. The dig safe procedure also incorporates the Cultural Resources Protection Plan. This plan ensures that a review of existing historic and archaeological information is completed prior to initiating any ground disturbing activities outside of the protected area. In the event that a known historic and archaeological resource is in the vicinity of planned ground-disturbing activities, the New Hampshire SHPO will be contacted to determine the appropriate measures needed to minimize or avoid any impacts to historic and archaeological resources.

Based on a review of New Hampshire SHPO files for the region, published literature, and information provided by NextEra, the NRC concludes that potential impacts from license renewal of Seabrook on historic and archaeological resources would be SMALL. This conclusion is based on a review of past surveys, the fact that most resources are located away from plant maintenance and operations activities in the protected area, and the Seabrook Cultural Resources Protection Plan and environmental protection procedures.

4.10.7 Environmental Justice

As described in Section 1.4 of this SEIS, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to environmental justice concerns, the final rule amends Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51 by adding a new Category 2 issue, "Minority and low-income populations," to evaluate the impacts of continued operations and any refurbishment activities during the license renewal term on minority and low-income populations living in the vicinity of the plant. The environmental justice issue listed in Table B-1 was uncategorized prior to this final rule since guidance for conducting an environmental justice impact analysis was not available prior to the completion of the 1996 GEIS. The finding stated that this issue will be addressed in plant-specific reviews.

Under Executive Order (EO) 12898 (59 FR 7629), Federal agencies are responsible for identifying and addressing, as appropriate, disproportionately high and adverse human health and environmental impacts on minority and low-income populations. In 2004, the NRC issued a *Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions* (69 FR 52040), which states, "The Commission is committed to the general goals set forth in EO 12898, and strives to meet those goals as part of its [National Environmental Policy Act] NEPA review process."

The Council on Environmental Quality (CEQ) provides the following information in *Environmental Justice: Guidance Under the National Environmental Policy Act* (CEQ 1997b):

> **Disproportionately High and Adverse Human Health Effects.**
>
> Adverse health effects are measured in risks and rates that could result in latent cancer fatalities, as well as other fatal or nonfatal adverse impacts on human health. Adverse health effects may include bodily impairment, infirmity, illness, or death. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant (as employed by NEPA) and appreciably exceeds the risk or exposure rate for the general population or for another appropriate comparison group (CEQ 1997b).
>
> **Disproportionately High and Adverse Environmental Effects.**
>
> A disproportionately high environmental impact that is significant (as employed by NEPA) refers to an impact or risk of an impact on the natural or physical environment in a low-income or minority community that appreciably exceeds the environmental impact on the larger community. Such effects may include ecological, cultural, human health, economic, or social impacts. An adverse environmental impact is an impact that is determined to be both harmful and significant (as employed by NEPA). In assessing cultural and aesthetic environmental impacts, impacts that uniquely affect geographically dislocated or dispersed minority or low-income populations or American Indian tribes are considered (CEQ 1997b).

The environmental justice analysis assesses the potential for disproportionately high and adverse human health or environmental effects on minority and low-income populations that

could result from the operation of Seabrook during the renewal term. In assessing the impacts, the following definitions of minority individuals and populations and low-income population were used (CEQ 1997b):

> Minority individuals. Individuals who identify themselves as members of the following population groups: Hispanic or Latino, American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, or two or more races, meaning individuals who identified themselves on a Census form as being a member of two or more races, for example, Hispanic and Asian.
>
> Minority populations. Minority populations are identified when (1) the minority population of an affected area exceeds 50 percent or (2) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.
>
> Low-income population. Low-income populations in an affected area are identified with the annual statistical poverty thresholds from the Census Bureau's Current Population Reports, Series P60, on Income and Poverty.

4.10.7.1 Minority Population

According to 2000 Census data, 18.6 percent of the population (approximately 4,148,000 persons) residing within a 50-mi (80-km) radius of Seabrook identified themselves as minority individuals. The largest minority group was Hispanic or Latino (approximately 270,000 persons or 6.5 percent), followed by Black or African American (approximately 268,000 persons or 6.5 percent) (USCB 2003).

Of the approximately 3,282 census block groups located within the 50-mi (80-km) radius of Seabrook, 612 block groups were determined to have minority race population percentages that exceeded the comparison area (State average) by 20 percent or more. Persons identifying themselves as Hispanic or Latino ethnicity comprised the largest minority race population with 219 block groups. There were 217 block groups where individuals identifying themselves as Black exceeded the comparison area average by 20 percent or more. An additional 107 block groups exceeded the comparison area average by 20 percent or more for individuals identifying themselves as Some Other Race. Block groups with minority populations are concentrated primarily in the Boston Metropolitan Area, with smaller concentrations in Lowell, Methuen, and Fitchburg/Leominster (all in Massachusetts). The minority population nearest to Seabrook is located in Haverhill, MA.

According to American Community Survey 2009 estimates, minority populations in the 2-county region (Rockingham and Strafford) increased by approximately 9,500 persons and comprised 6.0 percent of the total 2-county population (see Table 2.2-13). Most of this increase was due to an estimated increase of Hispanic or Latinos (over 4,100 persons), an increase in population of 91.9 percent from 2000. The next largest increase in minority population was Asian, an estimated additional 2,400 persons or an increase of 52.1 percent from 2000, followed by Black or African American, an estimated 1,100 persons or an increase of 49.9 percent from 2000 (USCB 2011).

Based on 2000 Census data, Figure 4–1 shows minority block groups within a 50-mi (80-km) radius of Seabrook.

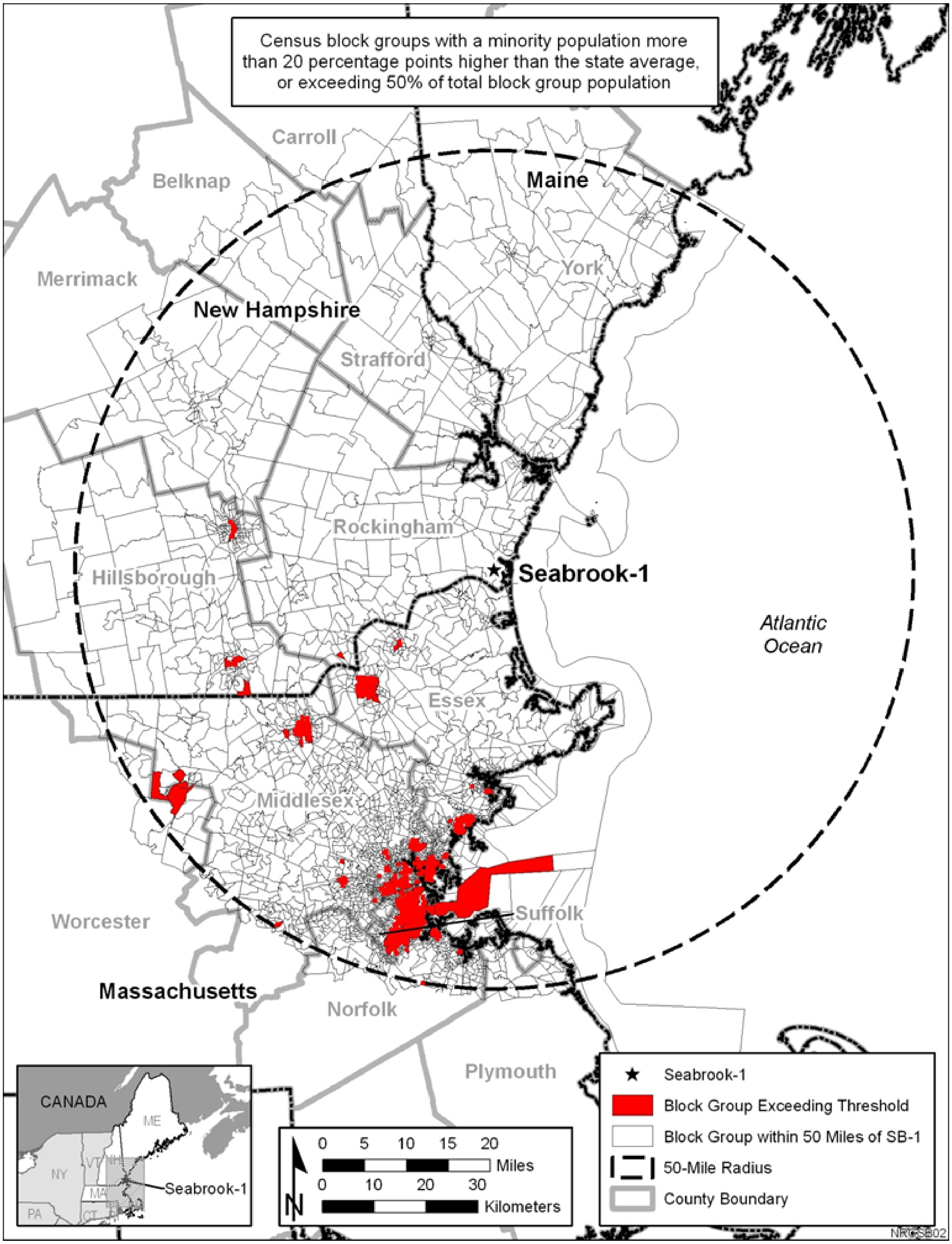
4.10.7.2 Low-Income Population

According to 2000 Census data, approximately 62,000 families (6.1 percent) and 356,000 individuals (8.6 percent) residing within a 50-mi (80-km) radius of Seabrook were identified as living below the Federal poverty threshold in 1999 (USCB 2003). (The 1999 Federal poverty threshold was $17,029 for a family of four). According to the 2000 Census, 7.3 percent of families and 12.6 percent of individuals in Maine, 7.3 percent of families and 10.0 percent of individuals in Massachusetts, and 7.9 percent of families and 7.6 percent of individuals in New Hampshire were living below the Federal poverty threshold in 1999 (USCB 2010).

Census block groups were considered low-income block groups if the percentage of individuals living below the Federal poverty threshold exceeded the comparison area (State average) by 20 percent or more. Based on 2000 Census data, there were 180 block groups within a 50-mi (80-km) radius of Seabrook that could be considered low-income block groups. The majority of low-income population census block groups were located in the Boston Metropolitan area, with smaller concentrations in Portsmouth, Durham, and Manchester (all in New Hampshire), and in Lowell, Methuen, and Fitchburg/Leominster (all in Massachusetts).

According to American Community Survey 2009 estimates, the median household income for New Hampshire was $60,567, with 8.5 percent of the State population and 5.5 percent of families living below the Federal poverty threshold. Strafford County had a slightly lower median household income average ($56,463) and higher percentages of individuals (9.2 percent) and a slightly lower percentage of families (5.2 percent) living below the poverty level when compared to the State average. Rockingham County had the highest median household income between the two counties ($70,160) and lowest percentages of individuals (6.0 percent) and families (4.0 percent) living below the poverty level when compared to Strafford County and the State (USCB 2011).

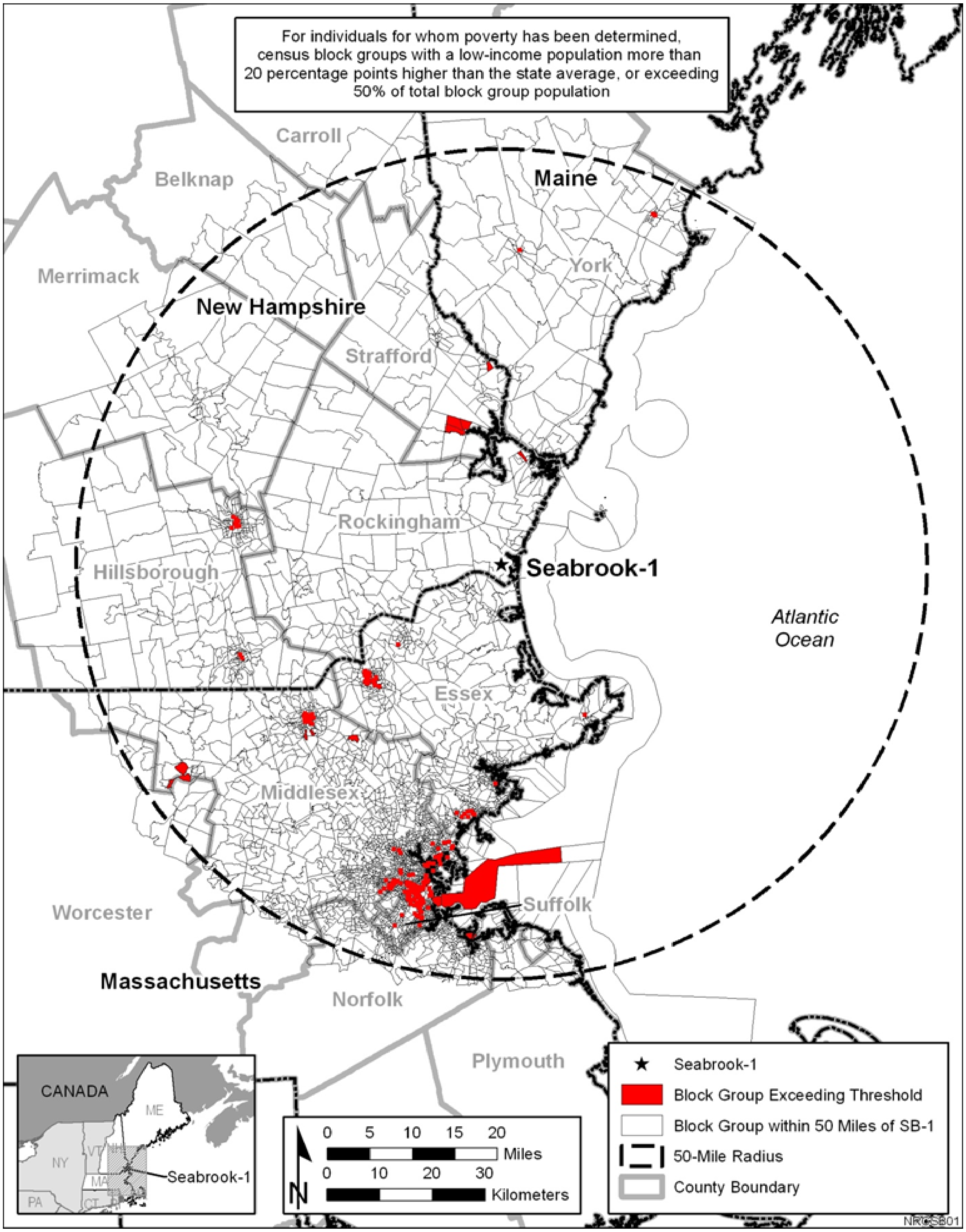
Figure 4–1. Census 2000 Minority Block Groups Within a 50-mi Radius of Seabrook



Source: (NextEra 2010)

Figure 4–2 shows low-income census block groups within a 50-mi (80-km) radius of Seabrook.

Figure 4–2. Census 2000 Low-Income Block Groups Within a 50-mi Radius of Seabrook



Source: (NextEra 2010)

4.10.7.3 Analysis of Impacts

The NRC addresses environmental justice matters for license renewal through identifying minority and low-income populations that may be affected by the proposed license renewal and examining any potential human health or environmental effects on these populations to determine if these effects may be disproportionately high and adverse.

The discussion and figures above identify the minority and low-income populations residing within a 50-mi (80-km) radius of Seabrook. This area of impact is consistent with the impact analysis for public and occupational health and safety, which also focuses on populations within a 50-mi (80-km) radius of the plant. As previously discussed, for the other resource areas in Chapter 4, the analyses of impacts for all environmental resource areas indicated that the impact from license renewal would be SMALL, except for the impact on aquatic resources, which would be SMALL to LARGE.

Potential impacts to minority and low-income populations would mostly consist of radiological effects; however, radiation doses from continued operations associated with this license renewal are expected to continue at current levels and would remain within regulatory limits. Chapter 5 of this SEIS discusses the environmental impacts from postulated accidents that might occur during the license renewal term, which include design basis accidents. The NRC has generically determined that impacts associated with such accidents are SMALL because the plant was designed to successfully withstand design basis accidents.

Therefore, based on this information and the analysis of human health and environmental impacts presented in Chapters 4 and 5, it is not likely there would be any disproportionately high and adverse impacts to minority and low-income populations from the continued operation of Seabrook during the license renewal term.

As part of addressing environmental justice concerns associated with license renewal, the NRC assessed the potential radiological risk to special population groups from exposure to radioactive material received through their unique consumption and interaction with the environment patterns. These included subsistence consumption of fish, native vegetation, surface waters, sediments, and local produce; absorption of contaminants in sediments through the skin; and inhalation of airborne radioactive material released from the plant during routine operation. This analysis is presented below.

4.10.7.4 Subsistence Consumption of Fish and Wildlife

The special pathway receptors analysis is important to the environmental justice analysis because consumption patterns may reflect the traditional or cultural practices of minority and low-income populations in the area.

Section 4-4 of EO 12898 (1994) directs Federal agencies, whenever practical and appropriate, to collect and analyze information on the consumption patterns of populations that rely principally on fish or wildlife or both for subsistence and to communicate the risks of these consumption patterns to the public. In this SEIS, NRC considered whether there were any means for minority or low-income populations to be disproportionately affected by examining impacts to American Indian, Hispanic, and other traditional lifestyle special pathway receptors. Special pathways that took into account the levels of contaminants in native vegetation, crops, soils and sediments, surface water, fish, and game animals on or near Seabrook were considered.

The following is a summary discussion of the NRC's evaluation from Section 4.9.1.3 of the REMPs that assess the potential impacts for subsistence consumption of fish and wildlife near the Seabrook site.

NextEra has an ongoing comprehensive REMP at Seabrook to assess the impact of site operations on the environment. To assess the impact of the nuclear power station on the environment, samples of environmental media are collected and analyzed for radioactivity. Two types of samples are taken. The first type, control samples, is collected from areas that are beyond measurable influence of the nuclear plant. These samples are used as reference data. Normal background radiation levels, or radiation present due to causes other than nuclear power generation, can be compared to the environment surrounding the nuclear plant. Indicator samples are the second sample type obtained. These samples show how much radiation or radioactivity is contributed to the environment by the nuclear power plant. Indicator samples are taken from areas close to the station where any contribution will be at the highest concentration. An effect would be indicated if the radioactive material detected in an indicator sample was significantly larger than the background level or control sample.

Samples of environmental media are collected from the aquatic and terrestrial pathways in the vicinity of Seabrook. The aquatic pathways include surface (ocean) water, fish and shellfish (including mussels and lobsters), drinking water supply, shallow well water, sea algae (Irish moss), and sediment. The terrestrial pathways include airborne particulates, milk, food products (green beans and tomatoes), and leafy vegetation. During 2009, analyses performed on samples of environmental media showed no significant or measurable radiological impact above background levels from site operations (NextEra 2010).

Conclusion

Based on the radiological environmental monitoring data from Seabrook, the NRC finds that no disproportionately high and adverse human health impacts would be expected in special pathway receptor populations in the region as a result of subsistence consumption of water, local food, fish, and wildlife.

4.11 Evaluation of New and Potentially-Significant Information

NextEra reported in its ER (NextEra 2010) that it is aware of one potentially new issue related to its license renewal application—elevated tritium concentrations in groundwater adjacent to Unit 1. In September 1999, NextEra discovered elevated tritium levels in groundwater that was seeping into the Unit 1 containment annulus. After investigation, the source of the tritium was found to be a leak from the cask loading area and transfer canal, which is connected to the SFP. Upon initial discovery, the tritiated water leak had a rate of approximately 0.1 gallons per day (gpd) (0.38 liters (L) per day (L/day)). The leak rate increased over the next 2 years to between 30–40 gpd (110–150 L/day) after the fuel storage building drain collection lines were cleaned and restored.

Tritium concentrations in the primary auxiliary building (PAB) were reported at up to 84,000 pCi/L in 2000. In the CEVA, concentrations were reported up to 3,560,000 pCi/L in 2003. Once a non-metallic liner was applied to the stainless steel liner in the cask loading area and transfer canal in 2004, tritium concentrations in both of these locations dropped significantly, with average tritium levels in 2009 recorded at 4,525 pCi/L in the PAB and 4,745 pCi/L in the containment enclosure area. From 2004–2009, tritium levels in the onsite surficial aquifer were recorded ranging from 617–2,930 pCi/L, all well below the EPA's drinking water standard of 20,000 pCi/L (NextEra 2010a). Based on 2011 monitoring data, the highest

tritium concentrations were found in one shallow (surficial) aquifer well (SW-1), ranging from 1,936 to a maximum of 2,850 pCi/L (NextEra 2012a).

NextEra installed dewatering systems in the fuel building, PAB, and containment area of Unit 1 as part of the tritium mitigation. The Unit 1 groundwater withdrawal system provides the hydraulic containment of the tritium, as well as an additional 32,000 gpd (120 m^3) of groundwater being pumped from the incomplete Unit 2 containment building, which acts to reverse the hydraulic gradient along the southern boundary of the site and slow the flow of groundwater offsite. No offsite migration of tritium in groundwater has been observed.

The applicant reported that groundwater is no longer used at Seabrook, as further discussed in Section 2.1.7.2. To track the progress of the dewatering program, 27 monitoring wells have been installed onsite as part of the plant's Groundwater Monitoring Program. NextEra has indicated that there are no plans to use its former supply wells in the future in any capacity, and it monitors the wells to provide annual updates to the State of New Hampshire Public Utilities Commission (NextEra 2010a).

The Town of Seabrook's 10 freshwater supply wells are located hydraulically upgradient from Seabrook and at least 2 mi (3.2 km) west of the site. Potential releases of tritiated water from the plant cannot lead to drinking water sources due to the site's hydrogeologic characteristics. Thus, the applicant's analysis concluded that there is no human exposure pathway; therefore, the tritium in groundwater at the site does not present a threat to public or occupational health or safety (NextEra 2010a).

The NRC staff agrees with NextEra's position that there are no significant impacts associated with tritium in the groundwater at Seabrook. This conclusion is supported by the following information. As discussed in Section 2.2.5, while tritium continues to be detected above background at several onsite locations, the applicant is actively controlling the groundwater with relatively high tritium concentrations. Dewatering operations pump out the groundwater to create a cone of depression that provides hydraulic containment of tritium-impacted groundwater. The tritium-impacted groundwater is sent to the facility's main outfall to the ocean, where it is released in compliance with NPDES and NRC's radiological limits. Tritium concentrations in groundwater, as measured in onsite l monitoring wells, have remained well below EPA's 20,000 pCi/L drinking water standard, and are not expected to impact human or biota receptors. The nearest groundwater users are over 3,000 ft (910 m) from the plant site and are upgradient, as the groundwater flow path beneath the plant site is generally to the east and southeast toward the tidal marsh. The applicant's REMP will monitor the groundwater and continue to report the results in its annual radiological environmental monitoring report. Also, NRC inspectors will periodically review the REMP data for compliance with NRC radiation protection standards.

4.12 Cumulative Impacts

As described in Section 1.4 of this SEIS, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to cumulative impacts, the final rule amends Table B-1 in Appendix B, Subpart A, to 10 CFR Part 51 by adding a new Category 2 issue, "Cumulative impacts," to evaluate the potential cumulative impacts of license renewal.

The NRC staff considered potential cumulative impacts in the environmental analysis of continued operation of Seabrook during the period of extended operations. Cumulative impacts may result when the environmental effects associated with the proposed action are overlaid or added to temporary or permanent effects associated with other past, present, and reasonably foreseeable actions. Cumulative impacts can result from individually minor, but collectively

significant, actions taking place over a period of time. It is possible that an impact that may be SMALL by itself could result in a MODERATE or LARGE cumulative impact when considered in combination with the impacts of other actions on the affected resource. Likewise, if a resource is regionally declining or imperiled, even a SMALL individual impact could be important if it contributes to or accelerates the overall resource decline.

For the purposes of this cumulative analysis, past actions are those prior to the receipt of the license renewal application. Present actions are those related to the resources at the time of current operation of the power plant, and future actions are those that are reasonably foreseeable through the end of plant operation including the period of extended operation. Therefore, the analysis considers potential impacts through the end of the current license terms as well as the 20-year renewal license term. The geographic area over which past, present, and reasonably foreseeable actions would occur is dependent on the type of action considered and is described below for each resource area.

To evaluate cumulative impacts, the incremental impacts of the proposed action, as described in Sections 4.1–4.10, are combined with other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such actions. The NRC staff used the information provided in the ER; responses to RAIs; information from other Federal, State, and local agencies; scoping comments; and information gathered during the visits to the Seabrook site to identify other past, present, and reasonably foreseeable actions. To be considered in the cumulative analysis, the NRC staff determined if the project would occur within the identified geographic areas of interest and within the period of extended operation, if it was reasonably foreseeable, and if there would be potential overlapping effect with the proposed project. For past actions, consideration within the cumulative impacts assessment is resource and project-specific. In general, the effects of past actions are included in the description of the affected environment in Chapter 2, which serves as the baseline for the cumulative impacts analysis. However, past actions that continue to have an overlapping effect on a resource potentially affected by the proposed action are considered in the cumulative analysis.

4.12.1 Cumulative Impacts on Water Resources

Because the station relies on ocean water for cooling purposes, it is not expected to contribute to cumulative impacts on surface water use. The station's discharge from Outfall 001 to the Atlantic Ocean is regulated under its NPDES permit and has not been found to have caused any significant impact on surface water quality.

Groundwater use at the site is limited to the dewatering action at the incomplete Unit 2 and the tritium control dewatering at Unit 1. In combination, this amounts to less than 24 gpm (91 liters per minute (L/min)) of extracted groundwater. The facility purchases an annual average of 80 gpm (300 L/min) of municipal water from a wellfield located over 2 mi (3.2 km) from the plant site. While the overall regional demand for groundwater is expected to grow, the station's water needs are expected to remain steady. Additionally, the station's usage constitutes 14 percent of the Town of Seabrook's total public water demands, and the station's usage is considered in the Town of Seabrook's permitted withdrawals to ensure supply availability (NextEra 2010).

As discussed in Section 2.2.2, the effects of global climate change are already being felt in the northeastern U.S. From 1982 to 2006, sea surface temperatures in coastal waters of the Northeast warmed almost twice the global rate. The rise in ocean temperatures is projected to persist into the future. Warmer average ocean waters would result in increased water usage for cooling systems and would increase thermal discharges to receiving waters. Sea level has

risen by 1 ft. (0.3 m) since 1900 in the Northeast, a rate that exceeds the global average of 0.67 ft. (0.20 m) (USGCRP 2014). Changes in sea level, at any one coastal location, depend not only on the increase in the global average sea level but on various regional geomorphic, meteorological, and hydrological factors (USGCRP 2009). While there is great uncertainty, global mean sea levels are expected to rise an additional 0.5 to 1 ft. (0.15 to 0.3 m) by 2050 and between 1 to 4 ft. (0.3 to 1.2 m) by the end of this century; sea level rise along the Northeast coast is expected to exceed the global rate due to local land subsidence and is projected to rise 0.7 to 1.7 ft. (0.2 to 0.5 m) by 2050. The intensity, frequency, and duration of North Atlantic hurricanes have increased since the 1980s, and the Northeast region has experienced the largest increase in heavy precipitation events. Hurricane-associated storm intensity and rainfall are projected to increase as well as heavy precipitation events. Sea level rise, increased coastal storm intensity, and heavy precipitation events can result in coastal flooding (USGCRP 2014). At Seabrook, all critical structures are located at a finished grade elevation of 20 ft. (6.1 m) above MSL (FPLE 2008c). Any sea level rise associated with climate change will cause increased upstream saltwater migration and potentially affect fresh water sources. This could lead to fresh water availability and water use conflicts. Furthermore, an increase in the intensity of storms and more frequent heavy downpours will likely cause faster runoff rates and a reduction in overall recharge of groundwater and aquifers. Soil moisture changes as a result of increased temperatures and greater evaporation will further impact the recharge of groundwater aquifers. For these reasons, the impact from climate change could be potentially significant.

Tritium has been under investigation at the site since 1999, and monitoring continues at the Unit 1 dewatering system and at shallow and deep monitoring wells across the site, as detailed in Sections 2.2.5 and 4.11 of this SEIS. Tritium levels above the 20,000 pCi/L EPA standard are limited to one dewatering point near the Unit 1 containment. Unit 2 dewatering provides hydraulic control of locations with above background tritium levels. Methyl tertiary butyl ether (MTBE) levels at the vehicle maintenance area have been declining. No receptors are expected to be impacted by groundwater contamination at the station.

Given the available information about surface water use and quality and groundwater use and quality, the cumulative impact of Seabrook operations on water resources during the license renewal term would be SMALL.

4.12.2 Cumulative Impacts on Air Quality

This section addresses the direct and indirect effects of license renewal on air quality resources when added to the aggregate effects of other past, present, and reasonably foreseeable future actions. In evaluating the potential impacts on air quality associated with license renewal, the NRC staff uses as its baseline the existing air quality conditions described in Section 2.2.2.1 of this SEIS. These baseline conditions encompass the existing air quality conditions (EPA's NAAQS county designations) potentially affected by air emissions from license renewal. As described in Section 2.2.2.1, the Town of Seabrook, which encompasses Seabrook, is designated as a nonattainment area for the 8-hour ozone NAAQS. In addition to local emissions, many of the ozone exceedances in New Hampshire are associated with the transport of ozone and its precursors from the upwind regions by the prevailing winds. The cities of Manchester and Nashua, in neighboring Hillsborough County, are designated as a maintenance area for the carbon monoxide NAAQS.

Currently, Seabrook is operating under a Title V air permit. Annual emissions of criteria pollutants, volatile organic compounds, and hazardous air pollutants at Seabrook vary from year to year but are well below the threshold for a major source (see Table 2.2-1). Rockingham County has experienced frequent exceedances of the 8-hour ozone NAAQS (EPA 2010).

However, as a result of precursor emission controls in upwind regions and New Hampshire, 8-hour ozone concentrations have a downward trend, albeit not a prominent one. Except for ozone, ambient air quality in the Rockingham County is relatively good. As stated by NextEra in the ER (NextEra 2010), and as confirmed by NRC staff, no refurbishment is planned at Seabrook during the license renewal period. Accordingly, air emissions from continued operation of the plant would not be expected to change during the license renewal period.

Operations at Seabrook release greenhouse gas (GHG) emissions, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride (SF_6). Combustion-related GHG emissions (such as CO_2, CH_4, and N_2O) at Seabrook are minor, because Seabrook does not burn fossil fuels to generate electricity. As discussed in Section 2.2.2.1, GHG stationary emission sources at the station include primarily auxiliary boilers, small and large emergency diesel generators, a diesel-powered engine-driven air compressor, and miscellaneous portable equipment. These combustion sources are designed for efficiency and operated using good combustion practices on a limited basis throughout the year (i.e., often only for testing). Other combustion-related GHG emission sources at Seabrook include commuter, visitor, support, and delivery vehicle traffic within, to, and from the plant. In addition, SF_6 is contained in the switchyard breakers and bust ducts at the 345-kV Seabrook transmission substation and is released into the atmosphere during the various stages of the equipment's life cycle. SF_6 is a GHG with a long atmospheric lifetime of 3,200 years, making it the most potent GHG with a global warming potential of 23,900 times that of CO_2. Annual GHG emissions from Seabrook have ranged from approximately 7,893–47,778 tons (7,159–43,336 metric tons) carbon dioxide equivalent (CO_2e), as detailed in Section 2.2.2.1. SF_6 emissions account for a considerable portion of annual total emissions at Seabrook.

Seabrook, through the Florida Power and Light (FPL)-New England Division, is participating in the voluntary SF_6 emissions reduction partnership to reduce GHG emissions from its operations via cost-effective technologies and practices (EPA 1999a). The NHDES Air Resources Division is currently administering the Energy and Climate Change Program. This program includes broad incentive-based efforts, such as energy efficiency and conservation and emission reduction trading programs, to address a range of emissions, especially GHGs, across large geographical areas. In addition, the State of New Hampshire has developed a climate action plan to achieve a long-term reduction in GHG emissions, 25 percent by 2025 and 80 percent by 2050, below 1990 levels—a goal similar to those of many other States (NHDES 2009). To advance the long-term goal and take advantage of the economic opportunity to the State, the plan includes increasing energy efficiency in all sectors, increasing renewable energy sources, and reducing the reliance on automobiles for transportation.

As discussed in Section 2.2.2 of this SEIS, the effects of global climate change are already being felt in the northeastern U.S. The Northeast is projected to face continued warming and more extensive climate-related changes. For the license renewal period of Seabrook (2030-2050), climate models (between 2021-2050 relative to the reference period (1971-1999)) indicate an increase in annual mean temperature for the Northeast Region of 1.5 °F to 3.5 °F (0.83 to 1.94 °C) (NOAA 2013, USGCRP 2014). The predicted increase in temperature during this time period occurs for all seasons with the largest increase occurring in the summertime (June, July, and August). Climate model simulations (for the time period 2021-2050) suggest spatial differences in annual mean precipitation changes for the Northeast; New Hampshire may experience up to a 6 percent increase in precipitation, and winter and spring precipitation will have the greatest increase (NOAA 2013, USGCRP 2014).

Changes in climate can impact air quality as a result of the changes in meteorological conditions. The formation, transport, dispersion, and deposition of air pollutants are sensitive to

winds, temperature, humidity, and precipitation. Sunshine, high temperatures, concentration of precursors and air stagnation are favorable meteorological conditions to higher levels of ozone (USGCRP 2014). The emission of ozone precursors (nitrogen oxides and volatile organic compounds) also depends on temperature, wind, and solar radiation (IPCC 2007). The hottest days in the Northeast have been associated with high concentrations of ozone (Horton et al. 2014). The combination of higher temperatures, stagnant air masses, sunlight, and emissions of precursors may make it difficult to meet ozone National Ambient Air Quality Standards (USGCRP 2009, 2014). Regional air quality modeling indicates that the Northern regions of the U.S. can experience a decrease in ozone concentration by the year 2050 (Tagaris, 2009). However, air quality projections (particularly ozone) are uncertain and indicate that concentrations are driven primarily by emissions rather than by physical climate change (IPCC 2013). States, however, must continue to comply with the Clean Air Act, so it is likely that additional limitations on ozone precursors could help counteract this effect.

As a reference, a brief discussion of the impacts on air quality if fossil-fuel power plant(s) replaced the generating capacity of Seabrook to meet electricity demands in the region is provided below. A more detailed analysis of alternatives and their associated potential impacts are presented in Chapter 8, including a discussion of the power generation technologies and control equipment likely to be used at the time the Seabrook licenses expire.

Nuclear power generation produces less GHG emissions than fossil-fuel power plants, such as coal- or natural gas-fired power plants. GHG emissions at fossil-fuel power plants result primarily from the burning of fossil fuels for power generation.

The amount of CO_2 releases from continued operation of Seabrook can be compared to an equivalent amount of electricity generation from fossil-fuel power plant(s). For 2005, the composite CO_2 emission factor (representing an average of all operating fossil-fuel power plants) is approximately 1,357 pounds per megawatt-hour (lb/MWh) for six New England States (EPA 2011). Seabrook generates approximately 9,816 gigawatt hours (GWh) per year (assuming a power generating capacity of 1245 MWe and a capacity factor of 90 percent). Thus, Seabrook's generating capacity releases approximately 6.6 million tons (6.0 million metric tons) less CO_2. This is approximately 32 percent of the fossil fuel combustion-related CO_2 emissions of 21 million tons (19 million metric tons) for New Hampshire in 2007 (EPA 2011a). This also equals about 0.09 percent of total GHG emissions in the U.S., at 7,668 million tons (6,956.8 million metric tons) CO_2e, in 2008 (EPA 2011b).

Based on all of the above, the NRC staff concludes that combined with the emissions from other past, present, and reasonably foreseeable future actions, cumulative impacts of criteria pollutants (e.g., ozone, particulate matter, carbon monoxide, nitrogen oxides, sulfur dioxides, and lead), and hazardous air pollutants on ambient air quality from operations at Seabrook would be SMALL.

4.12.3 Cumulative Impacts on Aquatic Resources

This section addresses the direct and indirect effects of license renewal on aquatic resources when added to the aggregate effects of other past, present, and reasonably foreseeable future actions. The geographic area considered in the cumulative aquatic resources analysis includes the vicinity of Seabrook, including the offshore intake and discharge structures, the Hampton-Seabrook Estuary, and the rivers that drain into the Hampton-Seabrook Harbor.

The baseline or benchmark for assessing cumulative impacts on aquatic resources takes into account the preoperational environment as recommended by the EPA (1999), for its review of NEPA documents, as follows:

> Designating existing environmental conditions as a benchmark may focus the environmental impact assessment too narrowly, overlooking cumulative impacts of past and present actions or limiting assessment to the proposed action and future actions. For example, if the current environmental condition were to serve as the condition for assessing the impacts of relicensing a dam, the analysis would only identify the marginal environmental changes between the continued operation of the dam and the existing degraded state of the environment. In this hypothetical case, the affected environment has been seriously degraded for more than 50 years with accompanying declines in flows, reductions in fish stocks, habitat loss, and disruption of hydrologic functions. If the assessment took into account the full extent of continued impacts, the significance of the continued operation would more accurately express the state of the environment and thereby better predict the consequences of relicensing the dam.

Sections 2.2.6 and 2.2.8 present an overview of the condition of the Gulf of Maine and the Hampton-Seabrook Estuary and the history and factors that led to its current condition. The direct and indirect impacts from fishing are some of the most influential human activities on the Gulf of Maine ecosystem (Sosebee et al. 2006) (see Section 2.2.6.2). Fishing has resulted in wide-scale changes in fish populations and food web dynamics within the Gulf of Maine (Sosebee et al. 2006; Steneck et al., 1994). In the Hampton-Seabrook Estuary, wetland habitat and water flow has been affected by human uses, such as harvesting salt marsh hay (*Spartina patens*) as feed for livestock in the 1700 and 1800s; digging ditches in an attempt to control mosquito populations in the early 1900s; and building roads, jetties, commercial buildings, and residential areas in the 1900 and 2000s (Eberhardt and Burdick 2009). The increased urbanization in the past 100 years has also led to increased runoff and levels of pollutants within the Hampton-Seabrook Estuary (NHDES 2004). In the rivers connected to Hampton-Seabrook Estuary, dams block fish migrations and have resulted in the precipitous decline of anadromous fish that move to freshwater to spawn and to marine waters to grow and feed (Eberhardt and Burdick 2009).

Many natural and anthropogenic activities can influence the current and future aquatic biota in the area surrounding Seabrook. Potential biological stressors include continued entrainment, impingement and potential heat shock from Seabrook (as described in Section 4.6), fishing mortality, climate change, energy development, and urbanization (as described below).

<u>Fishing</u>. Fishing has been a major influence on the population levels of commercially-sought fish species in the Gulf of Maine (Sosebee, et al. 2006). The Hampton-Seabrook Estuary and the Gulf of Maine support significant commercial and recreational fisheries for many of the fish and invertebrate species also affected by Seabrook operations. EPA (2002a) determined that 69 percent of all entrained and impinged fish species at Seabrook are commercially or recreationally fished. From 1990–2000, Atlantic cod comprised 33 percent of the catch in New Hampshire and 25 percent of the revenue. American lobster comprised 14 percent of the catch by weight in New Hampshire and 40 percent of the revenue (EPA 2002a). Other commercially important species in New Hampshire include spiny dogfish shark, pollock, Atlantic herring, bluefin tuna, American plaice, white hake, yellowtail flounder, and shrimp. Recreationally fished species include American lobster, striped bass, summer flounder, Atlantic cod, scup, and bluefish (EPA 2002a). Many of these species are managed by Federal, regional, and State agencies, although the biomass of many fish stocks have not rebounded to pre-1960s levels (Sosebee 2006). Indirect impacts from fishing include habitat alteration as well as indirect effects that propagate throughout the food web, as described in Section 2.2.6.2.

Some of the most productive soft-shell clam flats in New Hampshire are located in the Hampton-Seabrook Estuary. The area hosts a recreational soft-shell clam fishery, although sections of the fishery have been closed for large periods due to health concerns from high

bacteria loads in the water (NHDES 2004). Clam diggers can directly reduce the clam population by harvesting clams or indirectly by leaving clams behind that are eaten by green crabs, gulls, or other predators and by increasing turbidity and sedimentation while digging and disturbing the estuary bottom. Invasive species, such as green crabs, can also directly affect clam populations since green crabs are a major predator on soft-shell clams (Glude 1955; Ropes 1969).

For these reasons, the NRC staff concludes that fishing pressure has the potential to continue to influence the aquatic ecosystem, especially food webs, and may continue to contribute to cumulative impacts.

Climate Change. The potential cumulative effects of climate change on the Gulf of Maine and Hampton-Seabrook Estuary could result in a variety of changes that would affect aquatic resources. The environmental factors of significance identified by the U.S. Global Change Research Program (USGCRP) (2014) include temperature increases, coastal flooding, and sea level rise. From 1982 to 2006, sea surface temperatures in coastal waters of the Northeast warmed almost twice the global rate (USGCRP 2014). In the Gulf of Maine, sea surface temperature in 1999, 2002, and 2006 were the 4th, 5th, and 6th warmest years, respectively, on the record (Drinkwater et al. 2009). Projections from coarse-scale climate models coupled with finer-scale models suggest that spring sea surface temperatures in the Gulf of Maine may increase by about 2.2 °C (3.9 °F) in the 2080s under the high emission scenario (Frumhoff et al. 2007; NMFS 2011a).

Warming sea temperatures may influence the abundance and distribution of species, as well as earlier spawning times. Since 1968, species in the New England coastal waters have shifted their geographic distribution northward by up to 200 miles (USGCRP 2014). The USGCRP (2014) projects that lobster populations will decline and continue to shift northward in response to warming sea temperatures. Atlantic cod, which were subject to intense fishing pressure and other biological stressors, are likely to be adversely affected by the warmer temperatures since this species inhabits cold waters (USGCRP 2014). USGCRP (2009) projects that the Georges Bank Atlantic cod fishery is likely to be diminished by 2100. NMFS (2009) analyzed fish abundance data from 1968–2007 and determined that the range of several species of fish is moving northward or deeper, likely in response to warming sea temperatures.

Warmer temperatures can also lead to earlier spawning since spawning time is often correlated with a distinct temperature range. Seabrook monitoring studies showed a shift in blue mussel spawning times (NAI 2010). From 1996–2002, and select years from 2002–2009, the greatest blue mussel larval density occurred in mid-April, whereas the greatest blue mussel larval density occurred in late April in the 1970s, 1980s, and early 1990s. Furthermore, rising sea temperatures have been linked to marine-life diseases (USGCRP 2014). Increased disease outbreaks due to increase water temperatures can lead to increased mortality of marine life, which can then further change habitat and species relationships than ultimately affect the ecosystem.

Increased water temperatures from climate change may overlap with the impacts from Seabrook's cooling water system. For example, in the area near the discharge, the combined impacts of the thermal discharge and increase water temperature from climate change could push temperatures above the thermal thresholds of cold-water species (NMFS 2011a).

While there is great uncertainty, sea levels are expected to rise between 0.5 and 1 ft (0.15 to 0.3 m) by 2050 and by 1 to 4 ft (0.3 to 1.2 m) by the end of this century; sea level rise along the Northeast coast is expected to exceed the global rate due to local land subsidence and projected to rise 1.3 to 1.7 ft (0.4 to 0.5 m) by 2050 (USGCRP 2014). Sea level rise could result in dramatic effects to nearshore communities, including the reduction or redistribution of

kelp, eelgrass, and wetland communities. Aquatic vegetation is particularly susceptible to sea level rise since it is immobile and cannot move to shallower areas. In addition, most species grow within a relatively small range of water depth in order to receive sufficient light to photosynthesize while escaping predation.

The ocean absorbs nearly one-third of the CO_2 released into the atmosphere (NOAA 2011). As atmospheric CO_2 increases, there is a concurrent increase in CO_2 levels in the ocean (NOAA 2011). Ocean acidification is the process by which CO_2 is absorbed by the ocean, forming carbonic and carbolic acids that increase the acidity of ocean water. More acidic water can lead to a decrease in calcification (or a softening) of shells for bivalves (e.g., soft shell clams), decreases in growth, and increases in mortality in marine species (Nye 2010, USGCRP 2014). Ocean acidification is projected to continue due to the interaction between ocean water and atmospheric carbon dioxide concentrations (USGCRP 2014).

The extent and magnitude of climate change impacts to the aquatic resources of the Gulf of Maine and the Hampton-Seabrook Estuary are an important component of the cumulative assessment analyses and could be substantial.

Energy Development. As part of a technical workshop held by NOAA, Johnson, et al. (2008) categorized the largest non-fishing impacts to coastal fishery habitats. Johnson, et al. (2008) determined that the largest known and potential future impacts to marine habitats are primarily from the development of energy infrastructure, including petroleum exploration, production and transportation; liquefied natural gas development; offshore wind development; and cables and pipelines in aquatic ecosystems.

Petroleum explorations and offshore wind development can result in habitat conversion and a loss of benthic habitat as developers dig, blast, or fill biologically productive areas. Petroleum and liquefied natural gas development can impact water quality if there are oil spills or discharges of other contaminants during exploration- or transportation-related activities. Underwater cables and pipelines may block fish and other aquatic organisms from migrating to various habitats (Johnson et al. 2008). Thus, there is a variety of ways in which energy development may contribute to cumulative impacts in the future.

Urbanization. The area surrounding the Hampton-Seabrook Estuary experienced increased residential and commercial development in the 1900s, as the seaside town became a popular tourist destination (Eberhardt and Burdick 2009). At the beginning of the 21st century, moderate commercial and residential development surrounds the Hampton-Seabrook Estuary (NHNHB 2009). The town of Hampton's Master Plan calls for continued growth in the area to sustain its attractiveness for tourists (Hampton 2001).

As described in Section 2.2.6.2, increased urbanization has led, and will likely continue to lead, to additional stressors on the Hampton-Seabrook Estuary. Run-off from developed and agricultural areas has increased the concentration of nutrients, bacteria, and other pollutants to the estuary. Sections of the Hampton-Seabrook Estuary are listed on New Hampshire's 303(d) list as being impaired due to high concentrations of bacteria (NHDES 2004). NHDES (2004) also lists the estuary as impaired for fish and shellfish consumption due to polychlorinated biphenyl, dioxin, and mercury concentrations in fish tissue and lobster tomalley. Other activities that may affect marine aquatic resources in Hampton-Seabrook Estuary include periodic maintenance dredging, continued urbanization and development, and construction of new overwater or near-water structures (e.g., docks), and shoreline stabilization measures (e.g., sheet pile walls, rip-rap, or other hard structures).

Future threats to salt marshes in the Hampton-Seabrook Estuary include developmental activities that further hydrological alterations from filling wetlands or other physical changes that

alter the flow of tidal waters (NHNHB 2009; Johnson et al. 2008). Increased nutrients and pollutants in storm runoff are also current threats to the health of this ecosystem (NHNHB 2009). The NRC staff concludes that the direct and indirect impacts from future urbanization are likely to contribute to cumulative impacts in the Hampton-Seabrook Estuary.

Conclusion. The direct impacts to fish populations, from fishing pressure and alterations of aquatic habitat within the Hampton-Seabrook watershed from past activities, have had a significant effect on aquatic resources in the geographic area near Seabrook. These aquatic ecosystems have been noticeably altered, as evidenced by the low population numbers for several commercially-sought fisheries, the change in food web dynamics, habitat alterations, and the blockage of fish passage within the Hampton-Seabrook watershed. The incremental impacts from Seabrook would be SMALL for most species and LARGE for winter flounder and rainbow smelt because operation of Seabrook would have minimal impacts on most species and entrainment, impingement, and monitoring data indicate that Seabrook operations have destabilized the local abundance of winter flounder and rainbow smelt (see Section 4.6). The cumulative stress from the activities described above, spread across the geographic area of interest, depends on many factors that NRC staff cannot quantify but are likely to noticeably alter or destabilize aquatic resources when all stresses on the aquatic communities are assessed cumulatively. Therefore, the NRC staff concludes that the cumulative impacts from the proposed license renewal and other past, present, and reasonably foreseeable projects would be MODERATE for most species and LARGE for winter flounder, rainbow smelt, and other species that would be adversely affected from climate change, such as lobster and Atlantic cod.

4.12.4 Cumulative Impacts on Terrestrial Resources

This section addresses past, present, and future actions that could result in adverse cumulative impacts to terrestrial resources, including wildlife populations, invasive species, protected species, and land use. For purposes of this analysis, the geographic area considered in the evaluation includes the Seabrook site and in-scope transmission line ROWs.

Approximately 109 ac (44 ha) of the 780 ac (320 ha) of land on the Seabrook site are developed and maintained for operation of Seabrook (NextEra 2010). Developed areas with impervious surfaces, such as buildings and parking lots, have increased precipitation runoff and reduced infiltration into the soil, thus reducing groundwater recharge and increasing soil erosion. Before the Seabrook site was constructed, the land was a mixture of mixed hardwood uplands, wetlands, and tidal marsh, similar to the current undeveloped portions of the site.

The transmission lines constructed for the Seabrook site required the clearing of approximately 1,700 ac (690 ha) of land that was previously a combination of developed, residential, forested, open field, and marshland. Subsequent maintenance of the ROWs of the transmission lines for low-growing, shrubby vegetation has resulted in changes to the wildlife and plant species present within the vicinity of these ROWs. Some habitat fragmentation of natural areas may have occurred as a result of initial construction. Habitat fragmentation has likely resulted in increases in invasive species populations, which are typically more aggressive than native species in colonizing disturbed areas. The cumulative effect of ROW maintenance activities, such as mowing, has likely led to localized prevention of the natural successional stages of the surrounding vegetative communities. Oil and fuel from motorized vehicles may have accumulated in certain areas over time. Riparian areas, marshes, and wetlands are especially sensitive to chemical bioaccumulation because they serve as important habitat to wide variety of species, including migratory birds and spawning fish.

Protected terrestrial species, which are discussed in Sections 2.2.8.2 and 4.8.2, are not expected to be adversely affected due to future actions during the renewal term. The numerous marshes and natural areas within the vicinity of the Seabrook site will continue to provide habitat to protected species and other wildlife.

There are no known Federal projects within a 6-mi (10-km) radius of Seabrook. The nearest power generating facility is in Hampton. Foss Manufacturing Company owns a 12-megawatt power plant that burns a combination of natural gas and oil (NextEra 2010). The following additional power generating facilities are located in Rockingham County and create power from burning wood chips, coal and oil, or natural gas (EIA 2008):

- Schiller Station—a 171-megawatt facility near Portsmouth,
- Newington Station—a 414-megawatt facility in Newington,
- Newington Power Facility—a 605-megawatt facility in Newington, and
- Granite Ridge Power Plant—a 900-megawatt facility near Londonberry.

Fossil-fuel power facilities emit GHGs that have been linked to climate change and ozone depletion and other pollutants that result in acid rain, smog, and air pollution.

The East Coast Greenway is a developing trail system that spans nearly 3,000 mi (4,800 km) from Maine to Florida. The trail system makes use of former railway beds, and, within New Hampshire, the trail is proposed to run through the Seabrook site (NextEra 2010). The New Hampshire portion of the Greenway is currently all on road surface but is planned to be moved to entirely off-road trails from the Massachusetts border to Portsmouth (ECGA 2010). The New Hampshire portion would use the already-existing Boston and Maine Railroad corridor, so minimal habitat loss or modification would occur (ECGA 2010). Once completed, the increased bike and foot traffic may alter certain species' behavior and habitat range, but these impacts are not likely to be noticeable.

As discussed in Section 4.12.1, temperature within the Northeast are projected (between 2021-2050) to increase 1.5 °F to 3.5 °F (0.83 to 1.94 °C) and summer months will experience the greatest increase. Annual mean precipitation and the frequency of heavy rainfall events will also increase resulting in wetter conditions in the future for the Northeast (USGCRP 2014). As the climate changes, terrestrial resources will either need to be able to tolerate the new physical conditions or shift their population range to new areas with a more suitable climate. Such changes could favor non-native invasive species and promote the population increases of insect pests and plant pathogens. For instance, it has been found that migratory birds are arriving sooner and bird species and insect species (e.g., hemlock woolly adelgid) have expanded their ranges northward (USGCRP 2014). Climate change may also exacerbate the effects of existing stresses in the natural environment, such as those caused by habitat fragmentation, invasive species, nitrogen deposition and runoff from agriculture, and air. Wetlands are vulnerable to inundation from seal level rise, which is projected to increase in the Northeast 0.7 to 1.7 ft (0.2 to 0.5 m) by the year 2050 (USGCRP 2014). Furthermore, the Northeast region may be susceptible to crop damage from continued increasing intense precipitation events and heat stress (USGCRP 2014).

The NRC staff examined the cumulative effects of the construction of Seabrook, vegetative maintenance, impacts to protected species, climate change impacts, and effects of neighboring facilities. The NRC staff concludes that the minimal terrestrial impacts on the continued Seabrook operations would not contribute to the overall decline in the condition of terrestrial resources. The NRC staff believes that the cumulative impacts of other and future actions

during the term of license renewal on terrestrial habitat and associated species, when added to past, present, and reasonably foreseeable future actions, would be SMALL.

4.12.5 Cumulative Impacts of Human Health

The radiological dose limits, for protection of the public and workers, have been developed by the NRC and EPA to address the cumulative impact of acute and long-term exposure to radiation and radioactive material. These dose limits are codified in 10 CFR Part 20 and 40 CFR Part 190. For the purpose of this analysis, the area within a 50-mi (80.4-km) radius of Seabrook was included. The REMP conducted by NextEra in the vicinity of the Seabrook site measures radiation and radioactive materials from all sources (i.e., hospitals and other licensed users of radioactive material); therefore, the monitoring program measures cumulative radiological impacts. Within the 50-mi (80-km) radius of the Seabrook site, there are no other nuclear power reactors or uranium fuel cycle facilities. There is a U.S. nuclear submarine fleet maintained at Portsmouth Naval Shipyard, 12 mi from Seabrook, which could be a potential source of a radioactive release to the environment. There are 12 hospitals in Rockingham and Essex Counties that could potentially contribute to radiation discharges to potable waters.

Radioactive effluent and environmental monitoring data for the 5-year period from 2005–2009 were reviewed as part of the cumulative impacts assessment. In Section 4.8.1 of this SEIS, the NRC staff concluded that impacts of radiation exposure to the public and workers (occupational) from operation of Seabrook during the renewal term would be SMALL.

The applicant has dry horizontal storage modules for the storage of its radioactive spent fuel. The facility was built to allow for expansion for Seabrook operation through 2050 (NextEra 2010). The installation and monitoring of this facility is governed by NRC requirements in 10 CFR Part 72, Subpart K, "General license for storage of spent fuel at power reactors." Radiation from this facility, as well as from the operation of Seabrook, are required to be within the radiation dose limits in 10 CFR Part 20, 40 CFR Part 190, and 10 CFR Part 72. The NRC performs periodic inspections to verify compliance with its licensing and regulatory requirements.

The NRC and the State of New Hampshire would regulate any future actions near Seabrook that could contribute to cumulative radiological impacts. The environmental monitoring performed by Seabrook would measure the cumulative impact from any future nuclear operations.

For these reasons, the NRC staff concludes that cumulative radiological impacts would be SMALL, as are the contribution to radiological impacts from continued operation of Seabrook and its associated dry fuel storage facility.

For electromagnetic fields, the NRC staff determined that the Seabrook transmission lines are operating within design specifications and meet current NESC criteria; therefore, the transmission lines do not significantly affect the overall potential for electric shock from induced currents within the analyzed area of interest. With respect to the effects of chronic exposure to ELF-EMF, although the GEIS finding of "not applicable" is appropriate to Seabrook, the transmission lines associated with Seabrook are not likely to significantly contribute to the regional exposure to ELF-EMFs. Therefore, the NRC staff has determined that the cumulative impacts of continued operation of the Seabrook transmission lines and other transmission lines in the affected area would be SMALL.

4.12.6 Cumulative Socioeconomic Impacts

Socioeconomics. This section addresses socioeconomic factors that have the potential to be directly or indirectly affected by changes in operations at Seabrook as well as the aggregate effects of other past, present, and reasonably foreseeable future actions. The primary geographic area of interest considered in this cumulative analysis is Rockland and Strafford Counties, where approximately 67 percent of Seabrook employees reside. This area is where the economy, tax base, and infrastructure would most likely be affected since Seabrook employees and their families reside, spend their income, and use their benefits within these counties.

Rapid changes in climate conditions could affect the availability of jobs in certain industries. In 2010, U.S. shoreline counties accounted for 66 million jobs and $3.4 trillion in wages (USGCRP 2014). This economic activity is dependent on the physical and ecological characteristics of the coastal environment. Climate change, including changes in sea temperature and water levels, could affect the unique economic characteristics of coastal areas. As discussed in Section 4.12.3, lobster and cod populations have shifted northward and this has the potential to disrupt New England fisheries (USGCRP 2014). The economic impact of the shift of fish species northward will depend on the ability of the commercial fisheries industry to adapt. For instance, fisheries can follow commercial fish northward or switch to catching new commercial fish species as they enter the area. Furthermore, coastal area economies are also sustained by the income from tourism, recreation, and seaport commerce. Sea level rise, which increases coastal erosion, along the Northeast is projected to rise 0.7 to 1.7 ft. (0.2 to 0.5 m) by 2050; and hurricane rainfall and intensity is also projected to increase (USGCRP 2014). A changing climate resulting in stronger storms, coastal erosion, inundation, and flooding could damage seaports and reduced beach attractiveness.

As discussed in Section 4.10 of this SEIS, continued operation of Seabrook during the license renewal term would have no impact on socioeconomic conditions in the region beyond those already experienced. Since NextEra has no plans to hire additional workers during the license renewal term, overall expenditures and employment levels at Seabrook would remain relatively constant with no additional demand for permanent housing and public services. In addition, since employment levels and tax payments would not change, there would be no population or tax revenue-related land use impacts. Based on this, and other information presented in Chapter 4 of this SEIS, there would be no additional contributory effect on socioeconomic conditions in the region from the continued operation of Seabrook during the license renewal term beyond what is currently being experienced.

Environmental Justice. The environmental justice cumulative impact analysis assesses the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from past, present, and reasonably foreseeable future actions including Seabrook operations during the renewal term. Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant and exceeds the risk or exposure rate for the general population or for another appropriate comparison group. Disproportionately high environmental effects refer to impacts or risk of impacts, on the natural or physical environment in a minority or low-income community, which are significant and appreciably exceed the environmental impact on the larger community. Such effects may include biological, cultural, economic, or social impacts. Some of these potential effects have been identified in resource areas presented in Chapter 4 of this SEIS. As previously discussed in this chapter, the impact from license renewal for all resource

areas (e.g., land, air, water, ecology, and human health) would be SMALL, except in the area of aquatic resources, which would be SMALL to LARGE.

Rapid changes in climate conditions could disproportionately affect minority and low-income populations. More than 120 million Americans live in counties bordering the ocean (USGCRP 2014). Sea level rise has the potential to place communities in coastal areas at risk from storms, coastal erosion, inundation, and flooding. Specifically, minority and low-income communities in coastal areas may be more vulnerable to the impacts of climate change due to an inability to afford property insurance and other protective measures. Sea level rise and inundation of coastal lands could also cause the displacement of minority and low-income communities, resulting in reduced contact and declining community cohesiveness (USGCRP 2014).

As discussed in Section 4.10.7 of this SEIS, there would be no disproportionately high and adverse impacts to minority and low-income populations from the continued operation of Seabrook during the license renewal term. Since NextEra has no plans to hire additional workers during the license renewal term, employment levels at Seabrook would remain relatively constant with no additional demand for housing or increased traffic. Based on this information, and the analysis of human health and environmental impacts presented in Chapters 4 and 5, it is not likely there would be any disproportionately high and adverse contributory effect on minority and low-income populations from the continued operation of Seabrook during the license renewal term.

4.12.7 Historic and Archaeological Resources

Any ground-disturbing activities during the license renewal term could result in the cumulative loss of historic and archaeological resources. Historic and archaeological resources are non-renewable; therefore, the loss of archaeological resources can be cumulative if unique site types are removed. The continued operation of Seabrook during the license renewal term has the potential to impact historic and archaeological resources. The archaeological sites found on the Seabrook site represent the only known Middle Archaic and Woodland Period sites on the New Hampshire coast.

As discussed in Section 4.10.6, continued operation of Seabrook during the license renewal term would have a SMALL impact on historic and archaeological resources. Archaeological sites at Seabrook are located outside of the protected area. Areas that likely contain undiscovered historic and archaeological resources have been identified, and NextEra has established a Cultural Resources Protection Plan to protect historic and archaeological resources at Seabrook.

For the purposes of this cumulative impact assessment, the spatial bounds include the Seabrook site and transmission lines corridors. Cumulative impacts to historic and archaeological resources can result from the incremental loss of unique site types.

For instance, sea level rise could result in flooding, increased erosion, or inundation of shorelines and surrounding areas, potentially impacting historic and cultural resources located there. Some resources could be lost before they could be documented or otherwise studied due to these water-level changes. Increased coastal erosion can result from sea level rise, projected to rise 0.7 to 1.7 ft. (0.2 to 0.5 m) by 2050 along the Northeast coast, as well as an increase in hurricane related rainfall (USGCRP 2014). However, as discussed in section 4.12.1 there is great uncertainty in the extent of sea level changes and projected hurricane activity due to uncertain modeling; some models project increases in hurricane intensity, while others a decrease in hurricane intensity (USGCRP 2014). It is not expected that the limited extent of climate change that may occur during the 20-year license renewal term would result in any

significant loss of historic and cultural resources at Seabrook. NextEra has no plans to alter the station site for license renewal. Any ground-disturbing activities would be considered through the corporate Dig Safe and Cultural Resources Protection Plan procedures. Given that the Seabrook property has the potential for unknown resources, the NRC concludes that, when combined with other past, present, and reasonably foreseeable future ground-disturbing activities, the potential cumulative impacts on historic and archaeological resources would be SMALL.

4.12.8 Summary of Cumulative Impacts

The NRC staff considered the potential impacts resulting from the operation of Seabrook during the period of extended operation and other past, present, and reasonably foreseeable future actions near Seabrook. The determination is that the potential cumulative impacts would range from SMALL to LARGE, depending on the resource. Table 4–21 summarizes the cumulative impact by resource area.

Table 4–21. Summary of Cumulative Impacts on Resources Areas

Resource area	Summary
Air Quality	Impacts of air emissions over the proposed license renewal term would be SMALL. When combined with other past, present, and reasonably foreseeable future activities, impacts to air resources from Seabrook would constitute a SMALL cumulative impact on air quality. In comparison with the alternative of constructing and operating a comparable gas or coal-fired power plant, license renewal would result in a new cumulative deferral in both GHG and other toxic air emissions, which would otherwise be produced by a fossil-fueled plant, with a net beneficial impact on climate change.
Surface Water	Impacts on surface water from continued cooling water withdrawals and effluent discharges over the proposed license renewal term would be SMALL. When combined with other past, present, and reasonably foreseeable future activities, impacts to surface water from Seabrook facilities would constitute a SMALL cumulative impact.
Groundwater	Groundwater consumption constitutes a SMALL cumulative impact on the resource. When this consumption is added to other past, present, and reasonably foreseeable future withdrawals, cumulative impact on groundwater resources is SMALL. Groundwater contamination is below regulatory limits, is confined to the site, and is being actively controlled. Because contamination would be expected to diminish over time and would not foreseeably affect or be used by an offsite user, the cumulative impact on the site's groundwater use and quality would be SMALL.
Aquatic Resources	Fishing pressure and alterations of aquatic habitat within the Hampton-Seabrook Watershed from past activities have had a significant effect on the aquatic ecosystems near Seabrook. These activities are likely to noticeably alter or destabilize aquatic resources when all stresses on the aquatic communities are assessed cumulatively. The cumulative impacts, therefore, would be MODERATE for most species and LARGE for winter flounder, rainbow smelt, and other species that would be adversely affected from climate change, such as lobster and Atlantic cod. The incremental impacts from Seabrook license renewal would be SMALL for most species and LARGE for winter flounder, rainbow smelt and macroalgae.
Terrestrial Resources	Impacts from the continued operation of Seabrook through the license renewal period on terrestrial resources would be SMALL. Combined with other past, present, and future activities at Seabrook, the cumulative impacts on terrestrial resources would be SMALL and would not adversely affect terrestrial resources.
Human Health	The REMP conducted by NextEra in the vicinity of the Seabrook site measures radiation and radioactive materials from all sources (i.e., hospitals and other licensed users of radioactive material); therefore, the monitoring program measures cumulative radiological impacts. In Section 4.10.1 of this SEIS, the NRC staff concluded that impacts of radiation exposure to the public and workers (occupational) from operation of Seabrook during the renewal term would be SMALL. The NRC and the State of New Hampshire would regulate any future actions near Seabrook that could contribute to cumulative radiological impacts; therefore, the cumulative impacts from continued operation of Seabrook would be SMALL.
Socioeconomics	As discussed in Section 4.10 of this SEIS, continued operation of Seabrook during the license renewal term would have no impact on socioeconomic conditions in the region beyond those already experienced. Since NextEra has no plans to hire additional workers during the license renewal term, overall expenditures and employment levels at Seabrook would remain relatively constant. Combined with other past, present, and future activities, there would be no additional contributory effect on socioeconomic conditions in the future from the continued operation of Seabrook during the license renewal period.
Historic & Archaeological Resources	As discussed in Section 4.10.6, continued operation of Seabrook during the license renewal period would have a SMALL impact on historic and archaeological resources. Combined with other past, present, and reasonably foreseeable future ground-disturbing activities, the potential cumulative impacts on historic and archaeological resources would be SMALL.

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5.0 ENVIRONMENTAL IMPACTS OF POSTULATED ACCIDENTS

This chapter describes the environmental impacts from postulated accidents that Seabrook Station (Seabrook) might experience during the period of extended operation. A more detailed discussion of the severe accident mitigation alternative (SAMA) assessment is provided in Appendix F. The term “accident” refers to any unintentional event outside the normal plant operational envelope that results in a release or the potential for release of radioactive materials into the environment. Two classes of postulated accidents are evaluated in the *Generic Environmental Impact Statement (GEIS) for License Renewal of Nuclear Power Plants* prepared by the U.S. Nuclear Regulatory Commission (NRC) (NRC 1996), as listed in Table 5–1. These two classes include the following design-basis accidents (DBAs) and severe accidents.

Table 5–1. Issues Related to Postulated Accidents

Two issues related to postulated accidents are evaluated under the National Environmental Policy Act of 1969 (NEPA) in the license renewal review—DBAs and severe accidents.

Issues	GEIS sections	Category
DBAs	5.3.2; 5.5.1	1
Severe accidents	5.3.3; 5.3.3.2; 5.3.3.3; 5.3.3.4; 5.3.3.5; 5.4; 5.5.2	2

5.1 Design-Basis Accidents

In order to receive NRC approval to operate a nuclear power facility, an applicant for an initial operating license must submit a safety analysis report (SAR) as part of its application. The SAR presents the design criteria and design information for the proposed reactor and comprehensive data on the proposed site. The SAR also discusses various hypothetical accident situations and the safety features that prevent and mitigate accidents. The NRC staff reviews the application to determine if the plant design meets the NRC’s regulations and requirements and includes, in part, the nuclear plant design and its anticipated response to an accident.

DBAs are those accidents that both the applicant and the NRC staff evaluate to ensure that the plant can withstand normal and abnormal transients and a broad spectrum of postulated accidents, without undue hazard to the health and safety of the public. Many of these postulated accidents are not expected to occur during the life of the plant but are evaluated to establish the design basis for the preventative and mitigative safety systems of the facility. Title 10, Part 50, of the *U.S. Code of Federal Regulations* (10 CFR Part 50) and 10 CFR Part 100 describe the acceptance criteria for DBAs.

The environmental impacts of DBAs are evaluated during the initial licensing process, and the ability of the plant to withstand these accidents is demonstrated to be acceptable before issuance of the operating license. The results of these evaluations are found in license documentation such as the applicant’s final safety analysis report, the NRC staff’s safety evaluation report, the final environmental statement, and Section 5.1 of this supplemental environmental impact statement (SEIS). An applicant is required to maintain the acceptable design and performance criteria throughout the life of the plant, including any extended-life operation. The consequences for these events are evaluated for the hypothetical maximum exposed individual. Because of the requirements that continuous acceptability of the consequences and aging management programs be in effect for license renewal, the

environmental impacts, as calculated for DBAs, should not differ significantly from initial licensing assessments over the life of the plant, including the license renewal period. Accordingly, the design of the plant, relative to DBAs during the extended period, is considered to remain acceptable; therefore, the environmental impacts of those accidents were not examined further in the GEIS.

The NRC has determined that the environmental impacts of DBAs are of SMALL significance for all plants because the plants were designed to successfully withstand these accidents. Therefore, for the purposes of license renewal, DBAs are designated as a Category 1 issue in 10 CFR Part 51, Subpart A, Appendix B, Table B-1. The early resolution of the DBAs makes them a part of the current licensing basis (CLB) of the plant. The CLB of the plant is to be maintained by the applicant under its current license; therefore, under the provisions of 10 CFR 54.30, it is not subject to review under license renewal.

No new and significant information related to DBAs was identified during the review of the NextEra Energy Seabrook (NextEra) Environmental Report (ER), the site visit, the scoping process, or the NRC staff's evaluation of other available information. Therefore, there are no impacts related to DBAs beyond those discussed in the GEIS.

5.2 Severe Accidents

Severe nuclear accidents are those that are more severe than DBAs because they could result in substantial damage to the reactor core, whether or not there are serious offsite consequences. In the GEIS, the NRC staff assessed the impacts of severe accidents during the license renewal period, using the results of existing analyses and information from various sites to predict the environmental impacts of severe accidents for plants during the renewal period. Severe accidents initiated by external phenomena—such as tornadoes, floods, earthquakes, fires, and sabotage—have not traditionally been discussed in quantitative terms in the final environmental impact statements and were not specifically considered for the Seabrook site in the GEIS (NRC 1996). The GEIS, however, did evaluate existing impact assessments performed by the NRC staff and by the industry at 44 nuclear plants in the U.S. It segregated all sites into six general categories and then estimated that the risk consequences calculated in existing analyses bound the risks for all other plants within each category. The GEIS further concluded that the risk from beyond design-basis earthquakes at existing nuclear power plants is designated as SMALL. The Commission believes that NEPA does not require the NRC to consider the environmental consequences of hypothetical terrorist attacks on NRC-licensed facilities. However, the NRC staff's GEIS for license renewal contains a discretionary analysis of terrorist acts in connection with license renewal. The conclusion in the GEIS is that the core damage and radiological release from such acts would be no worse than the damage and release to be expected from internally initiated events. In the GEIS, the NRC staff concludes that the risk from sabotage and beyond design-basis earthquakes at existing nuclear power plants is designated as SMALL and that the risks from other external events are adequately addressed by a generic consideration of internally initiated severe accidents (NRC 1996). Based on information in the GEIS, the NRC staff found the following to be true:

> The generic analysis…applies to all plants and that the probability-weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to groundwater, and societal and economic impacts of severe accidents are of small significance for all plants. However, not all plants have performed a site-specific analysis of measures that could mitigate severe accidents. Consequently, severe accidents are a Category 2 issue for plants that have not

performed a site-specific consideration of severe accident mitigation and submitted that analysis for Commission review.

The NRC staff identified no new and significant information related to postulated accidents during the review of NextEra's ER, the site audit, the scoping process, or evaluation of other available information. Therefore, there are no impacts related to postulated accidents beyond those discussed in the GEIS. In accordance with 10 CFR 51.53(c)(3)(ii)(L), however, the NRC staff has reviewed SAMAs for Seabrook. Review results are discussed in Section 5.3.

5.3 Severe Accident Mitigation Alternatives

Under 10 CFR 51.53(c)(3)(ii)(L), license renewal applicants must consider alternatives to mitigate severe accidents if the NRC staff has not previously evaluated SAMAs for the applicant's plant in an environmental impact statement (EIS) or related supplement or in an environmental assessment. The purpose is to ensure that potentially cost-beneficial, aging-related plant changes (i.e., hardware, procedures, and training) with the potential for improving severe accident safety performance are identified and evaluated. SAMAs have not been previously considered by NextEra, for Seabrook; therefore, the remainder of Section 5.3 addresses those alternatives.

NextEra submitted an assessment of SAMAs for Seabrook as part of the ER (NextEra 2010), based on the most recently available Seabrook probabilistic risk assessment (PRA). This assessment is supplemented by a plant-specific offsite consequence analysis performed using the Methods for Estimation of Leakages and Consequences of Releases (MELCOR) Accident Consequence Code System 2 (MACCS2) computer code and insights from the Seabrook individual plant examination (IPE) (NHY 1991) and individual plant examination of external events (IPEEE) (North Atlantic Energy Service Corp. (NAESC) 1992). In identifying and evaluating potential SAMAs, NextEra considered SAMAs that addressed the major contributors to core damage frequency (CDF) and large early release frequency (LERF) at Seabrook, as well as a generic list of SAMA candidates for pressurized-water reactor (PWR) plants identified from other industry studies. In the original ER, NextEra identified 191 potential SAMA candidates. This list was reduced to 74 SAMA candidates by eliminating SAMAs for the following reasons:

- Seabrook has a different design.
- The SAMA has already been implemented at Seabrook.
- The intent of the SAMA has already been met at Seabrook.
- The SAMA has been combined with another SAMA candidate that is similar in nature.
- Estimated implementation costs would exceed the dollar value associated with eliminating all severe accident risk at Seabrook.
- The SAMA would be of very low benefit as it is related to a non-risk significant system.

NextEra assessed the costs and benefits associated with each of these 74 potential SAMAs and concluded in the ER that several of the candidate SAMAs evaluated are potentially cost beneficial.

Based on its review, the NRC staff issued requests for additional information (RAIs) to NextEra (NRC 2010a, 2011b). NextEra's responses addressed the NRC staff's concerns and resulted in the identification of additional potentially cost-beneficial SAMAs (NextEra 2011a, 2011b; NRC 2011a).

Subsequent to the RAI responses, NextEra submitted a supplement to the ER that incorporated updates to the PRA model (NextEra 2012a). NextEra identified four additional SAMA candidates that could be cost beneficial (three as a result of the 2012 SAMA supplement and one as a result of a sensitivity analysis) (three as a result of the 2012 SAMA supplement and one as a result of a sensitivity analysis). The supplement to the ER assessed the costs and benefits of these additional SAMA candidates and reassessed the costs and benefits of the previously-identified SAMA candidates. The result of this analysis and reassessment is one additional potentially cost-beneficial SAMA. Based on its review of this supplement, the NRC staff issued RAIs to NextEra (NRC 2012a). NextEra's responses addressed the NRC staff's questions (NextEra 2012b; NRC 2012b).

NextEra provided a sensitivity analysis of the MACCS2 meteorological model using the U.S. Environmental Protection Agency's (EPA's) CALMET wind field model (Hanna 2013; URS 2013). NextEra's analysis indicated that the use of the more complex CALMET model could potentially increase the calculated benefit of a SAMA by about 32 percent. However, NextEra's analysis did not directly assess the impact from a more complex meteorological model, uncertainty, and conservative assumptions in NextEra's model. Rather, it performed a sensitivity study to roughly assess the differences between MACCS2 and CALMET. The NRC staff's review included an evaluation of NextEra's use of the CALMET wind field model as well as an evaluation of the conservatisms in NextEra's SAMA analysis. This is discussed further in Section 5.3.2.

5.3.1 Risk Estimates for Seabrook

NextEra combined two distinct analyses to form the basis for the risk estimates used in the SAMA analysis—(1) the Seabrook Level 1 and 2 PRA model, which is an updated version of the IPE (NHY 1991), and (2) a supplemental analysis of offsite consequences and economic impacts (essentially a Level 3 PRA model) developed specifically for the SAMA analysis.[1] The SAMA analysis is based on the most recent Seabrook Level 1 and Level 2 PRA models available at the time of the ER, referred to as SSPSS-2011 (the model-of-record used to support SAMA evaluation). The scope of this Seabrook PRA includes both internal and external events.

Table 5–2 indicates the Seabrook CDF, based on initiating events, for internal events (plus internal and external flooding and severe weather), fires, and seismic events (NextEra 2012a, 2012b).

[1] The NRC uses PRA to estimate risk by computing real numbers to determine what can go wrong, how likely is it, and what are its consequences. Thus, PRA provides insights into the strengths and weaknesses of the design and operation of a nuclear power plant. For the type of nuclear plant currently operating in the U.S., a PRA can estimate three levels of risk. A Level 1 PRA estimates the frequency of accidents that cause damage to the nuclear reactor core. This is commonly called CDF. A Level 2 PRA, which starts with the Level 1 core damage accidents, estimates the frequency of accidents that release radioactivity from the nuclear power plant. A Level 3 PRA, which starts with the Level 2 radioactivity release accidents, estimates the consequences in terms of injury to the public and damage to the environment. (http://www.nrc.gov/about-nrc/regulatory/risk-informed/pra.html)

Table 5–2. Seabrook CDF for internal and external events

Initiating event	CDF (per year)	% Contribution to total CDF[(a)]
Loss of offsite power (LOOP)—due to weather[(e)]	6.8×10^{-7}	6
Flood in relay room from high-energy line break (HELB)[(e)]	5.9×10^{-7}	5
Steam generator tube rupture (SGTR)	5.7×10^{-7}	5
Reactor trip—condenser available	5.4×10^{-7}	4
Medium loss-of-coolant accident (LOCA)	5.3×10^{-7}	4
LOOP due to grid-related events	4.5×10^{-7}	4
Flood in yard due to service water (SW) common return rupture[(e)]	4.1×10^{-7}	3
Loss of essential alternating current (AC) power 4 kV bus	3.2×10^{-7}	3
Loss of primary component cooling water system (PCCW) B train	3.0×10^{-7}	3
Loss of PCCW system A train	2.3×10^{-7}	2
Major flood, rupture of SW Train A in primary auxiliary building (PAB)[(e)]	2.2×10^{-7}	2
LOOP due to switchyard	2.1×10^{-7}	2
Large flood, rupture SW Train A piping in PAB[(e)]	2.0×10^{-7}	2
Large flood, rupture SW Train B piping in PAB[(e)]	2.0×10^{-7}	2
Major flood, rupture of SW Train B in PAB[(e)]	2.0×10^{-7}	2
Major flood, rupture of fire protection piping in turbine building impacting offsite power[(e)]	1.8×10^{-7}	2
Loss of Train B essential AC Power (4 kV Bus E6)	1.6×10^{-7}	1
Large flood, rupture of SW common return piping in PAB[(e)]	1.4×10^{-7}	1
Large LOCA	3.4×10^{-7}	2
Other internal events[(b)]	1.6×10^{-6}	13
Total internal events CDF[(e)]	$\mathbf{7.8\times10^{-6}}$	**64**
Fire Initiating Event		
Fire in control room—power-operated relief valve (PORV) LOCA	3.6×10^{-7}	3
Fire in switchgear (SWGR) room B—loss of Bus E6	3.5×10^{-7}	3
Fire SWGR room A—loss of Bus E5	3.1×10^{-7}	2
Fire control room—AC power loss	1.8×10^{-7}	1
Other fire events[(c)]	3.8×10^{-7}	2
Total fire events CDF	$\mathbf{1.4\times10^{-6}}$	**11**

Initiating event	CDF (per year)	% Contribution to total CDF[(a)]
Seismic Initiating Event		
Seismic 0.7 g transient event	9.3×10^{-7}	8
Seismic 1.0 g transient event	8.9×10^{-7}	7
Seismic 1.4 g transient event	3.6×10^{-7}	3
Other seismic events[(d)]	8.8×10^{-7}	7
Total seismic events CDF	**3.1×10-6**	**25**
Total CDF (internal and external events)	$\mathbf{1.2\times10^{-5}}$	**100**

[References were revised, and only new text is provided below.]

(a) Individual percent contributions may not sum exactly to subtotals due to round off.

(b) Obtained by subtracting the sum of the internal initiating event contributors to internal event CDF from the total internal events CDF.

(c) Obtained by subtracting the sum of the fire initiating event contributors to fire event CDF from the total fire events CDF.

(d) Obtained by subtracting the sum of the seismic initiating event contributors to seismic event CDF from the total seismic events CDF.

(e) NextEra explained in response to an RAI the difference in the frequencies reported for many initiating events for the 2006 and 2011 PRA models. The total internal events CDF in the 2011 model decreased slightly as a result of model enhancements, the internal flooding CDF increased as result of a more detailed flooding analysis, and the severe weather CDF decreased primarily due to the incorporation of more recent data (NextEra 2012b).

The Level 2 Seabrook PRA model that forms the basis for the SAMA evaluation is an updated version of the Level 2 IPE model (New Hampshire Yankee (NHY 1991) and IPEEE model (NAESC 1992), using a single containment event tree (CET) to address both phenomenological and systemic events. The Level 1 core damage sequences are linked directly with the CET, for which the quantified sequences are binned into a set of 21 release categories, which are subsequently grouped into 13 source term categories that provide the input to the Level 3 consequence analysis (NextEra 2012a). Source terms were developed using the results of Modular Accident Analysis Program (MAAP), Version 4.0.7 computer code calculations. The offsite consequences and economic impact analyses use the MACCS2 code to determine the offsite risk impacts on the surrounding environment and public. Inputs for these analyses include plant-specific and site-specific input values for core radionuclide inventory, source term and release characteristics, site meteorological data, projected population distribution within a 50-mi (80-km) radius for the year 2050, emergency response evacuation planning, and economic parameters. The core radionuclide inventory corresponds to the end-of-cycle values for Seabrook operating at 3,659 MWt, which is slightly above the current licensed power level of 3,648 MWt. The magnitude of the onsite impacts (in terms of cleanup and decontamination costs and occupational dose) is based on information provided in NUREG/BR-0184 (NRC 1997a). NextEra estimated the dose to the population within 80 km (50 mi) of the Seabrook site to be approximately 37.8 person-rem (0.378 person-Sievert (Sv)) per year, as shown in Table 5–3 (NextEra 2012a).

Table 5–3. Breakdown of Population Dose by Containment Release Mode

Containment release mode	Population dose (Person-rem[a] per year)	% Contribution
Small early releases	1.7	5
Large early releases	1.7	4
Large late releases[b]	34.4	91
Intact containment	negligible	negligible
Total	**37.8**	**100**

[a] One person-rem = 0.01 person-Sv

[b] Includes small early containment penetration failure to isolate and large late containment basemat failure (SELL).

5.3.2 Adequacy of Seabrook PRA for SAMA Evaluation

The first Seabrook PRA was completed in December 1983 to provide a baseline risk assessment and an integrated plant and site model for use as a risk management tool. This model was subsequently updated in 1986, 1989, and 1990, with the last update used to support the IPE. Based on its review of the Seabrook IPE, as described in an NRC report dated March 1, 1992 (NRC 1992), the NRC staff concluded that the IPE submittal met the intent of generic letter (GL) 88-20, “Individual Plant Examination for Severe Accident Vulnerabilities” (NRC 1988). Although no severe accident vulnerabilities were identified in the Seabrook IPE, 14 potential plant improvements were identified. Four of the improvements have been implemented. Each of the 10 improvements not implemented is addressed by a SAMA in the current evaluation. The internal events CDF value from the 1991 Seabrook IPE (6.1×10^{-5} per year) is near the average of the range of the CDF values reported in the IPEs for Westinghouse four-loop plants, which ranges from about 3×10^{-6} per year to 2×10^{-4} per year, with an average CDF for the group of 6×10^{-5} per year (NRC 1997b). It is recognized that plants have updated the values for CDF subsequent to the IPE submittals to reflect modeling and hardware changes. Based on CDF values reported in the SAMA analyses for LRAs, the internal events CDF result for Seabrook used for the SAMA analysis (7.8×10^{-6} per year, including internal and external flooding) is somewhat lower than that for most other plants of similar vintage and characteristics.

There have been 11 revisions to the IPE model since the 1991 IPE submittal, and 3 revisions to the PRA model, from the original 1983 PRA model to the 1990 update used to support the IPE submittal. The SSPSA-2011 model was used for the SAMA analysis. NextEra identified the major changes in each revision of the PRA, with the associated change in internal and external event CDF (NextEra 2010, 2011a, 2012a). A comparison of the internal events CDF between the 1991 IPE and the 2011 PRA model used for the SAMA evaluation indicates a decrease of approximately 87 percent (from 6.1×10^{-5} per year to 7.8×10^{-6} per year). The external events CDF has increased by approximately 25 percent since the 1993 IPEEE (from 3.6×10^{-5} per year to 4.5×10^{-5} per year).

The Seabrook PRA model is an integrated internal and external events model that has integrated seismic-initiated, fire-initiated, and external flooding-initiated events with internal events since the initial 1983 PRA (NextEra 2011a). The external events models used in the SAMA evaluation are essentially those used in the IPEEE, with the exception of the seismic PRA model, which underwent a major update for the SSPSA-2005 model. The Seabrook IPEEE was submitted on October 2, 1992 (NAESC 1992), in response to Supplement 4 of

GL 88-20 (NRC 1991). The submittal used the same PRA as was used for the IPE (i.e., SSPSA-1990) except for updates to the external events. No fundamental weaknesses or vulnerabilities to severe accident risk with regard to external events were identified. Improvements that have already been realized as a result of the IPEEE process minimized the likelihood of there being cost-beneficial enhancements as a result of the SAMA analysis, especially with the inclusion of a multiplier to account for the additional risk of seismic events. In a letter dated May 2, 2001, the NRC staff concluded that the submittal met the intent of Supplement 4 to GL 88-20, and the applicant's IPEEE process is capable of identifying the most likely severe accidents and severe accident vulnerabilities (NRC 2001).

Internal Events CDF

NextEra identified three peer reviews that have been performed on the PRA—a 1999 Westinghouse Owner's Group (WOG) certification peer review, a 2005 focused peer review against the American Society of Mechanical Engineers (ASME) PRA standard (ASME 2003; NextEra 2010) and a 2009 peer review of the internal flood model against the ASME PRA standard (ASME 2009; NextEra 2012a). None of the peer reviews included examination of external flooding, fire, or seismic hazards. The 1999 certification peer review identified 30 Category A and B facts and observations (F&O), and the 2005 focused peer review identified 4 Category A and B F&Os.[2] NextEra provided the resolution of each of the 34 F&Os and stated that all have been dispositioned and implemented in the PRA model (NextEra 2010). NextEra also stated that there were no Category A and three Category B F&Os from the 2009 peer review, all of which were resolved and implemented in the PRA model (NextEra 2012a). NextEra explained that many other internal reviews including vendor-assisted reviews have been performed on specific model updates and that comments from these reviews, along with plant changes and potential model enhancements, are tracked through a model change database to ensure that the comments are addressed in the periodic update process (NextEra 2011a).

Consistent with the requirements of the ASME 2009 PRA standard (ASME 2009), NextEra maintains PRA quality control at Seabrook via an existing administrative procedure that defines the quality control process for PRA updates and ensures that the PRA model accurately reflects the current Seabrook plant design, operation, and performance (NextEra 2011a). The quality control process includes monitoring PRA inputs for new information, recording new applicable information, assessing significance of new information, performing PRA revisions, and controlling computer codes and models. NextEra also stated that the PRA training qualification is performed as part of the Engineering Support Personnel Training Program. Given that the Seabrook internal events PRA model has been peer-reviewed, and the peer review findings were all addressed, and that NextEra has satisfactorily addressed NRC staff questions regarding the PRA, the NRC staff concludes that the internal events Level 1 PRA model is of sufficient quality to support the SAMA evaluation.

Seismic CDF

The Seabrook IPEEE seismic analysis used a seismic PRA following NRC guidance (NRC 1991). The seismic PRA included the following:

- a seismic hazard analysis (based on the EPRI (1988) and the Lawrence Livermore National Laboratory (LLNL) (NRC 1994) hazard curves),

[2] Now termed a "Finding," a Category A or B F&Os is an "observation (an issue or discrepancy) that is necessary to address to ensure: [1] the technical adequacy of the PRA ... [2] the capability/robustness of the PRA update process, or [3] the process for evaluating the necessary capability of the PRA technical elements (to support applications)." (Nuclear Energy Institute (NEI) 05-04, "Process for Performing Internal Events PRA Peer Reviews Using the ASME/ANS PRA Standard," Revision 2, 2008)

- a seismic fragility assessment,
- seismic quantification to yield initiating event frequencies and conditional system failure probabilities, and
- plant model assembly to integrate seismic initiators and seismic-initiated component failures with random hardware failures and maintenance unavailabilities.

The seismic CDF resulting from the Seabrook IPEEE was calculated to be 1.2×10^{-5} per year using a site-specific seismic hazard curve, with sensitivity analyses yielding 1.3×10^{-4} per year using the LLNL seismic hazard curve and 6.1×10^{-6} per year using the EPRI seismic hazard curve. The Seabrook IPEEE did not identify any vulnerability due to seismic events but did identify two plant improvements to reduce seismic risk. Neither of the two improvements has been implemented. Each of the two improvements is addressed by a SAMA in the current evaluation.

Subsequent to the IPEEE, NextEra updated the seismic PRA analysis. These updates included expanding fragility analysis, with additional components; using the more current EPRI uniform hazard spectrum; and improving modeling and documentation of credited operator actions.

NextEra stated that extensive internal technical reviews of the seismic PRA analysis were performed for the original 1983 PRA and again when the seismic analysis was revised for the IPEEE and when the seismic analysis was revised for the SSPSA-2005 PRA model update. No significant comments were documented from these reviews, and no formal peer reviews have been conducted on the seismic PRA model (NextEra 2011a). In response to an NRC staff request to assess the impact on the SAMA evaluation of updated seismic hazard curves developed by the U.S. Geological Survey (USGS) in 2008 (USGS 2008), NextEra provided a revised SAMA evaluation using a multiplier of 2.1 to account for the maximum estimated seismic CDF for the Seabrook of 2.2×10^{-5} per year. This was noted in the attachments to NRC Information Notice 2010^{-18}, generic issue (GI) 199, “Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants” (NRC 2010a, 2010b; NextEra 2011a, 2011b, 2012a). Note that, in the process of estimating an appropriate multiplier, NextEra considered that the estimated seismic CDF of 2.2×10^{-5} per year did not credit the installation of the supplemental electrical power system (SEPS) diesel generators (DGs) in 2004, which, based on a subsequent PRA estimate, reduced seismic CDF by 26 percent. Therefore, in estimating the multiplier, NextEra first reduced the 2.2×10^{-5} per year estimate for seismic CDF by 26 percent to 1.6×10^{-5} per year. Using a seismic CDF of 1.6×10^{-5} per year, the total CDF equates to 2.5×10^{-5} per year or 2.1 times the total CDF from Table 5.3-1 (1.2×10^{-5} per year).

The NRC staff concludes that the seismic PRA model, in combination with the use of a seismic events multiplier of 2.1, provides an acceptable basis for identifying and evaluating the benefits of SAMAs. This conclusion is based on the fact that the Seabrook seismic PRA model is integrated with the internal events PRA, the seismic PRA has been updated to include additional components and to extend the fragility screening threshold, the SAMA evaluation was updated using a multiplier to account for a potentially higher seismic CDF, and NextEra has satisfactorily addressed NRC staff RAIs regarding the seismic PRA.

Fire CDF

The Seabrook IPEEE fire analysis employed EPRI’s fire-induced vulnerability evaluation (FIVE) methodology (Electric Power Research Institute (EPRI) 1992) based on definitions of Appendix R fire areas for Seabrook. Qualitative and quantitative screening was performed to

determine that 13 of the 73 fire areas contained important equipment (pumps, valves, and cabling, etc.). These were further assessed. Final quantification used the Seabrook IPE PRA model to calculate a fire-induced CDF of 1.2×10^{-5} per year. While no physical plant changes were found to be necessary as a result of the IPEEE fire analysis, potential plant improvements to reduce fire risk were identified—of which, four have been implemented. The one improvement not implemented is addressed by a SAMA in the current evaluation.

NextEra updated the fire PRA, subsequent to the IPEEE, in support of the SSPSS-2004 PRA update. NextEra stated that the fire analysis methodology used was essentially the same, with some variations, as that described previously for the IPEEE fire analysis (NextEra 2011a).

NextEra stated that extensive internal technical reviews of the fire PRA analysis were performed for the original 1983 PRA and, again, when the fire analysis was revised for the IPEEE and when the fire analysis was revised for the SSPSS-2005 PRA model update. No significant comments were documented from these reviews, and no formal peer reviews have been conducted on the fire PRA model (NextEra 2011a). Considering that the Seabrook fire PRA model is integrated with the internal events PRA, that the fire PRA has been updated to include more current data, and that NextEra has satisfactorily addressed NRC staff RAIs regarding the fire PRA, the NRC staff concludes that the fire PRA model provides an acceptable basis for identifying and evaluating the benefits of SAMAs.

“Other” External Event CDF

The Seabrook IPEEE analysis of “other” external events included high winds, external floods, transportation accidents, etc. (HFO events), and it followed the screening and evaluation approaches specified in Supplement 4 to GL 88-20 (NRC 1991), concluding that Seabrook met the 1975 Standard Review Plan (SRP) criteria (NRC 1975b). The following external event frequencies exceeded the 1.0×10^{-6} per year screening criterion (NAESC 1992):

- flooding resulting from a storm surge caused by a hurricane, which is modeled in the PRA (NextEra 2010) and reported to contribute 2×10^{-8} per year to the total Seabrook CDF and
- a truck crash into the SF6 transmission lines, which has been mitigated by the installation of jersey barriers and guard rails and that, as a result, has been screened from the PRA model (NextEra 2011a).

While no physical plant changes were found to be necessary as a result of the IPEEE HFO analysis, one plant improvement based on HFO analysis was recommended, but this has already been implemented (NextEra 2011a). The Seabrook IPEEE submittal also stated that, as a result of the Seabrook IPE, cost-benefit analyses were being performed for many potential plant improvements, which may also collaterally reduce external event risk. Four of these five potential plant improvements have been implemented, and the fifth is addressed by a SAMA in the current evaluation.

Level 2 and LERF

To translate the results of the Level 1 PRA into containment releases, as well as the results of the Level 2 analysis, NextEra significantly revised the 2005 PRA update (i.e., PRA model SSPSS-2005) from that used in the IPE to reflect the Seabrook plant as designed and operated as of 2006. NextEra explained that the quantification of the Level 1 and Level 2 models is done using a linked event tree method approach that does not employ plant damage states (NextEra 2011a). Therefore, all Level 1 sequences are evaluated by the CET. The Level 2 model is a single CET and evaluates the phenomenological progression of all the Level 1 sequences including internal, fire, and seismically initiated events. It has 37 branching events,

for each of which the split fraction is determined based on the type of event. End states resulting from the combinations of the branches are then assigned to one of 21 release categories based on characteristics that determine the timing and magnitude of the release, whether or not the containment remains intact, and isotopic composition of the released material. The quantified CET sequences are subsequently grouped into 13 source term categories by grouping those that occur due to different phenomena but for which the consequence is essentially the same. Eight of the release categories were mapped one-to-one into a corresponding source term category while 13 release categories were mapped into five combined source term categories. These 13 source term categories provide the input to the Level 3 consequence analysis.

Source terms were developed for each of the source term categories. The release fractions and timing for source term categories are based on the results of plant-specific calculations using the MAAP Version 4.0.7. NextEra generally selected the representative MAAP case based on that which resulted in the most realistic timing and source term release. For four of the combined source term categories, the source term for the release category (RC) having the highest (dominant) release frequency was used as the source term for the combined category. In the fifth combined source term category, one of the contributors had the most significant source term and the highest frequency so it was selected as the representative case.

The current Seabrook Level 2 PRA model is an update of that used in the IPE, which did not identify any severe accident vulnerabilities associated with containment performance. The NRC staff's review of the IPE back-end (i.e., Level 2) model concluded that it appeared to have addressed the severe accident phenomena normally associated with large dry containments, that it met the IPE requirements, and that there were no obvious or significant problems or errors. The LERF model was included in the 1999 industry peer review. All F&Os from this review have been dispositioned and implemented in the PRA model. NextEra explained that the apparently very low LERF for Seabrook (1.2×10^{-7} per year in the SSPSS-2006 model, which is less than 1 percent of the CDF) results from the very large-volume and strong containment building in comparison to most other nuclear power plant containment designs (NextEra 2011a), such that there are no conceivable severe accident progression scenarios that result in catastrophic failure early in the accident sequence. The NRC staff considers NextEra's explanation reasonable. Based on the NRC staff's review of the Level 2 methodology, the NRC staff concludes that NextEra has adequately addressed NRC staff RAIs, that the LERF model was reviewed in more detail as part of the 1999 WOG certification peer review, and that all F&Os have been resolved. Therefore, the NRC staff concludes that the Level 2 PRA provides an acceptable basis for evaluating the benefits associated with various SAMAs.

Level 3—Population Dose

NextEra extended the containment performance (Level 2) portion of the PRA to assess offsite consequences (essentially a Level 3 PRA) via Version 1.13.1 of the MACCS2 code, including consideration of the source terms used to characterize fission product releases for the applicable containment release categories and the major input assumptions used in the offsite consequence analyses (NRC 1998). Plant-specific input to the code included the following:

- the source terms for each RC;
- the reactor core radionuclide inventory;
- site-specific meteorological data for the year 2005;
- projected population distribution within an 80-km (50-mi) radius for the year 2050, based on year 2000 census data from SECPOP2000 (NRC 2003);

- emergency evacuation planning, using only 95 percent of the population (conservative relative to NUREG-1150, which assumed 99.5 percent (NRC 1990)); and
- economic parameters including agricultural production.

Multiple sensitivity cases were run, including the following:

- releases at ground level and 25 percent, 50 percent, and 75 percent of the containment building height (baseline is release at the top of containment);
- release plumes with 1 and 10 MW heat release;
- factor-of-two scaling of containment building wake effects;
- annual meteorological data from 2004 through 2008;
- variations in evacuation parameters, such as percent of population, evacuation speed, and delay time; and
- variations in sea-breeze circulation assumptions.

NextEra's results showed only minor variations from the baseline for these sensitivities, which is consistent with previous SAMA analyses. The NRC staff concludes that the methodology used by NextEra to estimate the offsite consequences for Seabrook provides an acceptable basis from which to proceed with an assessment of risk reduction potential for candidate SAMAs. Accordingly, the NRC staff based its assessment of offsite risk on the CDF and offsite doses reported by NextEra.

NextEra provided an analysis comparing the ATMOS meteorological model imbedded within MACCS2 to the EPA's CALMET wind field model (Hanna 2013; URS 2013). To accomplish this, NextEra performed an exposure index (EI) study using MACCS2 and CALMET. The EI is a metric used by the NRC in the assessment of future plant operation risk impacts from atmospheric release pathways. The EI is a function of the population distribution surrounding the plant of interest weighted by the site-specific wind direction frequencies for the 16 different principal compass directions.

NextEra performed an EI study to better understand the sensitivity of using localized wind trajectories throughout the modeled 50-mi radius around Seabrook, as compared to a single set of annual wind trajectories based on measurements for the Seabrook site. For this analysis, the single set of wind trajectories was based on the 2005 annual wind rose for Seabrook, as processed by Version 1.13.1 of the MACCS2 computer model, and the localized trajectory roses were calculated using Version 5 of the CALMET model. NextEra's analysis indicated that the use of the more complex CALMET model could potentially increase the calculated benefit of a SAMA by about 32 percent.

The NRC staff notes that CALMET does not treat radioactive decay and daughter ingrowth, calculate air concentrations accounting for dispersion, or calculate ground concentrations accounting for deposition. The NRC staff notes that the 32 percent increase in benefits estimated using the CALMET model is likely to be significantly larger than the increase that would have been observed had it been possible to have done a full analysis, accounting for factors such as radioactive decay and plume depletion from deposition.

Alternatively, the CALMET sensitivity analysis performed by NextEra could be treated as a new baseline analysis instead of a sensitivity analysis. Depending on how this analysis is considered, uncertainty may also need to be accounted for in the determination of the potential benefit of a SAMA. Conservatively, the NRC staff chose to treat the CALMET analysis as a

baseline analysis. After reviewing NextEra's analysis, the NRC staff determined that if the CALMET model was used as the baseline SAMA analysis and NextEra's uncertainty factor was applied, several additional SAMAs would be identified as potentially cost-beneficial including: SAMAs 13, 24, 44, 55, 56, 77, 96, 108, 109, 147, 163, 167, 168, 169, and 170.

The NRC staff notes that NextEra's original baseline SAMA analysis contained a number of conservative assumptions relative to accepted practice in performing SAMA analyses. To assess the quantitative impact of these conservatisms, the NRC staff contracted Sandia National Laboratories (Sandia) to aid it's review. Sandia documented their analyses in a report entitled, "Review of Conservatism in the Seabrook Consequence Analysis" (Sandia 2014). As documented in the Sandia report, the leading sources of conservatism in NextEra's SAMA analysis are (1) the assumption of perpetual rainfall in the area from 40 to 50 mi from the plant, which includes the city of Boston; (2) the choice of the worst case year for meteorological data; (3) the use of a value for surface roughness which is conservative for the area near Seabrook; and (4) the use of older and significantly higher EPA dose values for normal and hot spot relocation. The conservative assumptions made by NextEra inflated the potential benefit that could be realized by each potential cost-beneficial mitigation measure. In total, the increase in benefit resulting from the conservative assumptions used in NextEra's baseline analysis would off-set any increase in benefit associated with using CALMET, identified as part of NextEra's CALMET sensitivity analysis.

5.3.3 Potential Plant Improvements

NextEra's process for identifying potential plant improvements (SAMAs) consisted of the following elements:

- review of the most significant basic events from the 2011 plant-specific PRA, which was the most current PRA model at the time the SAMA evaluation was performed;
- review of potential plant improvements identified in the Seabrook IPE and IPEEE;
- review of other industry documentation discussing potential plant improvements; and
- insights from Seabrook personnel.

Based on this process, an initial set of 195 candidate "Phase I" SAMAs was identified, for which NextEra performed a qualitative screening to eliminate ones from further consideration using the following criteria:

- The SAMA is not applicable to Seabrook due to design differences (19 SAMAs screened).
- The SAMA has already been implemented at Seabrook or the Seabrook meets the intent of the SAMA (87 SAMAs screened).
- The SAMA is similar to another SAMA under consideration (11 SAMAs screened).
- The SAMA has estimated implementation costs that would exceed the dollar value associated with eliminating all severe accident risk at Seabrook (no SAMA screened).
- The SAMA was determined to provide very low benefit (no SAMA screened).

Based on this screening, 117 SAMAs were eliminated, leaving 78 for detailed evaluation in Phase II. In Phase II, a detailed evaluation was performed for each of the remaining 78 SAMA candidates. NextEra accounted for the potential risk reduction benefits associated with each SAMA by quantifying the benefits using the integrated internal and external events PRA model.

The NRC staff reviewed NextEra's process for identifying and screening potential SAMA candidates, as well as the methods for quantifying the benefits associated with potential risk reduction. This included reviewing insights from the plant-specific risk studies, reviewing plant improvements considered in previous SAMA analyses, and explicitly treating external events in the SAMA identification process. The NRC staff concludes that NextEra used a systematic and comprehensive process for identifying potential plant improvements for Seabrook, and the set of SAMAs evaluated in the ER, together with those evaluated in response to NRC staff inquiries, is reasonably comprehensive; therefore, it is acceptable.

5.3.3.1 Risk Reduction

NextEra evaluated the risk-reduction potential of the 78 SAMAs retained for the Phase II evaluation, which includes the risk-reduction potential of additional SAMAs identified in the 2012 SAMA supplement (NextEra 2012a) and in response to NRC staff RAIs (NextEra 2012b). NextEra used model re-quantification to determine the potential benefits based on the SSPSS-2011 PRA model. The majority of the SAMA evaluations were performed in a bounding fashion in that the SAMA was assumed to eliminate the risk associated with the proposed enhancement. On balance, such calculations overestimate the benefit and are conservative. The NRC staff reviewed NextEra's bases for calculating the risk reduction for the various plant improvements and concludes that the rationale and assumptions are reasonable and generally conservative (i.e., the estimated risk reduction is higher than what would actually be realized). Accordingly, the NRC staff based its estimates of averted risk for the various SAMAs on NextEra's risk reduction estimates.

5.3.3.2 Cost Impacts

NextEra developed plant-specific costs of implementing the 78 Phase II candidate SAMAs using an expert panel—composed of senior plant staff from the PRA group, the design group, operations, and license renewal—with experience in developing and implementing modifications at Seabrook. In most cases, detailed cost estimates were not developed because of the large margin between the estimated SAMA benefits and the estimated implementation costs (NextEra 2011a). The cost estimates, conservatively, did not specifically account for inflation, contingencies, implementation obstacles, or replacement power costs (RPC). The NRC staff reviewed the bases for the applicant's cost estimates and, for certain improvements, compared the cost estimates to estimates developed elsewhere for similar improvements, including estimates developed as part of other applicants' analyses of SAMAs for operating reactors and advanced light-water reactors. The NRC staff concludes that the cost estimates provided by NextEra are sufficient and appropriate for use in the SAMA evaluation.

5.3.3.3 Cost-Benefit Comparison

The methodology used by NextEra was based primarily on NRC's guidance for performing cost-benefit analysis (i.e., NUREG/BR-0184, *Regulatory Analysis Technical Evaluation Handbook* (NRC 1997a)). The guidance involves determining the net value for each SAMA according to the following formula:

Net Value = (APE + AOC + AOE + AOSC) – COE

where:

APE = present value of averted public exposure ($)

AOC = present value of averted offsite property damage costs ($)

AOE = present value of averted occupational exposure costs ($)

AOSC = present value of averted onsite costs ($)

COE = cost of enhancement ($)

If the net value of a SAMA is negative, the cost of implementing the SAMA is larger than the benefit associated with the SAMA, and it is not considered cost beneficial. Present values for both a 3 percent and 7 percent discount rate were considered. Using the NUREG/BR-0184 methods, NextEra estimated the total present dollar value equivalent associated with eliminating severe accidents from internal and external events at Seabrook to be about $3.05 million. Use of a multiplier of 2.1 to account for the additional risk from seismic events in the sensitivity analysis increases the value to $6.4 million. This represents the dollar value associated with completely eliminating all internal and external event severe accident risk at Seabrook, and it is also referred to as the maximum averted cost risk (MACR).

If the implementation costs for a candidate SAMA exceeded the calculated benefit, the SAMA was considered not to be cost beneficial. In the baseline analysis (using a 7 percent discount rate), NextEra identified three potentially cost-beneficial SAMAs (SAMA 157, 165, and 192, see Table 5–4). Based on the consideration of analysis uncertainties, NextEra identified three additional potentially cost-beneficial SAMAs (SAMA 164, 172, and 195, see Table 5–4). In addition, as a result of the sensitivity analysis using a multiplier of 2.1 to account for the additional risk from seismic events, NextEra identified one additional cost-beneficial SAMA (SAMA 193, see Table 5–4).

The seven potentially cost-beneficial SAMAs are discussed in Section 5.3.4. The NRC staff notes that these are included within the set of SAMAs that NextEra plans to enter into the Seabrook long-range plan development process for further implementation consideration. The NRC staff concludes that, with the exception of the seven potentially cost-beneficial SAMAs, the costs of the other SAMAs evaluated would be higher than the associated benefits.

5.3.4 Cost-Beneficial SAMAs

Highlighted in ***bold italics*** in Table 5–4 are the potentially cost-beneficial SAMAs (157, 164, 165, 172, 192, 193, and 195).

Table 5–4. SAMA Cost-Benefit Phase-II Analysis for Seabrook

Analysis case & applicable SAMAs (where multiples, only number & minimum cost are listed)	Modeling assumptions	% Risk reduction		Total benefit ($)		Cost ($)
				Baseline (with 2.1 multiplier)		
		CDF	Pop. dose	Internal + External	with uncer-tainty	
No station blackout (SBO): Six SAMAs analyzed	Eliminate failure of the emergency diesel generators (EDGs)	22	6	220K (470K)	525K (1.1M)	1.75M (minimum of six)
No LOOP: Three SAMAs analyzed	Eliminate LOOP events	18	17	530K (1.2M)	1.2M (2.7M)	>3M (minimum of three)
No loss of 4 kV in-feed breakers: #21—Develop procedures to repair or replace failed 4 kV breakers	Eliminate failure of the 4 kV bus in-feed breakers	1	<1	8K (17K)	15K (32K)	Screened
No loss of high-pressure injection (HPI): Two SAMAs analyzed	Eliminate failure of the HPI system	22	34	1.1M (2.3M)	2.5M (5.3M)	8.8M (minimum of both)
No loss of low-pressure injection: #28—Add a diverse low-pressure injection system	Eliminate failure of the low-pressure injection system	2	2	68K (140K)	160K (340K)	>1M
No depletion of reactor water storage tank (RWST): Two SAMAs analyzed	Eliminate RWST running out of water	13	10	310K (655K)	730K (1.5M)	>3M (minimum of both)
Reduce common cause failure of the safety injection (SI) system: #39—Replace two of the four electric SI pumps with diesel-powered pumps	Eliminate dependency of the existing intermediate head SI pump trains on AC power	<1	0	<1K (<1K)	<1K (<1K)	>5M
No small LOCAs: #41—Create a reactor coolant depressurization system	Eliminate all small LOCA events	2	1	27K (57K)	64K (130K)	>1M

Analysis case & applicable SAMAs (where multiples, only number & minimum cost are listed)	Modeling assumptions	% Risk reduction		Total benefit ($)		Cost ($)
				Baseline (with 2.1 multiplier)		
		CDF	Pop. dose	Internal + External	with uncer-tainty	
No direct current (DC) dependence for SW: #43—Add redundant DC control power for SW pumps	Eliminate the dependence of the SW pumps on DC power	<2	0	11K (24K)	26K (55K)	>100K
No loss of component cooling water (CCW): #44—Replace emergency core cooling system (ECCS) pump motors with air-cooled motors	Eliminate failure of the CCW pumps	14	31	920K (1.9M)	2.15M (4.6M)	>6M
No failure of support systems for core spray (CS) division B of HPI: Six SAMAs analyzed	Eliminate failures of support systems (e.g., AC and DC power, cooling) for division B of HPI	28	34	1.0M (2.2M)	2.45M (5.2M)	>6.4M (minimum of six)
No CCW pump failure when AC/DC power available: #59—Install a digital feed water upgrade	Eliminate CCW pump failure when AC and DC power support is available	4	11	335K (700K)	785K (1.7M)	>6.1M
No plant risk Two SAMAs analyzed	Eliminate all plant risk	100	100	3.05M (6.4M)	7.15M (15M)	>15M (minimum of two)
No PORV failures: #79—Install bigger pilot operated relief valve so only one is required	Eliminate all PORV failures	<1	0	1.7K (4K)	4.1K (9K)	>2.7M
No heating, ventilation, and air conditioning (HVAC) dependence for CS, SI, RH, & containment building spray (CBS): #80—Provide a redundant train or means of ventilation	Eliminate the dependence of CS, SI, residual heat removal (RHR), & CBS pumps on HVAC	3	5	150K (320K)	360K (750K)	>1M

Analysis case & applicable SAMAs (where multiples, only number & minimum cost are listed)	Modeling assumptions	% Risk reduction: CDF	% Risk reduction: Pop. dose	Total benefit ($) Baseline (with 2.1 multiplier): Internal + External	Total benefit ($): with uncer-tainty	Cost ($)
No HVAC dependence for emergency feedwater (EFW): #84—Switch for EFW room fan power supply to station batteries	Eliminate loss of EFW ventilation	<1	0	<1K (<2K)	<2K (<4K)	>250K
No CBS support system or common cause failures: Two SAMAs analyzed	Eliminate CBS power, signal, and cooling support system failures, and common cause failure among similar components for one division of CBS	0	58	1.7M (3.5M)	4.0M (8.3M)	>10M (minimum of two)
No failure of human action to vent containment: #93—Install an unfiltered hardened containment vent	Eliminate failure of the human action to vent containment	0	1	39K (82K)	92K (190K)	>3M
No release from containment venting and reduced release from basemat melt-through: #94—Install a filtered containment vent to remove decay heat	Eliminate release category LL3 (containment vent) and prevent 80 percent of release category LL5 (basemat melt-through)	0	69	2.0M (4.1M)	4.6M (9.7M)	>20M
Reduced likelihood of non-recovery of offsite power: #99—Strengthen primary & secondary containment (e.g., add ribbing to containment shell)	Reduce by a factor of 10 the non-recovery of offsite power before late containment pressure failure occurs	0	4	120K (245K)	270K (570K)	11.5M
Reduced failure of CBS: #107—Install a redundant containment spray system	Add redundant train of CBS	0	1	29K (62K)	69K (140K)	>10M

Analysis case & applicable SAMAs (where multiples, only number & minimum cost are listed)	Modeling assumptions	% Risk reduction		Total benefit ($)		Cost ($)
		CDF	Pop. dose	Baseline (with 2.1 multiplier)		
				Internal + External	with uncertainty	
No hydrogen burns or detonations: Three SAMAs analyzed	Eliminate all hydrogen ignition and burns	0	1	18K (39K)	43K (90K)	>100K (minimum of three)
No failure of operator action to transfer to long-term recirculation following large LOCA: #105—Delay containment spray actuation after a large LOCA	Eliminate the human failure to complete/ ensure the RHR/low-head safety injection (LHSI) transfer to long-term recirculation during large LOCA events	3	0	12K (25K)	27K (58K)	>100K
No high-pressure core ejection: #110—Erect a barrier that would provide enhanced protection of the containment walls (shell) from ejected core debris following a core melt scenario at high pressure	Eliminate high-pressure core ejection occurrences	0	0	<1K (<1K)	1K (2K)	>10M
No containment isolation valve (CIV) failures: Two SAMAs analyzed	Eliminate CIV failures	0	6	115K (240K)	270K (570K)	>1M (minimum of both)
No interfacing system loss-of-coolant accidents (ISLOCAs): Three SAMAs analyzed	Eliminate all ISLOCAs	<1	3	48K (100K)	110K (240K)	>500 (minimum of three)
No SGTRs: Five SAMAs analyzed	Eliminate all SGTR events	5	2	67K (140K)	160K (330K)	>500K (minimum of five)
No anticipated transient without scrams (ATWSs): Four SAMAs analyzed	Eliminate all ATWS events	4	2	60K (130K)	140K (290K)	>500K (minimum of four)

Analysis case & applicable SAMAs (where multiples, only number & minimum cost are listed)	Modeling assumptions	% Risk reduction		Total benefit ($)		Cost ($)
				Baseline (with 2.1 multiplier)		
		CDF	Pop. dose	Internal + External	with uncer-tainty	
No piping system LOCAs: #147—Install digital large break LOCA protection system	Eliminate all piping failure LOCAs	9	2	77K (160K)	180K (380K)	>500K
No secondary side depressurization from stem line break upstream of main steam isolation valves: #153—Install secondary side guard pipes up to the main steam isolation valves	Eliminate all steam line break events	<1	0	5K (11K)	11K (24K)	>500K
No operator error when aligning & loading SEPS DGs: #154—Modify SEPS design to accommodate: (a) automatic bus loading, (b) automatic bus alignment	Eliminate failure of all operator actions to align and load the SEPS DGs	8	2	64K (135K)	150K (320K)	>750K
Provide independent AC power to battery chargers: ***#157—Provide independent AC power source for battery chargers; for example, provide portable generator to charge station battery***	***Eliminate failure of operator action to shed DC loads to extend batteries to 12 hours & eliminate failure to recover offsite power for plant-related, grid-related, & weather-related LOOP events***	***<2***	***1***	***34K (72K)***	***80K (170K)***	***30K***
#159—Install additional batteries						>1.0M

Analysis case & applicable SAMAs (where multiples, only number & minimum cost are listed)	Modeling assumptions	% Risk reduction		Total benefit ($)		Cost ($)
				Baseline (with 2.1 multiplier)		
		CDF	Pop. dose	Internal + External	with uncertainty	
No depletion of condensate storage: #162—Increase the capacity margin of the condensate storage tank (CST) ***#164—Modify 10" condensate filter flange to have a 2-½" female fire hose adapter with isolation valve***	Eliminate CST running out of water	**<2**	1	**35K (73K**)	**81K (170K**)	 >2.5M >40K
No loss of turbine-driven auxiliary feedwater (TDAFW): #163—Install third EFW pump (steam-driven)	Eliminate failure of the TDAFW train	5	12	360K (750K)	835K (1.8M)	>2.0M
Guaranteed success of RWST long-term makeup without recirculation: ***#165—RWST fill from firewater during containment injection—Modify 6" RWST Flush Flange to have a 2½" female fire hose adapter with isolation valve***	***Guaranteed success of RWST makeup for long-term sequences where recirculation is not available***	***5***	***2***	***57K (120K)***	***130K (280K)***	***50K***
No loss of reactor coolant pump (RCP) seal cooling and no failure of RCP seals following a plant transient: ***#172—Evaluate installation of a "shutdown seal" in the RCPs being developed by Westinghouse***	***Eliminate failure of RCP seal cooling initiating event and RCP seal failures subsequent to a plant transient***	***34***	***49***	***1.5M (3.2M)***	***2.5M (7.4M)***	***>2M***

Analysis case & applicable SAMAs (where multiples, only number & minimum cost are listed)	Modeling assumptions	% Risk reduction		Total benefit ($)		Cost ($)
				Baseline (with 2.1 multiplier)		
		CDF	Pop. dose	Internal + External	with uncer-tainty	
No fire in turbine building at west wall or relay room: #175—Improve fire detection in turbine building relay room	This SAMA has been implemented (NextEra 2011b)					
No failure of operator action to close PORV block valve during a control room fire: #179—Fire-induced LOCA response procedure from alternate shutdown panel	Eliminate operator failure to close PORV block valve during a control room fire	0	0	<1K (<1K)	<1K (<2K)	>20K
No failures due to seismic relay chatter: #181—Improve relay chatter fragility	Eliminate all seismic relay chatter failures	12	3	87K (180K)	200K (470K)	>600K
No seismic-induced loss of DGs or turbine-driven emergency feedwater (TDEFW): #182—Improve seismic capacity of EDGs & steam-driven EFW pump	Eliminate all seismic failures of EDGs or TDEFW	<1	0	2.4K (6K)	5.6K (12K)	>500K
Containment purge valves are always closed: #184—Control/reduce time that the containment purge valves are in open position	Eliminate possibility of containment purge valves being open at the time of an event	0	0	<1K (<1K)	<1K (<2K)	>20K
No CDF contribution from pre-existing containment leakage: #186—Install containment leakage monitoring system	Eliminate all CDF contribution from pre-existing containment leakage	0	0	4.4K (12K)	10K (27K)	>500K

Analysis case & applicable SAMAs (where multiples, only number & minimum cost are listed)	Modeling assumptions	% Risk reduction		Total benefit ($)		Cost ($)
				Baseline (with 2.1 multiplier)		
		CDF	Pop. dose	Internal + External	with uncer-tainty	
Benefits of SEPS success criteria change, from two of two SEPS DGs to one of two SEPS DGs: #189—Modify or analyze SEPS capability; one of two SEPS for loss of system pressure (LOSP) non-SI loads, two of two for LOSP SI loads	Modify fault tree so that one of two SEPS DGs are required rather than both SEPS DGs being required	6	2	63K (130K)	150K (310K)	>2M
No inadvertent failures of redundant temperature logic during loss of PCCW: #191—Remove the 135 ºF temperature trip of the PCCW pumps	Eliminate inadvertent failure of the redundant temperature element/logic of the associated primary component cooling (PCC) division for both loss of PCCW initiating events & loss of PCCW mitigative function	<1	0	<1K (<1K)	<1K (<2K)	>100K
No flooding in control building due to fire protection system actuation: ***#192—Install a globe valve or flow limiting orifice upstream in the fire protection system***	***Eliminate control building fire protection flooding initiators***	***24***	***11***	***470K (990K)***	***1.1M (2.3M)***	***370K***
No failure of operator action to close CIV CS-V-167: ***#193—Hardware change to eliminate motor-operated valve (MOV) AC power dependency***	***Eliminate operator failure to close CIV CS-V-167***	***0***	***5***	***86K (180K)***	***200K (420K)***	***300K***

Analysis case & applicable SAMAs (where multiples, only number & minimum cost are listed)	Modeling assumptions	% Risk reduction		Total benefit ($)		Cost ($)
				Baseline (with 2.1 multiplier)		
		CDF	Pop. dose	Internal + External	with uncer-tainty	
No failure of main steam safety valves (MSSVs) to reseat: #194—Purchase or manufacture a "gagging device" that could be used to close a stuck-open steam generator safety valve	Eliminate failure of MSSVs to reseat	0	0	<1K (<1K)	<1K (<2K)	>30K
No failure of temperature elements for PCC Trains A and B: ***#195—Make improvements to PCCW temperature control reliability***	***Eliminate failure of temperature control and modulation for PCC Trains A and B that could fail PCCW***	***3***	***5***	***140K (300K)***	***340K (710K)***	***300K***

5.3.5 Conclusions

NextEra compiled a list of 191 SAMAs in the ER and 4 additional SAMAs in the 2012 SAMA supplement (NextEra 2012a) based on a review of the most significant basic events from the plant-specific PRA, insights from the plant-specific IPE and IPEEE, review of other industry documentation, and insights from Seabrook personnel. Of these, 117 SAMAs were eliminated qualitatively, leaving 78 candidate SAMAs for evaluation. These underwent more detailed design and cost estimates to show that three were potentially cost beneficial in the baseline analysis (SAMAs 157, 165, and 192). NextEra also performed additional analyses to evaluate the impact of parameter choices and uncertainties, resulting in three additional potentially cost-beneficial SAMAs (SAMAs 164, 172, and 195). In addition, NextEra performed a sensitivity analysis accounting for the additional risk of seismic events and identified one additional SAMA (SAMA 193) as being potentially cost beneficial. NextEra has indicated that all seven potentially cost-beneficial SAMAs will be entered into the Seabrook long-range plan development process for further implementation consideration.

NextEra provided a sensitivity analysis of the meteorological model using the EPA's CALMET wind field model (Hanna 2013; URS 2013). NextEra's analysis indicated that the use of the more complex CALMET model could potentially increase the calculated benefit of a SAMA by about 32 percent. The NRC staff determined that if the CALMET model was used in the baseline SAMA analysis and NextEra's uncertainty factor was applied, several additional SAMAs would be identified as potentially cost-beneficial including: SAMAs 13, 24, 44, 55, 56, 77, 96, 108, 109, 147, 163, 167, 168, 169, and 170.

However, based on an analysis of the conservatisms used in NextEra's baseline analysis and the overestimation of the increased benefits associated with NextEra's EI determination, the NRC staff concludes that NextEra's SAMA analysis was performed in a more conservative manner relative to accepted practices used in other applicant's evaluation of severe accidents. The NRC staff further concluded that NextEra's results represent a reasonable assessment of the identification of potentially cost beneficial SAMAs notwithstanding any variations resulting from the use of the more complex CALMET wind field model. Therefore, the NRC staff finds that SAMAs 157, 165, 164, 172, 192, 193, and 195 are the only SAMAs that should be considered as being potentially cost-beneficial.

Regarding the entire SAMA analysis, the NRC staff reviewed the NextEra analysis and concludes that the methods used and their implementation were acceptable. The treatment of SAMA benefits and costs support the general conclusion that the SAMA evaluations performed by NextEra are reasonable and sufficient for the license renewal submittal.

The NRC staff agrees with NextEra's identification of areas in which risk can be further reduced in a potentially cost-beneficial manner through the implementation of the identified, potentially cost-beneficial SAMAs. Given the potential for cost-beneficial risk reduction, the NRC staff agrees that further evaluation of these SAMAs by NextEra is warranted. However, the applicant stated that the seven potentially cost-beneficial SAMAs are not aging-related in that they do not involve aging management of passive, long-lived systems, structures, or components during the period of extended operation. Therefore, the NRC staff concludes that they need not be implemented as part of license renewal pursuant to 10 CFR Part 54.

5.4 References

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6.0 ENVIRONMENTAL IMPACTS OF THE URANIUM FUEL CYCLE, SOLID WASTE MANAGEMENT, AND GREENHOUSE GAS

6.1 The Uranium Fuel Cycle

This section addresses issues related to the uranium fuel cycle and solid waste management during the period of extended operation (listed in Table 6–1). The uranium cycle includes uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transportation of radioactive materials and management of low-level wastes and high-level wastes related to uranium fuel cycle activities. The generic potential impacts of the radiological and nonradiological environmental impacts of the uranium fuel cycle and transportation of nuclear fuel and wastes are described in detail in the Generic Environmental Impact Statement (GEIS) (NRC 1996, 1999, 2013a). They are based, in part, on the generic impacts provided in Title 10, Part 51.51(b) of the *Code of Federal Regulations* (10 CFR 51.51(b)), Table S-3, "Table of Uranium Fuel Cycle Environmental Data," and in 10 CFR 51.52(c), Table S-4, "Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor."

Table 6–1. Issues Related to the Uranium Fuel Cycle and Solid Waste Management

There are nine generic issues related to the fuel cycle and waste management. There are no site-specific issues.

Issues	GEIS Sections[(a)]	Category
Offsite radiological impacts (individual effects from other than the disposal of spent fuel & high-level waste)	6.1; 6.2.1; 6.2.2.1; 6.2.2.3; 6.2.3; 6.2.4; 6.6	1
Offsite radiological impacts (collective effects)	6.1; 6.2.2.1; 6.2.3; 6.2.4; 6.6	1
Offsite radiological impacts (spent fuel & high-level waste disposal)	6.1; 6.2.2.1; 6.2.3; 6.2.4; 6.6	1
Nonradiological impacts of the uranium fuel cycle	6.1; 6.2.2.6; 6.2.2.7; 6.2.2.8; 6.2.2.9; 6.2.3; 6.2.4; 6.6	1
Low-level waste storage & disposal	6.1; 6.2.2.2;6.4.2; 6.4.3; 6.4.3.1; 6.4.3.2; 6.4.3.3; 6.4.4; 6.4.4.1; 6.4.4.2; 6.4.4.3; 6.4.4.4; 6.4.4.5; 6.4.4.5.1; 6.4.4.5.2; 6.4.4.5.3; 6.4.4.5.4; 6.4.4.6;6.6	1
Mixed waste storage & disposal	6.4.5.1; 6.4.5.2; 6.4.5.3; 6.4.5.4; 6.4.5.5; 6.4.5.6; 6.4.5.6.1; 6.4.5.6.2; 6.4.5.6.3; 6.4.5.6.4; 6.6	1
Onsite spent fuel	6.1; 6.4.6; 6.4.6.1; 6.4.6.2; 6.4.6.3; 6.4.6.4; 6.4.6.5; 6.4.6.6; 6.4.6.7; 6.6	1
Nonradiological waste	6.1; 6.5; 6.5.1; 6.5.2; 6.5.3; 6.6	1
Transportation	6.1; 6.3.1; 6.3.2.3; 6.3.3; 6.3.4; 6.6, Addendum 1	1

[(a)] NRC 1996

The U.S. Nuclear Regulatory Commission (NRC) staff's evaluation of the environmental impacts associated with spent nuclear fuel is addressed in two issues in Table 6–1, "Offsite radiological

impacts (spent fuel and high-level waste disposal)" and "Onsite spent fuel." However, as explained later in this chapter, the scope of the evaluation of these two issues in this supplemental environmental impact statement (SEIS) has been revised from the discussion in the April 2013 supplement to the draft SEIS (NRC 2013a).

For the term of license renewal, the NRC staff did not find any new and significant information related to the remaining uranium fuel cycle and solid waste management issues listed in Table 6–1 during its review of the Seabrook Station Environmental Report (ER) (NextEra 2010), the site visit, and the scoping process. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS. For these Category 1 issues, the GEIS concludes that the impacts are SMALL, except for the issue, "Offsite radiological impacts (collective effects)," which the NRC has not assigned an impact level. This issue assesses the 100-year radiation dose to the U.S. population (i.e., collective effects or collective dose) from radioactive effluents released as part of the uranium fuel cycle for a nuclear power plant during the license renewal term compared to the radiation dose from natural background exposure. It is a comparative assessment for which there is no regulatory standard to base an impact level.

NRC's findings regarding the environmental impacts associated with the renewal of a power reactor operating license are contained in Table B-1, "Summary of Findings on [National Environmental Policy Act] NEPA Issues for License Renewal of Nuclear Power Plants." The table is located in Appendix B to Subpart A of 10 CFR Part 51, "Environmental Effect of Renewing the Operating License of a Nuclear Power Plant"[1] (Table B-1). In 1996, as part of the 10 CFR Part 51 license renewal rulemaking, the NRC determined that offsite radiological impacts of spent nuclear fuel and high-level waste disposal would be a Category 1 (generic) issue with no impact level assigned (61 FR 28467, 28495; June 5, 1996). The NRC analyzed the U.S. Environmental Protection Agency (EPA) generic repository standards and dose limits in existence at the time and concluded that offsite radiological impacts warranted a Category 1 determination (61 FR 28467, 28478; June 5, 1996). In its 2009 proposed rule, the NRC stated its intention to reaffirm that determination (74 FR 38117, 38127; July 31, 2009).

For the offsite radiological impacts resulting from spent fuel and high-level waste disposal and the onsite storage of spent fuel, which will occur after the reactor has been permanently shut down, the NRC's Waste Confidence Decision and Rule historically represented the Commission's generic determination that spent fuel can continue to be stored safely and without significant environmental impacts for a period of time after the end of the licensed life for operation. This generic determination meant that the NRC did not need to consider the storage of spent fuel after the end of a reactor's licensed life for operation in NEPA documents that support its reactor and spent fuel storage application reviews.

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

On December 23, 2010, the Commission published in the *Federal Register* a revision of the Waste Confidence Decision and Rule to reflect information gained from experience in the storage of spent fuel and the increased uncertainty in the siting and construction of a permanent geologic repository for the disposal of spent nuclear fuel and high-level waste (75 FR 81032

[1] The Commission issued Table B-1 in June 1996 (61 FR 28467; June 5, 1996). The Commission issued an additional rule in December 1996 that made minor clarifying changes to, and added language inadvertently omitted from, Table B-1 (61 FR 66537; December 18, 1996). The NRC revised Table B-1 and other regulations in 10 CFR Part 51, relating to the NRC's environmental review of a nuclear power plant's license renewal application in a 2013 rulemaking (78 FR 37282; June 20, 2013).

and 81037). In response to the 2010 Waste Confidence Decision and Rule, the States of New York, New Jersey, Connecticut, and Vermont—along with several other parties—challenged the Commission's NEPA analysis in the decision, which provided the regulatory basis for the rule. On June 8, 2012, the United States Court of Appeals, District of Columbia Circuit in New York v. NRC, 681 F.3d 471 (D.C. Cir. 2012) vacated the NRC's Waste Confidence Decision and Rule after finding that it did not comply with NEPA.

In response to the court's ruling, the Commission, in CLI-12-16 (NRC 2012a), determined that it would not issue licenses that rely upon the Waste Confidence Decision and Rule until the issues identified in the court's decision are appropriately addressed by the Commission. In CLI-12-16, the Commission also noted that the decision not to issue licenses only applied to final license issuance; all licensing reviews and proceedings should continue to move forward.

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

As discussed above, in New York v. NRC, 681 F.3d 471 (D.C. Cir. 2012), the court vacated the Commission's Waste Confidence Decision and Rule (10 CFR 51.23). In response to the court's vacatur, the Commission developed a revised rule and associated "Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel" (NUREG-2157, NRC-2014). Before the issuance of the revised rule and associated generic EIS, the NRC issued the 2013 final license renewal rule, which amended Table B-1—along with other 10 CFR part 51 regulations—it stated that upon finalization of the revised Waste Confidence rule (WCR) and accompanying technical analyses,[2] the NRC would make any necessary conforming amendments to Table B-1 (78 FR 37282, 37293; June 20, 2013).

The Continued Storage rule [3] and accompanying technical analyses were not finalized before the supplement to the draft SEIS was published. Thus, the environmental impacts for two issues, "Onsite spent fuel" and "Offsite radiological impacts (spent fuel and high-level waste disposal),"[4] were not completed prior to the April 2013 publication of the supplement to the draft SEIS for Seabrook (NRC 2013a). These two issues, which were contained in NRC's generic findings for license renewal of nuclear power plants codified in Table B-1, relied on the Commission's previous Waste Confidence Decision and Rule (10 CFR 51.23), which were vacated in New York v. NRC, 681 F.3d 471 (D.C. Cir. 2012). Therefore, the supplement to the Seabrook draft SEIS did not have an analysis of or make an impact determination on the environmental impacts associated with the onsite storage of spent nuclear fuel for the period

[2] At the time of 2013 final license renewal rule, the Continued Storage Rule was referred to by its long-standing historical moniker, Waste Confidence.

[3] For the purposes of this discussion, the Staff will generally refer to the Continued Storage Rule unless it is specifically referencing an earlier version of the rule.

[4] These two issues were renamed, ''Onsite storage of spent nuclear fuel' and ''Offsite radiological impacts of spent nuclear fuel and high-level waste disposal,'' respectively, by the 2013 license renewal rule. See "Revisions to Environmental Review for Renewal of Nuclear Power Plant Operating Licenses," 78 FR 37282–37324 (June 20, 2013).

after the licensed life for operation of a reactor and the offsite impacts of spent nuclear fuel and high-level waste disposal, including possible disposal in a deep geologic repository. Instead, the supplement to the Seabrook draft SEIS stated that it would rely on the revised 10 CFR 51.23 and its supporting Generic EIS to provide the NEPA analyses of the environmental impacts of spent fuel storage at the reactor site or at an away-from-reactor storage facility beyond the licensed life for reactor operations. On August 26, 2014, the Commission approved a revised rule at 10 CFR 51.23 and associated “Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel” (NUREG-2157, NRC 2014). Subsequently, on September 19, 2014, the NRC published the revised rule (79 FR 56238) in the *Federal Register* along with NUREG-2157 (79 FR 56263). The revised rule adopts the generic impact determinations made in NUREG-2157 and codifies the NRC’s generic determinations regarding the environmental impacts of continued storage of spent nuclear fuel beyond a reactor’s operating license (i.e., those impacts that could occur as a result of the storage of spent nuclear fuel at at-reactor or away-from-reactor sites after a reactor’s licensed life for operation and until a permanent repository becomes available). As directed by 10 CFR 51.23(b), the impacts assessed in NUREG-2157 regarding continued storage are deemed incorporated by rule into this Seabrook license renewal final SEIS.

In the revised 10 CFR 51.23 continued storage rule, the NRC made conforming changes to the two environmental issues in Table B-1 that were impacted by the vacated WCR: “Onsite spent fuel” and “Offsite radiological impacts (spent fuel and high-level waste disposal).” Although NUREG-2157 (the technical basis for revised 10 CFR 51.23) does not include high-level waste disposal in the analysis of impacts, it does address the technical feasibility of a repository in Appendix B of NUREG-2157 and concludes that a geologic repository for spent fuel is technically feasible and the same analysis applies to the feasibility of geologic disposal for high-level waste.

The Commission revised the Table B-1 finding for “Onsite storage of spent nuclear fuel” to add the phrase “during the license renewal term” to make clear that the SMALL impact is for the license renewal term only. Some minor clarifying changes are also made to the paragraph. The first paragraph of the column entry now reads, “During the license renewal term, SMALL. The expected increase in the volume of spent nuclear fuel from an additional 20 years of operation can be safely accommodated onsite during the license renewal term with small environmental impacts through dry or pool storage at all plants.” In addition, a new paragraph is added to address the impacts of onsite storage of spent fuel during the continued storage period. The second paragraph of the column entry reads, “For the period after the licensed life for reactor operations, the impacts of onsite storage of spent nuclear fuel during the continued storage period are discussed in NUREG-2157 and as stated in 10 CFR 51.23(b), shall be deemed incorporated into this issue.” The changes reflect that this issue covers the environmental impacts associated with the storage of spent nuclear fuel during the license renewal term as well as the period after the licensed life for reactor operations.

In addition, the Table B-1 entry for “Offsite radiological impacts of spent nuclear fuel and high-level waste disposal” was revised to reclassify the impact determination as a Category 1 issue with no impact level assigned. The finding column entry for this issue includes reference to EPA’s radiation protection standards for the high-level waste and spent nuclear fuel disposal component of the fuel cycle. Although the status of a repository, including a repository at Yucca Mountain, is uncertain and outside the scope of the generic environmental analysis conducted to support the revised 10 CFR 51.23, the NRC believes that the current radiation standards for Yucca Mountain are protective of public health and safety and the environment.

The changes to these two issues finalize the Table B-1 entries that the NRC had intended to promulgate in its 2013 license renewal rulemaking, but was unable to because the 2010 WCR had been vacated.

NUREG-2157 concludes that deep geologic disposal remains technically feasible, while the bases for the specific conclusions in Table B-1 are found elsewhere (e.g., the 1996 rule that issued Table B-1 and the 1996 license renewal GEIS, which provided the technical basis for that rulemaking, as reaffirmed by the 2013 rulemaking and final license renewal GEIS). Based on the revised 10 CFR 51.23, these two issues were revised accordingly in Table B-1.

CLI-14-08: Holding that Revised 10 CFR 51.23 and NUREG-2157 Satisfy NRC's NEPA Obligations for Continued Storage and Directing Staff to Account for Environmental Impacts In NUREG-2157

In CLI-14-08 (NRC 2014c), the Commission held that the revised 10 CFR 51.23 and associated NUREG-2157 cure the deficiencies identified by the court in New York v. NRC and stated that the rule satisfies the NRC's NEPA obligations with respect to continued storage for initial, renewed, and amended licenses for reactors.

Therefore, the April 2013 supplement to the Seabrook draft SEIS, which by rule now incorporates the impact determinations in NUREG-2157 regarding continued storage, contains an analysis for the generic issues of "Onsite storage of spent nuclear fuel" and "Offsite radiological impacts of spent nuclear fuel and high-level waste disposal" that satisfies NEPA. As the Commission noted in CLI-14-08, the NRC staff must account for these environmental impacts before finalizing its licensing decision in this proceeding.

To account for the revised 10 CFR 51.23 and associated NUREG-2157, and the impact determinations in NUREG-2157 regarding continued storage that are deemed incorporated into a SEIS for a renewed license, the staff analyzed whether the revised 10 CFR 51.23 and NUREG-2157 present new and significant information such that it could alter the staff's license renewal recommendation. As part of evaluating whether the information would alter the staff license renewal recommendation, the staff examined whether a supplement to the Seabrook draft SEIS is required under 10 CFR 51.72(a)(2). To merit a supplement, information must be both new and significant and it must bear on the proposed action or its impacts.

Requirements for Supplementing an EIS

As required by 10 CFR 51.72(a), the staff will prepare a supplement to the Seabrook draft SEIS if the proposed action (issuance of renewed operating licenses) has not been taken and:

(1) there are substantial changes in the proposed action that are relevant to environmental concerns; or

(2) there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts.

The applicant for the Seabrook renewed license has not proposed any changes to the proposed action in this case. Therefore, a supplement is not required under 10 CFR 51.72(a)(1).

The Commission has stated that new information would be considered significant if it presents "a seriously different picture of the environmental impact of the proposed project from what was previously envisioned." Union Electric Co. (Callaway Plant, Unit 2), CLI-11-5, 74 NRC 141, 167-68 (2011); Hydro Resources, Inc. (2929 Coors Road, Suite 101, Albuquerque, NM 87120), CLI-99-22, 50 NRC 3, 14 (1999) (citing Marsh v. Oregon Natural Resources Council, 490 U.S. 360, 373 (1989); Sierra Club v. Froehlke, 816 F.2d 205, 210 (5th Cir. 1987)).

In determining whether new information meets this “seriously different picture” standard, the NRC staff looks to, among other things: previous Commission decisions on claimed new and significant information, previous environmental analyses done for the proposed action at issue, and Marsh, which provides that agency decisions regarding the need to supplement an EIS based on new and significant information are subject to the “rule of reason.”

In other proceedings, the Commission explained that if it found any new information that presents a significant new environmental impact that should be addressed in site-specific environmental analyses, the Commission would supplement or otherwise incorporate the information into the environmental analyses as warranted. See CLI-12-15 (ADAMS Accession Number ML12159A152)). In doing so, the Commission will have provided access to the relevant information and the agency decision makers will have considered that information before a final decision on the matter is reached (Hydro Resources, Inc. (2929 Coors Road, Suite 101, Albuquerque, NM 87120), CLI-99-22, 50 NRC 3, 14 (1999)).

Analysis of Whether Revised 10 CFR 51.23 and NUREG-2157 Are New and Significant Information

As discussed above, the NRC staff did not evaluate or make an impact determination on the impacts of continued storage of spent fuel beyond the licensed life for reactor operations in the April 2013 supplement to the Seabrook draft SEIS. Instead, the NRC staff, in the supplement to the Seabrook draft SEIS, stated that it would rely on the revised 10 CFR 51.23 and its supporting generic EIS (i.e., NUREG-2157) to provide the NEPA analyses of the environmental impacts of spent fuel storage at the reactor site or at an away-from-reactor storage facility beyond the licensed life for reactor operations. By virtue of revised 10 CFR 51.23, the Seabrook final SEIS now incorporates the impact determinations in NUREG-2157 regarding continued storage such that there is a complete analysis of the environmental impacts associated with spent fuel storage beyond the licensed life for reactor operations. The NRC staff has determined that the findings in NUREG-2157 do not paint a seriously different picture from what was previously presented and analyzed in the supplement to the Seabrook draft SEIS for the license renewal term. Instead, NUREG-2157 does exactly what the supplement to the Seabrook draft SEIS indicated it would do. As discussed above, the public extensively participated in the 10 CFR 51.23 rulemaking process following the court’s remand in New York v. NRC.

The NRC staff also considered whether the revised rule and NUREG-2157 altered the NRC staff’s recommendation in the April 2013 supplement to the Seabrook draft SEIS that the adverse environmental impacts of license renewal for Seabrook are not great enough to deny the option of license renewal for energy planning decision-makers. After analyzing the impact determinations in NUREG-2157, discussed below, the staff concludes that they do not alter the NRC staff’s license renewal recommendation.

At-Reactor Storage

The analysis in NUREG-2157 concludes that the potential impacts of at-reactor storage during the short-term timeframe (the first 60 years after the end of licensed life for operations of the reactor) would be SMALL (see Section 4.20 of NUREG-2157). Further, the analysis in NUREG-2157 states that disposal of the spent fuel by the end of the short-term timeframe is the most likely outcome (see Section 1.2 of NUREG-2157). Thus, the potential impacts of at-reactor continued storage during the short-term timeframe are consistent with the evaluation in the Seabrook final SEIS regarding the impacts of onsite storage of spent fuel during the license renewal term.

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

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

As previously discussed, the NRC found in NUREG-2157 that disposal of the spent fuel is most likely to occur by the end of the short-term timeframe. Therefore, disposal during the long-term timeframe is less likely, and the scenario depicted in the indefinite timeframe—continuing to store spent nuclear fuel indefinitely—is unlikely. As a result, the most likely impacts of the continued storage of spent fuel are those considered in the short-term timeframe. In the unlikely event that fuel remains on site into the long-term and indefinite timeframes, the associated impact ranges in NUREG-2157 reflect the accordingly greater uncertainties regarding the potential impacts over these very long periods of time. Taking into account the impacts that the NRC considers most likely, which are SMALL; the greater uncertainty reflected in the ranges in the long-term and indefinite timeframes compared to the greater certainty in the SMALL findings; and the relative likelihood of the timeframes, the staff finds that the impact determinations for at-reactor storage presented in NUREG-2157 do not present a seriously different picture of the environmental impacts compared to the staff's analysis in Section 6.1, The Uranium Fuel Cycle, of the supplement of the Seabrook draft SEIS regarding the impacts from spent fuel storage during the license renewal term. The staff concludes that the environmental impacts from at-reactor storage do not alter the NRC staff's license renewal recommendation.

Away-From-Reactor Storage

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

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

The potential impacts to historic and cultural resources during the short-term storage timeframe would range from SMALL to LARGE. The magnitude of adverse effects on historic properties and impacts on historic and cultural resources largely depends on where facilities are sited, what resources are present, the extent of proposed land disturbance, whether the area has been previously surveyed to identify historic and cultural resources, and if the licensee has management plans and procedures that are protective of historic and cultural resources. Even a small amount of ground disturbance (e.g., clearing and grading) could affect a small but significant resource. In most instances, placement of storage facilities on the site can be adjusted to minimize or avoid impacts on any historic and cultural resources in the area. However, the NRC recognizes that this may not always be possible. The NRC's site-specific environmental review and compliance with the NHPA process could identify historic properties, identify adverse effects, and potentially resolve adverse effects on historic properties and impacts on other historic and cultural resources. Under the NHPA, mitigation does not eliminate a finding of adverse effect on historic properties. The potential impacts to historic and cultural resources during the long-term and indefinite storage timeframes would also range from SMALL to LARGE. This range takes into consideration routine maintenance and monitoring (i.e., no ground-disturbing activities), the absence or avoidance of historic and cultural resources, and potential ground-disturbing activities that could affect historic and cultural resources. The analysis also considers uncertainties inherent in analyzing this resource area over long timeframes. These uncertainties include any future discovery of previously unknown historic and cultural resources; resources that gain significance within the vicinity and the viewshed (e.g., nomination of a historic district) due to improvements in knowledge, technology, and excavation techniques and changes associated with predicting resources that future generations will consider significant. If construction of a DTS and replacement of the ISFSI and DTS occurs in an area with no historic or cultural resource present or construction occurs in a previously disturbed area that allows avoidance of historic and cultural resources then impacts would be SMALL. By contrast, a MODERATE or LARGE impact could result if historic and cultural resources are present at a site and, because they cannot be avoided, are impacted by ground-disturbing activities during the long-term and indefinite timeframes.

Impacts on Federally listed species, designated critical habitat, and essential fish habitat would be based on site-specific conditions and determined as part of consultations required by the Endangered Species Act and the Magnuson-Stevens Fishery Conservation and Management Act.

Continued storage of spent nuclear fuel at an away-from-reactor ISFSI is not expected to cause disproportionately high and adverse human health and environmental effects on minority and low-income populations. As indicated in the Commission's policy statement on environmental justice, should the NRC receive an application for a proposed away-from-reactor ISFSI, a site-specific NEPA analysis would be conducted, and this analysis would include consideration of environmental justice impacts. Thus, the staff finds that the impact determinations for away-from-reactor storage presented in NUREG-2157 do not present a seriously different picture of the environmental impacts compared to the NRC staff's analysis in Section 6.1, The Uranium Fuel Cycle, of the supplement to the Seabrook draft SEIS regarding the impacts from spent fuel storage during the license renewal term. The staff concludes that the environmental impacts from away-from-reactor storage do not alter the NRC staff's license renewal recommendation.

Cumulative Impacts

NUREG-2157 examines the incremental impact of continued storage on each resource area analyzed in NUREG-2157 in combination with other past, present, and reasonably foreseeable future actions. NUREG-2157 indicates ranges of potential cumulative impacts for multiple resource areas (see Section 6.5 of NUREG-2157). However, these ranges are primarily driven by impacts from activities other than the continued storage of spent fuel at the reactor site; the impacts from these other activities would occur regardless of whether spent nuclear fuel is stored during the continued storage period. In the short-term timeframe, which is the most likely timeframe for the disposal of the fuel, the potential impacts of continued storage for at-reactor storage are SMALL and would, therefore, not be a significant contributor to the cumulative impacts. In the longer timeframes for at-reactor storage, or in the less likely case of away-from-reactor storage, some of the impacts from the storage of spent nuclear fuel could be greater than SMALL.

As noted in NUREG-2157, other Federal and non-Federal activities occurring during the longer timeframes include uncertainties as well. It is primarily these uncertainties (i.e., those associated with activities other than continued storage) that contribute to the ranges of potential cumulative impacts discussed throughout Chapter 6 of NUREG-2157 and summarized in Table 6-4 of NUREG-2157. Because, as stated above, the impacts from these other activities would occur regardless of whether continued storage occurs, the overall cumulative impact conclusions in NUREG-2157 would still be the stated ranges regardless of whether there are impacts of continued storage from any individual licensing action.

Taking into account the impacts that the NRC considers most likely, which are SMALL; the uncertainty reflected by the ranges in some impacts; and the relative likelihood of the timeframes, the staff finds that NUREG-2157 does not present a seriously different picture of the environmental impacts compared to the NRC staff's analysis regarding the cumulative impacts of relicensing Seabrook from radiological wastes from the fuel cycle (which includes the impacts associated with spent nuclear fuel storage). The staff concludes that the cumulative environmental impacts do not alter the NRC staff's license renewal recommendation.

Overall Conclusion

The NRC staff analyzed the revised 10 CFR 51.23 and the conclusions in NUREG-2157 to determine whether they present a seriously different picture of the environmental impacts that were discussed in the Seabrook draft SEIS.

The supplement to the Seabrook draft SEIS indicated that it would rely on the revised rule and GEIS for its consideration of the environmental impacts of spent fuel storage and the offsite radiological impacts of spent nuclear fuel and high-level waste disposal. The Commission conducted a rulemaking, which involved extensive public participation, and has now adopted a revised rule and made generic determinations with respect to those issues, which are discussed in NUREG-2157 and incorporated into the Seabrook final SEIS. As previously stated, the Commission held in CLI-14-08 that the revised 10 CFR 51.23 and associated NUREG-2157 satisfies the NRC's NEPA obligations with respect to continued storage as it pertains to the issues, "Onsite storage of spent nuclear fuel" and "Offsite radiological impacts of spent nuclear fuel and high level waste disposal" for a renewed license for Seabrook. Therefore, the Seabrook final SEIS incorporates the generic impact determination codified in the revised rule and supporting NUREG-2157 and does not need to be supplemented.

The revised rule and NUREG-2157 also do not change the NRC staff's determination in the supplement to the Seabrook draft SEIS that the adverse environmental impacts of license renewal for Seabrook are not great enough to deny the option of license renewal for energy planning decision-makers. The analysis in NUREG-2157 supports the conclusion that the most likely impacts of continued storage are those discussed for at-reactor storage. For continued at-reactor storage, impacts in the short-term timeframe would be SMALL. Over the longer timeframes, impacts to certain resource areas would be a range (for historic and cultural resources during both the long-term and indefinite timeframes the range is SMALL to LARGE and for nonradioactive waste during the indefinite timeframe the range is SMALL to MODERATE). In NUREG-2157, the NRC stated that disposal of the spent fuel before the end of the short-term timeframe is most likely. There are inherent uncertainties in determining impacts for the long-term and indefinite timeframes, and, with respect to some resource areas, those uncertainties could result in impacts that, although less likely, could be larger than those that are to be expected at most sites and have therefore been presented as ranges rather than as a single impact level. Those uncertainties exist, however, regardless of whether the impacts are analyzed generically or site-specifically. As a result, these impact ranges provide correspondingly more limited insights to the decisionmaker in the overall picture of the environmental impacts from the proposed action (i.e., license renewal).

The NRC staff concludes that when weighed against the array of other fuel cycle impacts presented in the April 2013 supplement to the Seabrook draft SEIS, and the more-likely impacts of continued storage during the short-term timeframe in NUREG-2157, which are SMALL, the uncertainties associated with the impact ranges for the long-term and indefinite timeframes do not present a seriously different picture of the direct, indirect, and cumulative environmental impacts compared to the NRC staff's analysis of the impacts from issuance of a renewed operating license for Seabrook attributable to the uranium fuel cycle and waste management (which includes the impacts associated with spent fuel storage). Additionally, for the reasons discussed above, continued at-reactor storage is not expected to contribute noticeably to cumulative impacts. In addition, the revised rule and the impact determinations contained in NUREG-2157 also do not alter the NRC staff's recommendation in the April 2013 supplement to the Seabrook draft SEIS that the adverse environmental impacts of license renewal for Seabrook are not great enough to deny the option of license renewal for energy planning decisionmakers.

6.2 Greenhouse Gas Emissions

This section discusses the potential impacts from greenhouse gases (GHGs) emitted from the nuclear fuel cycle. The GEIS does not directly address these emissions, and its discussion is limited to an inference that substantial carbon dioxide (CO_2) emissions may occur if coal- or oil-fired alternatives to license renewal are carried out.

6.2.1 Existing Studies

Since the development of the GEIS, the relative volumes of GHGs emitted by nuclear and other electricity-generating methods have been widely studied. However, estimates and projections of the carbon footprint of the nuclear power lifecycle vary depending on the type of study done. Additionally, considerable debate exists among researchers regarding the relative effects of nuclear and other forms of electricity generation on GHG emissions. Existing studies on GHG emissions from nuclear power plants generally take one of the following forms:

- qualitative discussions of the potential to use nuclear power to reduce GHG emissions and mitigate global warming
- technical analyses and quantitative estimates of the actual amount of GHGs generated by the nuclear fuel cycle or entire nuclear power plant life cycle and comparisons to the operational or life cycle emissions from other energy generation alternatives

6.2.1.1 Qualitative Studies

The qualitative studies consist primarily of broad, large-scale public policy or investment evaluations on whether an expansion of nuclear power is likely to be a technically, economically, or politically workable means of achieving global GHG reductions. Studies found by the NRC staff during the subsequent literature search include the following:

- Evaluations determined if investments in nuclear power in developing countries should be accepted as a flexibility mechanism to assist industrialized nations in achieving their GHG reduction goals under the Kyoto Protocols (IAEA 2000; NEA 2002; Schneider 2000). Ultimately, the parties to the Kyoto Protocol did not approve nuclear power as a component under the Clean Development Mechanism (CDM) due to safety and waste disposal concerns (NEA 2002).
- Analyses were developed to assist governments, including the U.S. Government, in making long-term investment and public policy decisions in nuclear power (Hagen, et al. 2001; Keepin 1988; MIT 2003).

Although the qualitative studies sometimes reference and analyze the existing quantitative estimates of GHGs produced by the nuclear fuel cycle or life cycle, their conclusions generally rely heavily on discussions of other aspects of nuclear policy decisions and investment such as safety, cost, waste generation, and political acceptability. Therefore, these studies are typically not directly applicable to an evaluation of GHG emissions associated with the proposed license renewal for a given nuclear power plant.

6.2.1.2 Quantitative Studies

A large number of technical studies, including calculations and estimates of the amount of GHGs emitted by nuclear and other power generation options, are available in the literature and were useful to the NRC staff's efforts to address relative GHG emission levels. Examples of

these studies include—but are not limited to—Mortimer (1990), Andseta et al. (1998), Spadaro (2000), Storm van Leeuwen and Smith (2005), Fritsche (2006), Parliamentary Office of Science and Technology (POST) (2006), Atomic Energy Authority (AEA) (2006), Weisser (2006), Fthenakis and Kim (2007), and Dones (2007). In addition, Sovacool (2008) provides a review and synthesis of studies in existence through 2008; however, the Sovacool synthesis ultimately uses only 19 of the 103 studies initially considered. The remaining 84 were excluded because they were more than 10 years old, not publicly available, available only in a language other than English, or they presented methodological challenges by relying on inaccessible data, providing overall GHG estimates without allocating relative GHG impacts to different parts of the nuclear lifecycle, or they were otherwise not methodologically explicit.

Comparing these studies, and others like them, is difficult because the assumptions and components of the lifecycles that the authors evaluate vary widely. Examples of areas in which differing assumptions make comparing the studies difficult include the following:

- energy sources that may be used to mine uranium deposits in the future;
- reprocessing or disposal of spent nuclear fuel;
- current and potential future processes to enrich uranium and the energy sources that will power them;
- estimated grades and quantities of recoverable uranium resources;
- estimated grades and quantities of recoverable fossil fuel resources;
- estimated GHG emissions other than CO_2, including the conversion to CO_2 equivalents per unit of electric energy produced;
- performance of future fossil fuel power systems;
- projected capacity factors for alternatives means of generation; and
- current and potential future reactor technologies.

In addition, studies may vary with respect to whether all or parts of a power plant’s lifecycle are analyzed. For example, a full lifecycle analysis will typically address plant construction, operations, resource extraction (for fuel and construction materials), and decommissioning. A partial lifecycle analysis primarily focuses on operational differences. In addition, as Sovacool (2008) noted, studies vary greatly in terms of age, data availability, and methodological transparency.

In the case of license renewal, a GHG analysis for that portion of the plant’s lifecycle (operation for an additional 20 years) would not involve GHG emissions associated with construction because construction activities have already been completed at the time of relicensing. In addition, the proposed action of license renewal would also not involve additional GHG emissions associated with facility decommissioning because that decommissioning must occur whether the facility is relicensed or not. However, in some of the above-mentioned studies, the specific contribution of GHG emissions from construction, decommissioning, or other portions of a plant’s lifecycle cannot be clearly separated from one another. In such cases, an analysis of GHG emissions would overestimate the GHG emissions attributed to a specific portion of a plant’s lifecycle. As Sovacool (2008) noted, many of the available analyses provide markedly lower GHG emissions per unit of plant output when one assumes that a power plant operates for a longer period of time. Nonetheless, these studies supply some meaningful information with respect to the relative magnitude of the emissions among nuclear power plants and other forms of electric generation, as discussed in the following sections.

In Tables 6.2-1, 6.2-2, and 6.2-3, the NRC staff presents the results of the above-mentioned quantitative studies to supply a weight-of-evidence evaluation of the relative GHG emissions that may result from the proposed license renewal as compared to the potential alternative use of coal-fired, natural gas-fired, and renewable generation. Most studies from Mortimer (1990) onward (through Sovacool 2008) suggest that uranium ore grades and uranium enrichment processes are leading determinants in the ultimate GHG emissions attributable to nuclear power generation. These studies show that the relatively lower order of magnitude of GHG emissions from nuclear power, when compared to fossil-fueled alternatives (especially natural gas), could potentially disappear if available uranium ore grades drop sufficiently while enrichment processes continued to rely on the same technologies.

Sovacool's synthesis of 19 existing studies found that nuclear power generation causes carbon emissions in a range of 1.4 grams of carbon equivalent per kilowatt-hour (g C_{eq}/kWh) to 288 g C_{eq}/kWh, with a mean value of 66 g C_{eq}/kWh. The results of his synthesis and the results of others' efforts are included in the tables in this chapter.

6.2.1.3 Summary of Nuclear Greenhouse Gas Emissions Compared to Coal

Considering that coal fuels the largest share of electricity generation in the U.S., and that its burning results in the largest emissions of GHGs for any of the likely alternatives to nuclear power generation (including Seabrook), most of the available quantitative studies focused on comparisons of the relative GHG emissions of nuclear to coal-fired generation. The quantitative estimates of the GHG emissions associated with the nuclear fuel cycle—and, in some cases, the nuclear lifecycle—as compared to an equivalent coal-fired plant, are presented in Table 6–2. This table does not include all existing studies, but it gives an illustrative range of estimates developed by various sources.

Table 6–2. Nuclear Greenhouse Gas Emissions Compared to Coal

Source	GHG Emission Results
Mortimer (1990)	Nuclear—230,000 tons CO_2 Coal—5,912,000 tons CO_2 Note: Future GHG emissions from nuclear to increase because of declining ore grade.
Andseta et al. (1998)	Nuclear energy produces 1.4% of the GHG emissions compared to coal. Note: Future reprocessing and use of nuclear-generated electrical power in the mining and enrichment steps are likely to change the projections of earlier authors, such as Mortimer (1990).
Spadaro (2000)	Nuclear—2.5–5.7 g C_{eq}/kWh Coal—264–357 g C_{eq}/kWh
Storm van Leeuwen & Smith (2005)	Authors did not evaluate nuclear versus coal.
Fritsche (2006) (Values estimated from graph in Figure 4)	Nuclear—33 g C_{eq}/kWh Coal—950 g C_{eq}/kWh
POST (2006) (Nuclear calculations from AEA, 2006)	Nuclear—5 g C_{eq}/kWh Coal—>1000 g C_{eq}/kWh Note: Decrease of uranium ore grade to 0.03% would increase nuclear to 6.8 g C_{eq}/kWh. Future improved technology and carbon capture and storage could reduce coal-fired GHG emissions by 90%.
Weisser (2006) (Compilation of results from other studies)	Nuclear—2.8–24 g C_{eq}/kWh Coal—950–1250 g C_{eq}/kWh
Fthenakis & Kim (2007)	Authors did not evaluate nuclear versus coal.
Dones (2007)	Author did not evaluate nuclear versus coal.
Sovacool (2008)	Nuclear—66 g C_{eq}/kWh Coal—960 to 1,050 g C_{eq}/kWh (coal adopted from Gagnon et al. 2002)

6.2.1.4 Summary of Nuclear Greenhouse Gas Emissions Compared to Natural Gas

The quantitative estimates of the GHG emissions associated with the nuclear fuel cycle—and, in some cases, the nuclear lifecycle—as compared to an equivalent natural gas-fired plant, are presented in Table 6–3. This table does not include all existing studies, but it gives an illustrative range of estimates developed by various sources.

Table 6–3. Nuclear Greenhouse Gas Emissions Compared to Natural Gas

Source	GHG Emission Results
Mortimer (1990)	Author did not evaluate nuclear versus natural gas.
Andseta et al. (1998)	Author did not evaluate nuclear versus natural gas.
Spadaro (2000)	Nuclear—2.5–5.7 g C_{eq}/kWh Natural Gas—120–188 g C_{eq}/kWh
Storm van Leeuwen & Smith (2005)	Nuclear fuel cycle produces 20–33% of the GHG emissions compared to natural gas (at high ore grades). Note: Future nuclear GHG emissions to increase because of declining ore grade.
Fritsche (2006) (Values estimated from graph in Figure 4)	Nuclear—33 g C_{eq}/kWh Co-generation combined cycle natural gas—150 g C_{eq}/kWh
POST (2006) (Nuclear calculations from AEA, 2006)	Nuclear—5 g C_{eq}/kWh Natural Gas—500 g C_{eq}/kWh Note: Decrease of uranium ore grade to 0.03% would increase nuclear to 6.8 g Ceq/kWh. Future improved technology and carbon capture and storage could reduce natural gas GHG emissions by 90%.
Weisser (2006) (Compilation of results from other studies)	Nuclear—2.8–24 g C_{eq}/kWh Natural Gas—440–780 g C_{eq}/kWh
Fthenakis & Kim (2007)	Authors did not evaluate nuclear versus natural gas.
Dones (2007)	Author critiqued methods and assumptions of Storm van Leeuwen and Smith (2005), and concluded that the nuclear fuel cycle produces 15–27% of the GHG emissions of natural gas.
Sovacool (2008)	Nuclear—66 g C_{eq}/kWh Natural Gas—443 g C_{eq}/kWh (natural gas adopted from Gagnon et al. 2002)

6.2.1.5 Summary of Nuclear Greenhouse Gas Emissions Compared to Renewable Energy Sources

The quantitative estimates of the GHG emissions associated with the nuclear fuel cycle, as compared to equivalent renewable energy sources, are presented in Table 6–4. Calculation of GHG emissions associated with these sources is more difficult than the calculations for nuclear energy and fossil fuels because of the large variation in efficiencies due to their different sources and locations. For example, the efficiency of solar and wind energy is highly dependent on the location in which the power generation facility is installed. Similarly, the range of GHG emissions estimates for hydropower varies greatly depending on the type of dam or reservoir involved (if used at all). Therefore, the GHG emissions estimates for these energy sources have a greater range of variability than the estimates for nuclear and fossil fuel sources. As noted in Section 6.2.1.2, the following table does not include all existing studies, but it gives an illustrative range of estimates developed by various sources.

Table 6–4. Nuclear Greenhouse Gas Emissions Compared to Renewable Energy Sources

Source	GHG Emission Results
Mortimer (1990)	Nuclear—230,000 tons CO_2 Hydropower—78,000 tons CO_2 Wind power—54,000 tons CO_2 Tidal power—52,500 tons CO_2 Note: Future GHG emissions from nuclear to increase because of declining ore grade.
Andseta et al. (1998)	Author did not evaluate nuclear versus renewable energy sources.
Spadaro (2000)	Nuclear—2.5–5.7 g C_{eq}/kWh Solar Photovoltaic (PV)—27.3–76.4 g C_{eq}/kWh Hydroelectric—1.1–64.6 g C_{eq}/kWh Biomass—8.4–16.6 g C_{eq}/kWh Wind—2.5–13.1 g C_{eq}/kWh
Storm van Leeuwen & Smith (2005)	Author did not evaluate nuclear versus renewable energy sources.
Fritsche (2006) (Values estimated from graph in Figure 4)	Nuclear—33 g C_{eq}/kWh Solar PV—125 g C_{eq}/kWh Hydroelectric—50 g C_{eq}/kWh Wind—20 g C_{eq}/kWh
POST (2006) (Nuclear calculations from AEA, 2006)	Nuclear—5 g C_{eq}/kWh Biomass—25–93 g C_{eq}/kWh Solar PV—35–58 g C_{eq}/kWh Wave/Tidal—25–50 g C_{eq}/kWh Hydroelectric—5–30 g C_{eq}/kWh Wind—4.64–5.25 g C_{eq}/kWh Note: Decrease of uranium ore grade to 0.03% would increase nuclear to 6.8 g C_{eq}/kWh
Weisser (2006) (Compilation of results from other studies)	Nuclear—2.8–24 g C_{eq}/kWh Solar PV—43–73 g C_{eq}/kWh Hydroelectric—1–34 g C_{eq}/kWh Biomass—35–99 g C_{eq}/kWh Wind—8–30 g C_{eq}/kWh
Fthenakis & Kim (2007)	Nuclear—16–55 g C_{eq}/kWh Solar PV—17–49 g C_{eq}/kWh
Dones (2007)	Author did not evaluate nuclear versus renewable energy sources.
Sovacool (2008)	Nuclear—66 g C_{eq}/kWh Wind—9–10 g C_{eq}/kWh Hydroelectric (small, distributed)—10–13 g C_{eq}/kWh Biomass digester—11 g C_{eq}/kWh Solar thermal—13 g C_{eq}/kWh Biomass—14–35 g C_{eq}/kWh Solar PV—32 g C_{eq}/kWh Geothermal (hot, dry rock)—38 g C_{eq}/kWh (solar PV value adopted from Fthenakis et al. 2008; all other renewable generation values adopted from Pehnt 2006)

6.2.2 Conclusions: Relative Greenhouse Gas Emissions

The sampling of data presented in Tables 6.2-1, 6.2-2, and 6.2-3 demonstrates the challenges of any attempt to determine the specific amount of GHG emission attributable to nuclear energy production sources, as different assumptions and calculation methods will yield differing results. The differences and complexities in these assumptions and analyses will further increase when they are used to project future GHG emissions. Nevertheless, several conclusions can be drawn from the information presented.

First, the various studies show a general consensus that nuclear power currently produces fewer GHG emissions than fossil-fuel-based electrical generation. The GHG emissions from a complete nuclear fuel cycle currently range from 2.5–55 grams of Carbon equivalent per Kilowatt hour (g C_{eq}/kWh), as compared to the use of coal plants (264–1250 g C_{eq}/kWh) and natural gas plants (120–780 g C_{eq}/kWh). The studies also give estimates of GHG emissions from five renewable energy sources based on current technology. These estimates included solar-photovoltaic (17–125 g C_{eq}/kWh), hydroelectric (1–64.6 g C_{eq}/kWh), biomass (8.4–99 g C_{eq}/kWh), wind (2.5–30 g C_{eq}/kWh), and tidal (25–50 g C_{eq}/kWh). The range of these estimates is wide, but the general conclusion is that current GHG emissions from the nuclear fuel cycle are of the same order of magnitude as from these renewable energy sources.

Second, the studies show no consensus regarding future relative GHG emissions from nuclear power and other sources of electricity. There is substantial disagreement among the various authors about the GHG emissions associated with declining uranium ore concentrations, future uranium enrichment methods, and other factors to include changes in technology. Similar disagreement exists about future GHG emissions associated with coal and natural gas for electricity generation. Even the most conservative studies conclude that the nuclear fuel cycle currently produces fewer GHG emissions than fossil-fuel-based sources and is expected to continue to do so in the near future. The primary difference between the authors is the projected cross-over date (the time at which GHG emissions from the nuclear fuel cycle exceed those of fossil-fuel-based sources) or whether cross-over will actually occur.

Considering the current estimates and future uncertainties, it appears that GHG emissions associated with the proposed Seabrook relicensing action are likely to be lower than those associated with fossil-fuel-based energy sources. The NRC staff bases this conclusion on the following rationale:

- As shown in Table 6–2 and Table 6–3, the current estimates of GHG emissions from the nuclear fuel cycle are far below those for fossil-fuel-based energy sources.
- License renewal of a nuclear power plant like Seabrook will involve continued GHG emissions due to uranium mining, processing, and enrichment, but it will not result in increased GHG emissions associated with plant construction or decommissioning (as the plant will have to be decommissioned at some point whether the license is renewed or not).
- Few studies predict that nuclear fuel cycle emissions will exceed those of fossil fuels within a timeframe that includes the Seabrook period of extended operation. Several studies suggest that future extraction and enrichment methods, the potential for higher grade resource discovery, and technology improvements could extend this timeframe.

With respect to comparison of GHG emissions among the proposed Seabrook license renewal action and renewable energy sources, it appears likely that there will be future technology

improvements and changes in the type of energy used for mining, processing, and constructing facilities of all types. Currently, the GHG emissions associated with the nuclear fuel cycle and renewable energy sources are within the same order of magnitude. Because nuclear fuel production is the most significant contributor to possible future increases in GHG emissions from nuclear power—and because most renewable energy sources lack a fuel component—it is likely that GHG emissions from renewable energy sources would be lower than those associated with Seabrook at some point during the period of extended operation.

The NRC staff also supplies an additional discussion about the contribution of GHG to cumulative air quality impacts in Section 4.11.2 of this supplemental environmental impact statement (SEIS).

6.3 References

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7.0 ENVIRONMENTAL IMPACTS OF DECOMMISSIONING

Environmental impacts from the activities associated with the decommissioning of any reactor before, or at the end of, an initial or renewed license are evaluated in the *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities: Supplement 1, Regarding the Decommissioning of Nuclear Power Reactors*, NUREG-0586, Supplement 1 (NRC 2002). The U.S. Nuclear Regulatory Commission (NRC) staff's evaluation of the environmental impacts of decommissioning—presented in NUREG-0586, Supplement 1—notes a range of impacts for each environmental issue.

Additionally, the incremental environmental impacts associated with decommissioning activities, resulting from continued plant operation during the renewal term, are discussed in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS)*, NUREG-1437, Volumes 1 and 2 (NRC 1996, 1999).[1] 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 were 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:

- 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.
- 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).
- 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 unless new and significant information is identified.

Category 2 issues are those that do not meet one or more of the criteria for Category 1; therefore, additional plant-specific review of these issues is required. There are no Category 2 issues related to decommissioning.

7.1 Decommissioning

Table 7–1 lists the Category 1 issues from Table B-1 of Title 10 of the *Code of Federal Regulations* (CFR) Part 51, Subpart A, Appendix B that are applicable to Seabrook Station (Seabrook) decommissioning following the renewal term.

[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.

Table 7–1. Issues Related to Decommissioning

Issue	GEIS Section(s)	Category
Radiation doses	7.3.1; 7.4	1
Waste management	7.3.2; 7.4	1
Air quality	7.3.3; 7.4	1
Water quality	7.3.4; 7.4	1
Ecological resources	7.3.5; 7.4	1
Socioeconomic impacts	7.3.7; 7.4	1

Decommissioning would occur whether Seabrook shuts down at the end of its current operating license or at the end of the period of extended operation. There are no site-specific issues related to decommissioning.

A brief description of the NRC staff's review and the GEIS conclusions—as codified in Table B-1 of 10 CFR Part 51—for each of the issues follows:

Radiation doses. Based on information in the GEIS, the NRC noted that "[d]oses to the public will be well below applicable regulatory standards regardless of which decommissioning method is used. Occupational doses would increase no more than 1 person-rem (1 person-mSv) caused by buildup of long-lived radionuclides during the license renewal term."

Waste management. Based on information in the GEIS, the NRC noted that "[d]ecommissioning at the end of a 20-year license renewal period would generate no more solid wastes than at the end of the current license term. No increase in the quantities of Class C or greater than Class C wastes would be expected."

Air quality. Based on information in the GEIS, the NRC noted that "[a]ir quality impacts of decommissioning are expected to be negligible either at the end of the current operating term or at the end of the license renewal term."

Water quality. Based on information in the GEIS, the NRC noted that "[t]he potential for significant water quality impacts from erosion or spills is no greater whether decommissioning occurs after a 20-year license renewal period or after the original 40-year operation period, and measures are readily available to avoid such impacts."

Ecological resources. Based on information in the GEIS, the NRC noted that "[d]ecommissioning after either the initial operating period or after a 20-year license renewal period is not expected to have any direct ecological impacts."

Socioeconomic Impacts. Based on information in the GEIS, the NRC noted that "[d]ecommissioning would have some short-term socioeconomic impacts. The impacts would not be increased by delaying decommissioning until the end of a 20-year relicense period, but they might be decreased by population and economic growth."

NextEra Energy Seabrook, LLC (NextEra) stated in its Environmental Report (ER) that it is not aware of any new and significant information on the environmental impacts of Seabrook license renewal (NextEra 2010). The NRC staff has not found any new and significant information during its independent review of the NextEra ER, the site visit, the scoping process, or its evaluation of other available information. Therefore, the NRC staff concludes that there are no impacts related to these issues, beyond those discussed in the GEIS. For all of these issues, the NRC staff concluded in the GEIS that the impacts are SMALL, and additional plant-specific mitigation measures are unlikely to be sufficiently beneficial to be warranted.

7.2 References

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8.0 ENVIRONMENTAL IMPACTS OF ALTERNATIVES

The National Environmental Policy Act (NEPA) requires the consideration of a range of reasonable alternatives to the proposed action in an environmental impact statement (EIS). In this case, the proposed action is whether to issue a renewed license for the Seabrook Station (Seabrook), which will allow the plant to operate for 20 years beyond its current license expiration date. A license is just one of a number of authorizations that a licensee must obtain in order to operate its nuclear plant. Energy-planning decision makers and the owners of the nuclear power plant ultimately decide if the plant will operate, and economic and environmental considerations play a primary role in this decision. The U.S. Nuclear Regulatory Commission's (NRC's) responsibility is to ensure the safe operation of nuclear power facilities and not to formulate energy policy or encourage or discourage the development of alternative power generation.

The license renewal process is designed to assure safe operation of the nuclear power plant during the license renewal term. Under the NRC's environmental protection regulations in Title 10, Part 51, of the *Code of Federal Regulations* (10 CFR Part 51), which implement Section 102(2) of NEPA, renewal of a nuclear power plant operating license requires the preparation of an EIS.

To support the preparation of these EISs, the NRC prepared the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS)*, NUREG-1437, in 1996. The 1996 GEIS for license renewal was prepared to assess the environmental impacts associated with the continued operation of nuclear power plants during the license renewal term. The intent was to determine which environmental impacts would result in essentially the same impact at all nuclear power plants and which ones could result in different levels of impacts at different plants and would require a plant-specific analysis to determine the impacts. For those issues that could not be generically addressed, the NRC develops a plant-specific supplemental environmental impact statement (SEIS) to the GEIS.

NRC regulations 10 CFR 51.71(d) implementing NEPA for license renewal require that a SEIS include an analysis that "considers and weighs the environmental effects, including any cumulative effects, of the proposed action [license renewal]; the environmental impacts of alternatives to the proposed action; and alternatives available for reducing or avoiding adverse environmental effects."

In this chapter, the potential environmental impacts of alternatives to license renewal for Seabrook are examined as well as alternatives that may reduce or avoid adverse environmental impacts from license renewal, when and where these alternatives are applicable.

While the 1996 GEIS reached generic conclusions regarding many environmental issues associated with license renewal, it did not determine which alternatives are reasonable or reach conclusions about site-specific environmental impact levels. As such, the NRC must evaluate environmental impacts of alternatives on a site-specific basis.

As stated in Chapter 1 of this document, alternatives to the proposed action of license renewal for Seabrook must meet the purpose and need for issuing a renewed license. They must "provide an option that allows for baseload power generation capability beyond the term of the current nuclear power plant operating license to meet future system generating needs. Such needs may be determined by other energy-planning decision-makers, such as State, utility, and, where authorized, Federal agencies (other than NRC)."

The NRC ultimately makes no decision about which alternative (or the proposed action) to carry out because that decision falls to utility, State, or other Federal officials to decide. Comparing the environmental effects of these alternatives will help the NRC decide whether the adverse environmental impacts of license renewal are great enough to deny the option of license renewal for energy-planning decision makers (10 CFR 51.95(c)(4)). If the NRC acts to issue a renewed license, all of the alternatives, including the proposed action, will be available to energy planning decision makers. If NRC decides not to renew the license (or takes no action at all), then energy-planning decision makers may no longer elect to continue operating Seabrook and will have to resort to another alternative—which may or may not be one of the alternatives considered in this section—to meet their energy needs now being satisfied by Seabrook.

Alternatives Evaluated In-Depth:

- Natural-gas-fired combined-cycle (NGCC)
- New nuclear
- Combination alternative (NGCC and Wind)

Other Alternatives Considered:

- Wind power
- Solar power
- Wood waste
- Conventional hydroelectric power
- Ocean wave and current energy
- Geothermal power
- Municipal solid waste (MSW)
- Biofuels
- Oil-fired power
- Fuel cells
- Coal-fired power
- Energy conservation and energy efficiency
- Purchased power

In evaluating alternatives to license renewal, energy technologies or options currently in commercial operation are considered, as well as some technologies not currently in commercial operation but likely to be commercially available by the time the current Seabrook operating license expires. The current operating license for the reactor at Seabrook will expire on March 15, 2030. Our analysis assumes that an alternative must be available (constructed, permitted, and connected to the grid) by the time the current Seabrook license expires.

Alternatives that cannot meet future system needs by providing amounts of baseload power equivalent to Seabrook's current generating capacity and whose costs or benefits do not justify inclusion in the range of reasonable alternatives were eliminated from detailed study. The remaining alternatives were evaluated and are discussed in-depth in this section. Each alternative eliminated from detailed study is briefly discussed, and a basis for its removal is provided at the end of this section. In total, 16 energy technology options and alternatives to the proposed action were considered (see text box) and then narrowed to the 3 alternatives considered in Sections 8.1 through 8.3.

The 1996 GEIS presents an overview of some energy technologies but does not reach any conclusions about which alternatives are most appropriate. Since 1996, many energy technologies have evolved significantly in capability and cost, while regulatory structures have changed to either promote or impede development of particular alternatives.

As a result, the analyses include updated information from the following sources:

- Energy Information Administration (EIA);
- other offices within the U.S. Department of Energy (DOE);
- U.S. Environmental Protection Agency (EPA);
- New England's Independent System Operator (ISO-NE);
- industry sources and publications; and
- information submitted by the applicant in the NextEra Energy Seabrook, LLC's (NextEra) Environmental Report (ER).

The evaluation of each alternative considers the environmental impacts across seven impact categories: (1) air quality, (2) groundwater use and quality, (3) surface water use and quality, (4) ecology, (5) human health, (6) socioeconomics, and (7) waste management. A three-level standard of significance—SMALL, MODERATE, or LARGE—is used to indicate the intensity of environmental effects for each alternative undergoing in-depth evaluation. The order of presentation is not meant to imply increasing or decreasing level of impact. Nor does it imply that an energy-planning decision maker would select one or another alternative.

For each alternative where it is feasible to do so, the NRC considers the environmental effects of locating the alternative at the existing Seabrook site, as well as at an alternate site. Selecting the existing plant site allows for the maximum use of existing transmission and cooling system infrastructures and minimizes the overall environmental impact. However, in the case of Seabrook, there may not be sufficient land available to site some of the alternatives evaluated here while, at the same time, allowing the continued operation of the reactor until its license expiration date.

The ISO-NE provides electric service to the six states comprising northern New England: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut. To ensure that the alternatives analysis was consistent with State or regional energy policies, the NRC reviewed energy related statutes, regulations, and policies within the ISO-NE states. The current generation capacity mix and electricity production data within the ISO-NE service area was also considered. New Hampshire's total generating capacity of 4,100 megawatts (MW), approximately one-third of which comes from nuclear, represents 13 percent of the total capacity in the ISO-NE service area. However, New Hampshire accounts for only 9 percent of the region's total consumption, making New Hampshire a net exporting area for electricity (ISO-NE 2010b). The NRC concludes that, because a loss of power from the Seabrook reactor would potentially impact electricity consumers throughout the ISO-NE service area, the evaluation of alternatives should consider alternatives located throughout the entire ISO-NE service area, not just New Hampshire.

Sections 8.1 through 8.5 describe the environmental impacts of alternatives to license renewal. These include an NGCC in 8.1, new nuclear generation in 8.2, and a combination alternative of NGCC and wind in Section 8.3. In Section 8.4, alternatives considered but eliminated from detailed study are briefly discussed. Finally, the environmental effects that may occur if NRC takes no action and does not issue a renewed license for Seabrook are described in Section 8.5. Section 8.6 summarizes, in detail, the impacts of each of the alternatives considered.

8.1 Natural-Gas-Fired Combined-Cycle Alternative

This section presents the environmental impacts of an NGCC generation at the Seabrook site.

Natural gas accounted for 42.4 percent of all electricity generation in the ISO-NE service area in 2009, accounting for the greatest share of electrical power (ISO-NE 2010a). Development of new natural gas-fired plants may be affected by future regulations that may limit greenhouse gas (GHG) emissions. A gas-fired power plant, however, produces markedly fewer GHGs per unit of electrical output than a coal-fired plant of the same electrical output. NGCC power plants are feasible, commercially available options for providing electric-generating capacity beyond Seabrook's current license expiration.

Combined-cycle power plants differ significantly from coal-fired and existing nuclear power plants. Combined-cycle plants derive the majority of their electrical output from a gas-turbine and then generate additional power—without burning any additional fuel—through a second,

steam-turbine cycle. The exhaust gas from the gas turbine is still hot enough to boil water to steam. Ducts carry the hot exhaust to a heat-recovery steam generator, which produces steam to drive a steam turbine and produce additional electrical power. The combined-cycle approach is significantly more efficient than any one cycle on its own; thermal efficiency can exceed 60 percent. Because the natural-gas-fired alternative derives much of its power from a gas turbine cycle, and because it wastes less heat than the existing Seabrook plant, it requires significantly less cooling water.

To replace the 1,245 megawatt electric (MWe) power that Seabrook generates, and to compensate for differences in the 92 percent capacity factor of a nuclear reactor and the expected 85 percent capacity factor of a typical NGCC plant, the NRC staff assumes power equivalency would require an NGCC facility with a nameplate capacity of 1,348 MWe. Typical power trains for large-scale combined cycle power generation would involve one, two, or three combined-cycle units, available in a variety of standard sizes. To complete the assessment of an NGCC alternative, the NRC staff presumes that appropriately sized units could be assembled to annually produce electrical power in amounts equivalent to the Seabrook reactor. The combined-cycle units are presumed to each be Advanced F-Class design, equipped with water or steam injection as a pre-combustion control to suppress nitrogen oxide (NO_x) formation and selective catalytic reduction (SCR) of the exhaust with ammonia for post-combustion control of NO_x emissions.

As noted above, the gas-fired alternative would require much less cooling water than Seabrook because it operates at a higher thermal efficiency (nearly 60 percent) and because it requires much less water for steam cycle condenser cooling. The existing once-through cooling system now supporting the reactor would be able to support a natural gas alternative on the Seabrook site without any increase in its current capacity. However, in recognition of the mounting concerns for the potential adverse impacts to aquatic ecosystems from once-through cooling systems and to ensure a conservative evaluation, NRC assumes that the NGCC alternative would not use the existing once-through cooling system. Instead, it would be supported by a closed-loop cooling system, using seawater recovered from the existing cooling water intake and discharging blowdown water through the existing cooling system discharge pipe. Under such a configuration, the rate of withdrawal of seawater to support steam cycle cooling would be dramatically reduced.

This gas-fired alternative would produce relatively little waste, primarily in the form of spent catalysts used for control of NO_x emissions. The NRC staff presumes that the SCR technology employed would involve introducing ammonia into the exhaust ducts of the cooling towers where it combines with NO_x in a nickel catalyst bed to form zero-valent nitrogen and water. Based on data provided by the Institute of Clean Air Companies, EPA acknowledges that typical SCR devices can demonstrate removal efficiencies of between 70 and 90 percent (EPA 2000a).

The NRC staff presumes that buildable land of sufficient acreage and appropriate location would be available to support an onsite natural gas combined cycle plant and its new closed-loop cooling system. Environmental impacts from construction of the gas-fired alternative will include the release of criteria pollutants and GHGs from the operation of construction equipment and construction vehicles, the generation of fugitive dust from ground disturbing activities, construction noise, and terrestrial habitat fragmentation. Site crews will clear vegetation from the site, prepare the site surface relocating existing facilities, if necessary, and begin excavations for foundations and buried utilities before other crews begin actual construction on the plant and any associated infrastructure. Offsite impacts will also occur as a result of construction of a natural gas pipeline connecting the site to existing infrastructure. Modifications to existing electricity transmission infrastructure are expected to be minimal and will have only minimal environmental impacts. Modifications and rejuvenation of a rail spur connecting to

Seabrook may also create some short-term impacts, including criteria pollutant releases and noise. Construction related impacts will all be of relatively short duration.

Environmental impacts from the NGCC alternative are summarized in Table 8–1.

Table 8–1. Environmental Impacts of NGCC Alternative

	New NGCC at the Seabrook Site
Air Quality	SMALL to MODERATE
Groundwater	SMALL
Surface Water	SMALL
Aquatic & Terrestrial Resources	SMALL
Human Health	SMALL
Socioeconomics	SMALL to MODERATE
Historic and Archaeological	SMALL to MODERATE
Waste Management	SMALL

8.1.1 Air Quality

Various Federal and State regulations aimed at controlling air pollution would impact a fossil fuel-fired power plant, including the NGCC alternative, located anywhere within the ISO-NE service area. Seabrook is located in Rockingham County, which is part of the Merrimack Valley Southern New Hampshire Interstate Air Quality Control Region (AQCR). The portion of this control region, containing Seabrook, is currently a non-attainment area for 8-hour ozone. A new, gas-fired 1,348 MWe net generating plant developed at the Seabrook site would qualify as a new major source of criteria pollutants and require a New Source Review (NSR) and Prevention of Significant Deterioration of Air Quality Review. The natural, gas-fired plant would need to comply with the standards of performance for stationary gas turbines set forth in 40 CFR Part 60, Subpart GG.

Section 169A of the Clean Air Act (CAA) (42 U.S.C. 7401) establishes a national goal of preventing future, and remedying existing, impairment of visibility in mandatory Class I Federal areas when impairment results from man-made air pollution. The Regional Haze Rule, promulgated by EPA in 1999 and last amended in October 2006 (71 FR 60631), requires states to demonstrate reasonable progress towards the national visibility goal established in 1977 to prevent future impairment of visibility due to man-made pollution in Class I areas. The visibility protection regulatory requirements are contained in 40 CFR Part 51, Subpart P, including the review of the new sources that would be constructed in the attainment or unclassified areas and may affect visibility in any Federal Class I area. If a gas-fired alternative were located close to a mandatory Class I area, additional air pollution control requirements would potentially apply; however, there are no Class I areas within 50 miles (mi) of the Seabrook site.

In response to the Consolidated Appropriations Action of 2008 (Public Law 110-161), EPA recently promulgated final mandatory GHG reporting regulations for major sources (emitting more than 25,000 tons per year of all GHGs), effective in December 2009 (EPA 2010a). This new NGCC plant would be subject to those reporting regulations. Future regulations may require control of carbon dioxide (CO_2) emissions.

Under the Federal Acid Rain Program, a new natural gas-fired plant would have to comply with Title IV of the CAA reduction requirements for SO_2 and NO_x, which are the main precursors of acid rain and the major cause of reduced visibility. Title IV establishes maximum SO_2 and NO_x emission rates from the existing plants and a system of the SO_2 emission allowances that can be used, sold, or saved for future use by new plants.

The Clean Air Interstate Rule (CAIR) was first promulgated by EPA in 2005, permanently capping SO_2 and NO_x emissions from stationary sources located in 28 states, including two ISO-NE states (Connecticut and Massachusetts). A new fossil fuel-fired source constructed in either of those states would be subject to revised emission limits for SO_2 and $NO_{x,}$ promulgated under CAIR. However, the Federal rule was vacated by the D.C. Circuit Court on February 8, 2008. In December 2008, the U.S. Court of Appeals for the D.C. Circuit reinstated the rule, allowing it to remain in effect but also requiring EPA to revise the rule and its implementation plan. On July 6, 2010, EPA proposed replacing CAIR with the Transport Rule for control of SO_2 and NO_x emissions that cross state lines, the regulations of which would be implemented in 2011 and finalized in 2012. It is expected that SO_2 emission allowances allocated to stationary sources under the Acid Rain Program would be used to meet SO_2 emission limits under CAIR. NO_x emission allowances would be allocated to sources, based on each impacted state's budget, under the Model NO_x Trading Program being formulated by EPA (EPA 2011).

Finally, although there are no Federal rules requiring control of GHG emissions currently in effect, the New Hampshire Climate Change Action Plan (NHDES 2009) sets a statewide goal of reducing GHG emissions by 80 percent of 1990 levels by 2050. Reaching that goal may ultimately involve establishment of state emission limits of GHG emissions from major stationary sources, and a new fossil fuel-fired facility located in New Hampshire would likely be subject to those controls. On a regional level, the Governors of all six of the ISO-NE states, together with Governors from Delaware, Maryland, New Jersey, and New York are signatories to the Regional Greenhouse Gas Initiative (RGGI) Memorandum of Understanding, executed initially on December 20, 2005, and since amended twice (RGGI 2005, 2006, 2007). The RGGI establishes a regional cap on CO_2 emissions from the power sector and requires each power generator using fossil fuels to possess tradable CO_2 allowances for each ton of CO_2 they emit. It states subsequently promulgated regulations that establish budget trading programs for CO_2 allowances. Any fossil fuel-fired facility located within the ISO-NE states would be subject to that State's budget trading program and would be required to either install control equipment to reduce CO_2 emissions or trade for CO_2 allowances with other CO_2 sources to stay within its CO_2 emission allowance.

Using data and algorithms published by EPA and EIA, and performance guarantees provided by pollution control equipment vendors, the NRC staff projects the following emissions for an NGCC alternative to the Seabrook reactor:

- Sulfur oxides (SO_x)—104 tons (94 metric tons (MT)) per year,
- NO_x—398 tons (361 MT) per year,
- Carbon monoxide (CO)—918 tons (832 MT) per year,
- Particulate matter less than or equal to 10 µm (PM_{10})—202 tons (183 MT) per year, and
- CO_2—3,364,526 tons (3,052,298 MT) per year.

8.1.1.1 Sulfur and Nitrogen Oxides

As stated above, the new natural gas-fired alternative would produce 104 tons (94 MT) per year of SO_x and 398 tons (361 MT) per year of NO_x, based on the use of the dry low NO_x combustion technology and use of the SCR, in order to significantly reduce NO_x emissions.

The new plant would be subjected to the continuous monitoring requirements of SO_2, NO_x, and CO_2 specified in 40 CFR Part 75. The natural gas-fired plant would emit approximately 3.36 million tons (approximately 3.05 million MT) per year of (currently) unregulated CO_2 emissions.

8.1.1.2 Particulates

The new, natural gas-fired alternative would produce 202 tons (183 MT) per year of particulates, all of which would be emitted as PM_{10}. Small amounts of particulate would be released as drift from the newly installed closed-loop cooling system's cooling tower (regardless of whether it involves a natural draft or mechanical draft tower). Particulate control would likely not be required, and this drift would not present a new impact to extant vegetation, which already experiences sea spray during some weather conditions.

8.1.1.3 Carbon Monoxide

Based on EPA emission factors (EPA 1998), the NRC staff estimates that the total CO emissions would be approximately 918 tons (832 MT) per year.

8.1.1.4 Hazardous Air Pollutants

In December 2000, the EPA issued regulatory findings (EPA 2000b) on emissions of hazardous air pollutants (HAPs) from electric utility steam-generating units. These findings indicated that natural gas-fired plants emit HAPs such as arsenic, formaldehyde and nickel and stated that "[t]he impacts due to hazardous air pollutants (HAP) emissions from natural gas-fired electric utility steam generating units were negligible based on the results of the study. The Administrator finds that regulation of HAP emissions from natural gas-fired electric utility steam generating units is not appropriate or necessary."

Impacts to air quality from the operation of the NGCC alternative would be the same at an alternative site or the Seabrook site. However, given the extant ambient air quality at an alternative site, regulatory authorities may introduce additional pollution control requirements, including derating the unit.

8.1.1.5 Construction Impacts

Activities associated with the construction of the new, natural gas-fired plant at the Seabrook site would cause some additional air impacts as a result of emissions from construction equipment and fugitive dust from operation of the earth-moving and material handling equipment. Impacts to climate change from the construction of an NGCC alternative would result primarily from the consumption of fossil fuels in combustion engines of construction vehicles and equipment, workforce vehicles used in commuting to and from the work site, and delivery vehicles. Analogous impacts would occur in association with offsite pipeline construction. All such impacts would be temporary. Workers' vehicles and motorized construction equipment would generate temporary criteria pollutant emissions. Dust control practices would reduce fugitive dust, which would be temporary in nature. Given the expected, relatively small workforces and a relatively short construction period for both the NGCC facility and the pipeline, the NRC staff concludes that the impact of vehicle exhaust emissions and fugitive dust from operation of earth-moving and material handling equipment would be SMALL.

The overall air quality impacts associated with construction of a new natural gas-fired plant located at the Seabrook site and with construction of a natural gas pipeline at offsite areas would be SMALL.

8.1.1.6 Additional Operating Impacts

In addition to the air quality impacts associated with operation of the NGCC facility, additional air quality impacts would result from vehicles used by the commuting operating workforce. However, the NGCC workforce is substantially smaller than the current operating workforce for the reactor, so a change to an NGCC alternative will result in substantial reductions in commuting-related air emissions. The impacts to air quality from ancillary activities during operation of an NGCC alternative would be SMALL.

EPA reported that, in 2008, the total amount of carbon dioxide equivalent (CO_2e) emissions related to electricity production was 2,397.2 teragrams (2,363.5 million metric tons (MMT)) (EPA 2010b). EIA reports that, in 2008, electricity production in New Hampshire was responsible for 6,777 thousand MTs (6.8 MMT), or 0.29 percent of the national total (EIA 2010d). The NRC staff estimates that uncontrolled emissions of CO_2e from operation of the NGCC alternative would amount to 3.36 MT per year (MT/y) (3.05 MMT per year (MMT/y)). This amount represents 0.12 percent and 41.5 percent, respectively, of 2008 U.S. and New Hampshire CO_2e emissions. Although natural gas combustion in the combustion turbines would be the primary source, other miscellaneous ancillary sources—such as truck and rail deliveries of materials to the site and commuting of the workforce—would make minor contributions.

The National Energy Technology Laboratory (NETL) estimates that carbon capture and storage (CCS) technologies will capture and remove as much as 90 percent of the CO_2 from the exhausts of combustion turbines. However, NETL estimates that such equipment imposes a significant parasitic load that will result in a power production capacity decrease of approximately 14 percent, a reduction in net overall thermal efficiency of the combustion turbines studied from 50.8 percent to 43.7 percent, and a potential increase in the levelized cost of electricity produced in NGCC units so equipped by as much as 30 percent (NETL 2007). Further, permanent sequestering of the CO_2 would involve removing impurities (including water), pressurizing it to meet pipeline specifications, and transferring it by pipeline to acceptable geologic formations. Even when opportunities exist to use the CO_2 for enhanced oil recovery (rather than simply dispose of the CO_2 in geologic formations), permanent disposal costs could be substantial, especially if the gas-fired units are far removed from acceptable geologic formations. With CCS in place, the gas-fired alternative would release 0.28 MMT/yr of CO_2. If future regulations require the capture and sequestration of CO_2 from gas-fired facilities, the impact on climate change from this alternative would be further reduced.

Based on this information, the overall air quality impacts of a new natural gas-fired plant located at the Seabrook site would be SMALL to MODERATE.

8.1.2 Groundwater Resources

Construction activities associated with the NGCC alternative would likely require groundwater dewatering of foundation excavations, as some excavations may intrude into either the brackish groundwater zone or lower freshwater aquifers or both. Open excavations create a potential pathway for groundwater contamination and may also establish communication between aquifers. All open excavations that require dewatering can impact surface waters. However, construction would be accomplished with the use of cofferdams, sumps, wells, or other methods as necessary to address high water-table conditions, as they exist at Seabrook. Dewatering systems may also be installed to manage high groundwater conditions during operations. Any such discharges would be subject to controls and limitations of an EPA-issued

National Pollutant Discharge Elimination System (NPDES) Dewatering General Permit (DGP) (EPA 2012a).

Facility construction would also increase the amount of impervious surface at the site location as well as alter the subsurface strata because of excavation work and the placement of backfill following facility completion. While an increase in impervious surface would reduce infiltration and reduce groundwater recharge, the effects on water table elevations would likely be very small. Below-grade portions of the new NGCC facility could also alter the direction of groundwater flow beneath the site. Such effects would likely be localized and would not be expected to affect offsite wells. With the application of best management practices (BMPs) and the controls (including appropriate waste management, water discharge, and spill prevention practices) established in an NPDES Construction General Permit for stormwater discharges from EPA (EPA 2012b) and under an Alteration of Terrain Permit issued by the New Hampshire Department of Environmental Services (NHDES) (NHDES 2012), no impacts on groundwater quality are expected.

No use of onsite groundwater would be expected for the construction or operation of the NGCC alternative. Instead, it is likely that water to support construction activities would be supplied via the Town of Seabrook system, which currently serves Seabrook. This municipal system relies on a system of 10 groundwater supply wells located upgradient of the site. Water could be supplied via a temporary utility connection or trucked to the point of use. Regardless, water would be supplied for such needs as worker potable and sanitary uses, concrete production, dust suppression, and soil compaction during the construction period. NextEra (2010) estimated a peak construction workforce of 991. This is a smaller workforce than the existing Seabrook workforce, which uses less than 100 gallons per minute (gpm) (380 liters per minute (L/min)) for its combined potable and sanitary uses, fire suppression, and other industrial freshwater uses (see Section 2.1.7.2). For the construction workforce, however, the use of portable sanitary facilities that are serviced offsite would greatly reduce the need for potable and sanitary water. The 1996 GEIS (NRC 1996) determined that pumping rates of less than 100 gpm (380 L/min) have not been shown to adversely affect groundwater availability, and construction water needs are projected to be a fraction of this rate for the NGCC alternative.

For NGCC facility operations, the NRC conservatively assumed that the NGCC alternative would entail the same relative ratio of groundwater use to surface water use as that used for Seabrook Unit 1. Consequently, the NRC staff expects that total groundwater usage and associated effects on the Town of Seabrook municipal well system would be much less under this alternative than those under current Seabrook operations because of the smaller number of auxiliary systems requiring groundwater and the much smaller operations workforce under the NGCC alternative.

Based on this assessment, the impacts on groundwater quality and use from construction and operation of the NGCC alternative at Seabrook would be SMALL.

8.1.3 Surface Water Resources

A new NGCC facility at the Seabrook site would occupy a much smaller footprint (about 44 acres (ac) (18 hectares (ha)) as compared to the current Seabrook reactor complex or facilities under the new nuclear alternative, as discussed in Section 8.2. This would also result in less extensive excavation and earthwork than was required for Seabrook Unit 1. The NRC staff assumes that no surface water would be used during construction for the NGCC alternative.

Some temporary impacts to surface water quality may result from increased sediment loading and from any pollutants in stormwater runoff from disturbed areas and from any dredging

activities. During facility construction, runoff from disturbed areas in the plant footprint would be controlled under permits issued by the EPA and NHDES, as noted in Section 8.1.2. These controls would include the requirement to develop and implement a stormwater pollution prevention plan and associated BMPs to prevent or significantly mitigate soil erosion and contamination of stormwater runoff that could impact soils, surface water, or groundwater.

Additionally, depending on the path of the gas pipeline to supply the NGCC facility, some creeks could be crossed. However, the pipeline would be routed along existing rights-of-way to the extent possible (NextEra 2010), and it is expected that associated, hydrologic alterations and sedimentation would be localized and temporary. In addition, modern pipeline construction techniques would further minimize the potential for water quality impacts in the affected streams. Any dredging would also would be conducted under a permit from the U.S. Army Corps of Engineers (USACE) or a NHDES Wetlands Standard Dredge and Fill Permit (NHDES 2012) requiring the implementation of BMPs to minimize impacts.

For facility operations, the NGCC alternative at the Seabrook site is expected to use a new, closed-loop cooling system, but it would likely use the existing seawater withdrawal and discharge structures. Throughout the operating period of the NGCC facility, conversion to a closed-loop system will result in greatly reduced withdrawal rates of seawater (to replace water lost to evaporation and drift from the cooling tower) and discharges through Seabrook's ocean outfall compared to those now occurring from operation of Seabrook's once-through system. Cooling tower blowdown discharged to the ocean would also contain various chemicals used to treat the water in the closed-loop system to maintain cooling tower performance. Discharges would be controlled either by a revision of Seabrook's current NPDES permit (see Section 2.2.4) or under a new, individual NPDES permit issued for the NGCC facility by EPA.

In consideration of the information above, the impacts on surface water quality and use from construction and operation of the NGCC alternative at Seabrook would be SMALL.

8.1.4 Aquatic and Terrestrial Ecology

8.1.4.1 Aquatic Ecology

Minimal impacts to aquatic ecology are anticipated throughout the construction phase of an NGCC alternative. Seawater would continue to be used to support the operation of the new closed-loop cooling system. However, withdrawal rates would be substantially reduced from those now occurring in the once-through system supporting the Seabrook reactor. The NRC staff concludes that impacts to aquatic ecology would be SMALL.

8.1.4.2 Terrestrial Ecology

As indicated in previous sections, the NRC staff presumes that an NGCC alternative could be constructed on the existing Seabrook property. While much of the plant is likely to be located on previously disturbed, industrialized portions of the site, some fallow areas may also be involved. Terrestrial ecology in these fallow areas will be affected, primarily resulting in habitat fragmentation and loss of food sources. Offsite impacts will occur at the locations impacted by the construction of the natural gas pipeline connecting the site to existing infrastructure. However, impacts to terrestrial resources on the site will be minimal since existing activities on the site will likely have already caused indigenous terrestrial resources to relocate from the site.

Operation of the cooling tower would cause some deposition of dissolved solids (including salt) on surrounding vegetation and soil from cooling tower drift; however, since the potentially impacted areas are already subject to sea spray or other natural mechanisms of salt deposition, the impacts from cooling tower drift would be incremental and probably insignificant to the

existing plant community. Impacts to terrestrial resources from the construction and operation of the NGCC alternative on the Seabrook site would be SMALL.

8.1.5 Human Health

Impacts to human health from construction of the NGCC alternative would be similar to impacts associated with the construction of any major industrial facility. Compliance with worker protection rules would control those impacts to workers to acceptable levels. Impacts from construction on the general public would be minimal since limiting active construction area access to authorized individuals is expected. Human health effects of gas-fired generation are generally low, although in Table 8-2 of the GEIS (NRC 1996), the NRC staff identified both cancer and emphysema as potential health risks from gas-fired plants. NO_x emissions contribute to ozone formation, which, in turn, contributes to human health risks. Emission controls on the NGCC alternative can be expected to maintain NO_x emissions well below air quality standards established for the purposes of protecting human health, and emissions trading or offset requirements mean that overall NO_x releases in the region will not increase. Health risks to workers may also result from handling spent catalysts, used for NO_x control, which may contain heavy metals.

Overall, human health risks to occupational workers and to members of the public from the construction and operation of the NGCC alternative at Seabrook would be SMALL.

8.1.6 Socioeconomics

8.1.6.1 Land Use

The GEIS generically evaluates the impacts of nuclear power plant operations on land use both on and off each power plant site (NRC 1996). The analysis of land use impacts focuses on the amount of land area that would be affected by the construction and operation of a natural gas-fired combined-cycle power plant at the Seabrook site.

A new NGCC plant would require approximately 44 ac (18 ha) of land to support a natural gas-fired alternative to replace the Seabrook reactor. Ancillary support activities for the reactor may need to be relocated to provide sufficient land area for an NGCC plant, and some fallow areas may need to be used in addition to land areas in the previously disturbed industrial footprint of the site. Nevertheless, onsite land use impacts from construction and operation of the NGCC alternative on Seabrook would be SMALL.

In addition to onsite land requirements, new areas of offsite land would be affected by construction of the gas pipeline. In addition to onsite land requirements, land would be required offsite for natural gas wells and collection stations. Most of this land requirement would occur on land where gas extraction already occurs. In addition, some natural gas could come from outside the U.S. and be delivered as liquefied gas. Some natural gas could also come from outside of the U.S. and be delivered as liquefied gas to a seaport.

The elimination of uranium fuel for the Seabrook reactor could partially offset offsite land requirements by reducing land needed for mining of uranium ore. The NGCC alternative and its necessary support equipment (including an alternative closed-loop cooling system) could be constructed largely within the existing developed industrial footprint of the Seabrook site and therefore overall land use impacts would be SMALL.

8.1.6.2 Socioeconomics

Socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics and social conditions of a region. For example, the number of jobs created by

the construction and operation of a new NGCC power plant could affect regional employment, income, and expenditures. Two types of jobs would be created by this alternative: (1) construction-related jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact; and (2) operation-related jobs in support of power plant operations, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements for the construction and operation of the NGCC power plant alternative were evaluated in order to measure their possible effects on current socioeconomic conditions.

NextEra estimates an average construction workforce of 548, with a peak construction workforce of 991. During construction of the NGCC, the communities surrounding the power plant site would experience increased demand for rental housing and public services. The relative economic effect of construction workers on the local economy and tax base would vary over time.

The majority of the impacts from these two workforces would occur within the town of Seabrook and neighboring towns. Other construction jobs would be created to support construction of the pipeline. However, given the relatively short duration of the construction periods for both the NGCC facility and the pipeline, impacts to most social services from construction will be SMALL.

After construction, local communities could be temporarily affected by the loss of construction jobs and associated loss in demand for business services, and the rental housing market could experience increased vacancies and decreased prices. Since Seabrook is located near the Boston metropolitan area, these effects would be smaller because workers are likely to commute to the site instead of relocating to be closer to the construction site. Because of Seabrook's proximity to large population centers, the impact of construction on socioeconomic conditions would be SMALL.

NextEra estimates an operations workforce of 47. The NextEra estimate appears to be reasonable and is consistent with trends toward lowering labor costs by reducing the size of power plant operations workforces. The amount of taxes paid under the NGCC alternative may increase if additional land is required offsite to support this alternative. Operational impacts would be SMALL.

8.1.6.3 Transportation

Transportation impacts associated with construction and operation of the NGCC alternative would consist of commuting workers and truck deliveries of construction materials and equipment to the Seabrook site. During periods of peak construction activity, 991 workers would be commuting to the site increasing the amount of traffic on local roads. The increase in vehicular traffic would peak during shift changes, resulting in temporary (LOS) impacts and delays at intersections. Some plant components would be delivered by train via the existing but currently unused rail spur serving the Seabrook site. Pipeline construction and modification to existing natural gas pipeline systems could also have an impact on local transportation. Traffic-related transportation impacts during construction would likely range from SMALL to MODERATE depending on the time of day.

During plant operations, traffic-related transportation impacts would almost disappear. According to NextEra, approximately 47 workers would be needed to operate the NGCC power plant. Since fuel is transported by pipeline, the transportation infrastructure would experience little to no increased traffic from plant operations. Overall, the NGCC alternative transportation impacts would be SMALL during power plant operations.

8.1.6.4 Aesthetics

The aesthetics impact analysis focuses on the degree of contrast between the natural gas-fired alternative and the surrounding landscape and the visibility of the natural gas-fired plant.

The power block of the NGCC alternative would look very similar to the Seabrook power block. The addition of mechanical draft or natural draft cooling towers and associated condensate plumes would add to the visual impact. The NGCC units could have exhaust stacks higher and more prominent than the existing off-gas stack of the nuclear plant.

Mechanical draft cooling towers would generate operational noise. Noise during power plant operations would be limited to industrial processes and communications. Pipelines delivering natural gas fuel could be audible offsite near gas compressor stations.

In general, aesthetic impacts would be limited to the immediate vicinity of the Seabrook site and would likely be similar to those associated with the currently operating Seabrook reactor. Impacts would be SMALL.

8.1.6.5 Historic and Archaeological Resources

Cultural resources are the indications of human occupation and use of the landscape, as defined and protected by a series of Federal laws, regulations, and guidelines. Prehistoric resources are physical remains of human activities that predate written records; they generally consist of artifacts that may alone or collectively yield information about the past. Historic resources consist of physical remains that postdate the emergence of written records; in the U.S., they are architectural structures or districts, archaeological objects, and archaeological features dating from 1492 and later. Ordinarily, sites less than 50 years old are not considered historic, but exceptions can be made for such properties if they are of particular importance, such as structures associated with the development of nuclear power (e.g., Shippingport Atomic Power Station) or Cold War themes. American Indian resources are sites, areas, and materials important to American Indians for religious or heritage reasons. Such resources may include geographic features, plants, animals, cemeteries, battlefields, trails, and environmental features. The cultural resource analysis encompassed the power plant site and adjacent areas that could potentially be disturbed by the construction and operation of alternative power plants.

The potential for historic and archaeological resources can vary greatly depending on the location of the proposed site. To consider a project's effects on historic and archaeological resources, any affected areas would need to be surveyed to identify and record historic and archaeological resources, identify cultural resources (e.g., traditional cultural properties), and develop possible mitigation measures to address any adverse effects from ground-disturbing activities.

Based on a review of the Seabrook Cultural Resources Protection Plan, New Hampshire State Historic Preservation Officer (SHPO) files for the region, published literature, and additional information provided by NextEra, the potential impacts of constructing and operating an NGCC alternative at the Seabrook Site on historic and archaeological resources could be SMALL to MODERATE. This impact is based on the results of archaeological surveys. There is a high potential for additional archaeological sites and resource materials to be discovered during construction, including a high potential for encountering human remains. NextEra could mitigate MODERATE impacts by following the Seabrook Cultural Resources Protection Plan to ensure that any adverse impacts to archaeological resources at the Seabrook site are avoided.

8.1.6.6 Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health, environmental, and socioeconomic effects on minority and low-income

populations that could result from the construction and operation of a new NGCC plant. Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant and exceeds the risk or exposure rate for the general population or for another appropriate comparison group. Such effects may include biological, cultural, economic, or social impacts. Some of these potential effects have been identified in resource areas discussed in this SEIS. For example, increased demand for rental housing during power plant construction could disproportionately affect low-income populations. Section 4.9.7, Environmental Justice, provides socioeconomic data regarding the analysis of environmental justice issues.

Potential impacts to minority and low-income populations from the construction and operation of a new NGCC power plant at the Seabrook site would mostly consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts from construction would be short-term and primarily limited to onsite activities. Minority and low-income populations residing along site access roads would also be affected by increased commuter vehicle traffic during shift changes and truck traffic. However, these effects would be temporary during certain hours of the day and not likely to be high and adverse. Increased demand for rental housing during construction in the vicinity of Seabrook could affect low-income populations. Given the proximity of Seabrook to the Boston metropolitan area, most construction workers would likely commute to the site, thereby reducing the potential demand for rental housing.

Based on this information and the analysis of human health and environmental impacts presented in this SEIS, the construction and operation of a new NGCC power plant would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations residing in the vicinity of the Seabrook site.

8.1.7 Waste Management

During the construction stage of this alternative, land clearing and other construction activities would generate waste that can be recycled, disposed of onsite, or shipped to an offsite waste disposal facility. Because the NGCC would most likely be constructed on the previously disturbed portions of the Seabrook site, the amounts of wastes produced during land clearing would be minimal.

During the operational stage, spent SCR catalysts used to control NOx emissions would make up the majority of the industrial waste generated by this alternative. Because the specific NOx emission control equipment cannot be specified at this time, the amount of spent catalysts that would be generated during each year of operation of the NGCC alternative also cannot be calculated with precision. However, the amount would be modest. Domestic and sanitary wastes would be expected to decrease from amounts now generated during the operation of the reactors due to a greatly reduced operating workforce for the NGCC alternative. According to the 1996 GEIS a natural gas-fired plant would generate minimal waste; therefore, waste impacts would be SMALL for an NGCC alternative located at the Seabrook site.

8.2 New Nuclear Alternative

This section presents the environmental impacts of new nuclear generation at the Seabrook site.

In evaluating the new nuclear alternative in its ER, NextEra presumed that a replacement reactor would be installed on the Seabrook site, allowing for the maximum use of existing ancillary facilities such as the cooling system and transmission infrastructure. Although the Seabrook site contains the containment building for a second reactor that was never built, NextEra did not presume to use that containment structure for the replacement reactor.

In conducting its own evaluation of the nuclear alternative, the NRC staff presumes that the replacement reactor would be a pressurized water reactor of the Areva U.S. Evolutionary Power Reactor (EPR) Design, similar to the reactor recently proposed by Constellation Energy for installation as Unit 3 at the Calvert Cliffs Power Plant in Maryland. That reactor is rated at a core thermal power of 4,590 megawatt-thermal (MWt) and a net electrical output of 1,562 MWe. The parameters of that reactor and conditions of the Calvert Cliff site are sufficiently similar to conditions at the Seabrook site. Additionally, the NRC's assessment of the impacts of construction and operation of the Calvert Cliffs Unit 3 reactor—as represented in a recently issued Draft SEIS (NRC 2010)—are generally representative of impacts that could be anticipated from construction and operation of a reactor of similar design and capacity at Seabrook. Unless otherwise noted, the evaluation presented in the following sections was derived from the Calvert Cliffs Unit 3 Draft SEIS to the appropriate extent.

As with the NGCC alternative, NRC staff presumes that the alternative reactor would not use once-through cooling, but would use closed-cycle cooling using either a mechanical draft or natural draft-cooling tower. However, the cooling system would use seawater, and the existing intake and discharge structures at Seabrook would continue in service with little to no structural modifications. The existing electrical switchyard and substation on Seabrook, and the transmission lines leaving the site, are expected to serve the replacement reactor with little to no modifications required. Finally, although Seabrook is in a coastal area, NRC staff presumes that barges would not be used to bring materials and equipment to the site.

Environmental impacts from the new nuclear alternative at the Seabrook site are summarized in Table 8–2.

Table 8–2. Environmental Impacts of New Nuclear Alternative

	New Nuclear at the Seabrook Site
Air Quality	SMALL
Groundwater	SMALL
Surface Water	SMALL
Aquatic & Terrestrial Resources	SMALL
Human Health	SMALL
Socioeconomics	MODERATE to LARGE
Historic and Archaeological	MODERATE to LARGE
Waste Management	SMALL

8.2.1 Air Quality

8.2.1.1 Construction Impacts

During construction, air quality would be affected by the release of criteria pollutants from construction vehicles and equipment, workforce commuting vehicles, and material delivery vehicles. Releases of volatile organic compounds (VOCs) can be expected from onsite vehicle and equipment fueling activities and from the use of cleaning agents and corrosion control

coatings. Finally, although the new reactor would be located primarily on previously disturbed land areas within the industrial footprint of the Seabrook, some virgin areas may also be impacted. Ground disturbances—such as ground clearing and cut and fill activities, movement of construction vehicles on unpaved and disturbed land surfaces, and delivery and stockpiling of natural materials used in construction (e.g., sand and gravel)—would all still occur and would increase fugitive dust releases. NextEra would be expected to apply BMPs to control such air quality impacts to acceptable levels. Climate impacts during construction of the alternative reactor would result primarily from the operation of construction vehicles and equipment using combustion engines and from the operation of delivery vehicles and vehicles used by the commuting workforce. Those impacts will be short-lived and are expected to be SMALL.

Overall, air impacts during construction would be of relatively short duration and would be SMALL.

8.2.1.2 Additional Operating Impacts

During operation, air quality impacts would include release of criteria pollutants from vehicles of the commuting operating workforce and those delivering supplies and equipment to the site (primarily trucks). The expected operation of diesel-fuel emergency generators for preventative maintenance purposes or during refueling operations would represent additional sources of criteria pollutants during operation. Finally, operation of the cooling tower would result in the release of particulates in the form of drift. Overall, impacts to air quality during operation would be SMALL.

Operation of a new nuclear alternative would have essentially identical effects on climate change as operating the current Seabrook reactor. Operation of the reactor itself does not result in the release of GHG that could impact climate. However, GHG emissions do result from some ancillary support activities such as the periodic preventative maintenance operation of diesel-fuel emergency generators, the onsite travel of vehicles, and commuting of the operating workforce. Because operating parameters of an alternative reactor would be essentially the same as the existing reactor and the operating workforce would be of the same approximate size as the current workforce, impacts on climate from an alternative reactor at Seabrook can be expected to be essentially the same as climate impacts of the current reactor—SMALL. Those impacts are discussed in detail and quantified in Section 4.2.

8.2.2 Groundwater Resources

For construction of a new nuclear generation facility, excavation of the containment structure, extending to 40 feet (ft) (12.2 meters (m)) or more below grade, would very likely encounter both brackish groundwater at shallow depths and deeper fresh groundwater, creating a potential pathway for groundwater contamination and communication between aquifers. Given the site's proximity to the ocean, open excavations might require continuous dewatering until construction is completed. Permanent foundation dewatering systems may also need to be installed and maintained during operations. Regardless, construction excavation would be accomplished with the use of cofferdams, sumps, wells, or other methods as necessary to address high water-table conditions. Any such discharges would be subject to controls and limitations of an EPA-issued NPDES DGP (EPA 2012a).

Construction of a new nuclear generating facility would increase the amount of impervious surface at the site location as well as alter the subsurface strata because of excavation work and the placement of backfill following facility completion. Impacts would generally be similar to, but greater than, those described for the NGCC alternative. The reason for this is due to the greater volume of excavation work required and the larger land area disturbed, which would be permanently converted to impervious surface, under this alternative. Nevertheless, such

activities would be subject to the same BMPs, controls, and permitting requirements identified in Section 8.1.2.

Groundwater sources may be directly accessed to support construction activities, especially to provide water for onsite fugitive dust control, soil compaction, and concrete production and could total as much as 100,000 gallons per day (gpd) or 69 gpm (260 L/min). Water would also be required to meet the potable and sanitary needs of workers, with a peak construction workforce of about 4,000. For the construction workforce, however, the use of portable sanitary facilities that are serviced offsite would greatly reduce the need for potable and sanitary water. Nonetheless, well drilling and withdrawal permits issued by State and local authorities would be the primary control mechanisms for avoiding adverse impacts to groundwater by specifying groundwater well construction, use, and abandonment standards and procedures and limiting water withdrawals. Specifically, such withdrawals would likely require a Large Groundwater Withdrawal Permit from NHDES (NHDES 2012). As described in Section 8.1.2 for the NGCC alternative, water could be supplied by the Town of Seabrook system to meet all or part of the water demand to support construction. The projected peak construction water demand of 69 gpm (260 L/min) is less than that currently required to support Seabrook operations and supplied via the Town of Seabrook (see Section 2.1.7.2). The 1996 GEIS (NRC 1996) determined that pumping rates of less than 100 gpm (380 L/min) have not been shown to adversely affect groundwater availability.

To support operations of a new nuclear generation facility, the NRC assumed that this alternative would entail the same relative ratio of groundwater use to surface water use as that for Seabrook Unit 1 (see Section 2.1.7.2), along with a similar-sized workforce and operational activities. Therefore, the groundwater resources impact assessment presented in Section 4.4.1 of this SEIS is applicable to this new nuclear alternative, including the finding that operational impacts on groundwater would be SMALL.

In conclusion, impacts on groundwater quality and use from construction and operation of the new nuclear alternative at Seabrook would be SMALL.

8.2.3 Surface Water Resources

Construction would result in impacts to surface water due to altered drainage patterns and the potential for increased sediment and construction-related pollutants in runoff from active construction sites. Impacts would be similar to, but greater than, those described for the NGCC alternative in Section 8.1.3 by virtue of the much larger land area that would be disturbed (i.e., up to 460 ac (190 ha)), with a portion similar to the area occupied by Seabrook converted to impervious surface. However, because the NRC assumes that components of existing cooling system intake and discharge structures would continue in service, major direct impacts to surface water that could result during construction of new intake and discharge components would be avoided. BMPs, controls, and conditions and constraints of a required EPA-issued Construction General Permit (EPA 2012b) and NHDES-issued Alteration of Terrain Permit (NHDES 2012) would further limit impacts to surface water during construction.

During operation, the closed-loop cooling system of the alternative reactor would withdraw seawater at a substantially reduced rate as compared to Seabrook Unit 1's once-through system. Actual rates of use would be dependent on power levels of the reactor as well as meteorological conditions. Based on the projected design basis for the cooling system, operations would involve withdrawals at a rate of 44,320 gpm, (99 cfs or 2.8 m^3/s), a water consumption rate (evaporation and drift from the cooling tower) of 22,199 gpm (49 cfs or 1.4 m^3/s, and a blowdown discharge rate of 22,121 gpm (.49 cfs or 1.4 m^3/s). The discharge from the closed-loop system would be expected to have similar characteristics to the current

discharge; however, the discharge water would contain additional chemicals used to treat the water to ensure continued performance of the closed-loop system. A new or revised NPDES permit, issued by the EPA, would guarantee acceptable thermal and chemical characteristics of the discharged cooling water. As a result, impacts on surface water quality and use from construction and operation of the new nuclear alternative at Seabrook would be SMALL.

8.2.4 Aquatic and Terrestrial Ecology

8.2.4.1 Aquatic Ecology

Because of the reduced rate of water withdrawal for cooling, impingement, and entrainment, impacts to aquatic ecosystems can be expected to be less than is currently occurring with the once-through cooling system. However, blowdown from the newly installed closed-loop cooling system would represent a new impact to aquatic ecosystems. The limitations imposed in a new or revised NPDES permit, issued by the EPA, would control adverse impacts to aquatic ecosystems from cooling system discharges. The NRC staff concludes that impacts to aquatic ecology would be SMALL at the Seabrook site.

8.2.4.2 Terrestrial Ecology

As noted in previous sections, the NRC staff presumes that a new nuclear alternative could be constructed on the existing Seabrook property. While much of the plant is likely to be located on previously disturbed industrialized portions of the site, some fallow areas may also be involved, and some wetland areas may experience temporary impacts during the construction phase. Impacts to wetland would be controlled by conditions (including mitigations, where appropriate) in a necessary USACE-issued permit or a NHDES Wetlands Standard Dredge and Fill Permit (NHDES 2012) or both. The terrestrial ecosystem on Seabrook has already adjusted to the presence of an operating nuclear reactor. Some increased human presence will occur during construction, and some additional habitat fragmentation will result from the application of additional acreages to industrial use, but impacts to terrestrial ecosystems during operation are expected to be essentially equivalent to those now occurring from the operating reactor. Construction is expected to impact approximately 460 ac (186 ha). Once construction is complete, laydown and assembly areas and vehicle and equipment staging and maintenance areas will be returned to their natural state, and the amount of permanently impacted land area would be reduced to approximately 320 ac (130 ha). Some additional acreage may be affected if existing ancillary facilities need to be relocated. The operation of a closed-loop cooling system will result in drift and salt deposition on vegetation in the immediate vicinity of the newly installed closed-loop cooling tower (regardless of whether a mechanical draft or natural draft tower is selected). However, given the proximity of the Seabrook site to the Atlantic Ocean and the presence of wetland marshes throughout the site, the extant vegetation can be expected to be salt-tolerant, and additional impacts from cooling tower drift would be incremental. Overall, the NRC concludes that impacts to terrestrial ecology will be SMALL.

8.2.5 Human Health

Human health effects of a new nuclear power plant would be similar to those of the existing Seabrook reactor. Human health issues related to construction would be equivalent to those associated with the construction of any major complex industrial facility and would be controlled to acceptable levels through the application of BMPs and NextEra's compliance with applicable Federal and State worker protection regulations. Both continuous and impulse noise impacts can be expected at offsite locations, including at the closest residences during construction. NRC estimates peak noise levels of 83 to 108 decibels (dBA) at the point of noise generation,

with noise levels of 70 to 102 dBA at a distance of 50 ft (15.2 m). The following actions can be expected to control noise impacts to acceptable levels:

- confining noise-producing activities to core hours of the day (7:00 a.m. to 5:00 p.m.),
- suspending the use of any explosives during certain meteorological conditions (primarily inversion conditions and heavy cloud cover, or both, that allows sound to propagate long distances without appreciable attenuation), and
- notifying potentially affected parties beforehand of such events can be expected to control noise impacts to acceptable levels.

Heavily wooded areas on the site would also serve to reduce offsite noise impacts. If the rail spur leading to the site were to be put into service to bring materials and equipment to the site during construction, noise from rail operations would impact individuals in the residential area that now abuts the rail line. Human health impacts from operation of the nuclear alternative would be equivalent to those associated with continued operation of the existing reactor under license renewal. Noise impacts from facility operation would be much reduced from that occurring during construction. NRC staff expects that operational human health effects would be SMALL. Overall, human health impacts from construction and operation would be SMALL.

8.2.6 Socioeconomics

8.2.6.1 Land Use

As discussed in Section 8.1.6, the GEIS generically evaluates the impacts of nuclear power plant operations on land use, both on and off each power plant site. The analysis of land use impacts focuses on the amount of land area that would be affected by the construction and operation of a new nuclear power plant at the Seabrook site.

Approximately 460 ac (186 ha) of land would be needed to support a new nuclear power plant to replace the Seabrook reactor. There is sufficient buildable land available on the Seabrook site for a replacement reactor. However, some wetlands may be affected during construction. Onsite land use impacts from construction would be SMALL at the Seabrook site.

Land use impacts would be greater at an alternate site where no supporting infrastructure exists, including offsite impacts from the construction of transmission lines.

Offsite impacts associated with uranium mining and fuel fabrication to support the new nuclear alternative would generally be no different from those occurring in support of the existing Seabrook reactor, although land would be required for mining the additional uranium. Overall land use impacts from a new nuclear power plant would range from SMALL to MODERATE.

8.2.6.2 Socioeconomics

Socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics and social conditions of a region. For example, the number of jobs created by the construction and operation of a new nuclear power plant could affect regional employment, income, and expenditures. Two types of job creation would result: (1) construction-related jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact; and (2) operation-related jobs in support of power plant operations, which have the greater potential for permanent, long-term socioeconomic impacts.

A peak construction workforce of 4,000 workers would be required. During construction of a new nuclear power plant, the communities surrounding the construction site would experience

increased demand for rental housing and public services. The relative economic effect of construction workers on the local economy and tax base would vary over time.

After construction, local communities might could be temporarily affected by the loss of construction jobs and associated loss in demand for business services, and the rental housing market could experience increased vacancies and decreased prices. Since Seabrook is located near the Boston metropolitan area, these effects would be smaller because workers are likely to commute to the site instead of relocating to be closer to the construction site. Because of Seabrook's proximity to large population centers, the impact of construction on socioeconomic conditions could range from SMALL to MODERATE.

The number of operations workers could have a noticeable effect on socioeconomic conditions in the region. The permanent relocation of operations workers and their families would create additional job opportunities in the region and could strain social services in surrounding communities. Several tax revenue categories would be affected to include taxes on wages and salaries, sales and use taxes on purchases, workforce expenditures, property taxes on the new reactor, and personal property taxes on owned real property. Socioeconomic impacts associated with the operation of a new nuclear power plant at the Seabrook site would range from SMALL to MODERATE.

8.2.6.3 Transportation

During periods of peak construction activity, as many as 4,000 workers could be commuting daily to the site. In addition to commuting workers, trucks would be transporting construction materials and equipment to the worksite, increasing the amount of traffic on local roads. The increase in vehicular traffic would peak during shift changes, resulting in temporary LOS impacts and delays at intersections. Some plant components are likely to be delivered by train via the existing rail spur. Since the town of Seabrook already experiences high traffic volumes during certain times of the day, transportation impacts could range from MODERATE to LARGE.

Transportation traffic-related impacts would be greatly reduced after construction but would not disappear during plant operations. Transportation impacts would include daily commuting by the operating workforce, equipment and materials deliveries, and removal of waste material to offsite disposal or recycling facilities by truck. Traffic-related transportation impacts would be similar to those experienced during the operation of the existing Seabrook reactor. Overall, the new nuclear alternative would have a SMALL to MODERATE impact on transportation conditions in the region around the Seabrook site.

8.2.6.4 Aesthetics

The aesthetics impact analysis focuses on the degree of contrast between the new nuclear alternative and the surrounding landscape and the visibility of the new nuclear plant.

The appearance of the power block for the new nuclear power plant would be virtually identical to the existing Seabrook power block. The addition of mechanical draft or natural draft cooling towers and associated condensate plumes would add to the visual impact.

Mechanical draft cooling towers would generate more operational noise. Noise during power plant operations would primarily be limited to industrial processes and communications.

In general, aesthetic impacts would be limited to the immediate vicinity of the Seabrook site and would likely be similar to those associated with the currently operating Seabrook reactor. Aesthetic impacts would be SMALL.

8.2.6.5 Historic and Archaeological Resources

The same considerations, discussed in Section 8.1.6.5, for the impact of the construction of a gas-fired plant on historic and archaeological resources apply to the construction activities that would occur on the Seabrook site for a new nuclear reactor.

As previously noted, the potential for historic and archaeological resources can vary greatly depending on the location of the proposed site. To consider a project's effects on historic and archaeological resources, any affected areas would need to be surveyed to identify and record historic and archaeological resources, identify cultural resources (e.g., traditional cultural properties), and develop possible mitigation measures to address any adverse effects from ground disturbing activities.

Based on a review of the Seabrook Cultural Resources Protection Plan, New Hampshire SHPO files for the region, published literature, and additional information provided by NextEra, the potential impacts of constructing and operating a new nuclear power plant at the Seabrook Site on historic and archaeological resources could be SMALL to MODERATE. This impact is based on the results of archaeological surveys. There is a high potential for additional archaeological sites and resource materials to be discovered during construction, including a high potential for encountering human remains. NextEra could mitigate MODERATE impacts by following the Seabrook Cultural Resources Protection Plan to ensure that any adverse impacts to archaeological resources at the Seabrook site are avoided.

8.2.6.6 Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from the construction and operation of a new nuclear power plant. Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant and exceeds the risk or exposure rate for the general population or for another appropriate comparison group. Disproportionately high environmental effects refer to impacts, or risk of impact, on the natural or physical environment in a minority or low-income community that are significant and appreciably exceed the environmental impact on the larger community. Such effects may include biological, cultural, economic, or social impacts. Some of these potential effects have been identified in resource areas discussed in this SEIS. For example, increased demand for rental housing during power plant construction could disproportionately affect low-income populations.

Potential impacts to minority and low-income populations from the construction and operation of a new nuclear power plant at Seabrook would mostly consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts from construction would be short-term and primarily limited to onsite activities. Minority and low-income populations residing along site access roads would also be affected by increased commuter vehicle traffic during shift changes and truck traffic. However, these effects would be temporary during certain hours of the day and not likely to be high and adverse. Increased demand for rental housing during construction in the vicinity of the Seabrook site could affect low-income populations. Given the close proximity to the Boston metropolitan area, most construction workers would likely commute to the site, thereby reducing the potential demand for rental housing.

Based on this information and the analysis of human health and environmental impacts presented in this SEIS, the construction and operation of a new nuclear power plant would not

have disproportionately high and adverse human health and environmental effects on minority and low-income populations residing in the vicinity of Seabrook.

8.2.7 Waste Management

During the construction stage of this alternative, land clearing and other construction activities would generate waste that can be recycled, disposed onsite, or shipped to an offsite waste disposal facility. Construction related wastes would be solid, liquid, or gaseous, and some would require management, treatment, and disposal as hazardous. Various permits, issued by State or local authorities, would control the disposition of all construction-related wastes. Permits issued by USACE would control disposition of dredged spoils from wetland areas. Because the alternative would be constructed on the previously disturbed Seabrook site, the amounts of wastes produced during land clearing would be minimal.

Wastes associated with construction will be similar in nature and amount to wastes from similar industrial construction endeavors and should be easily managed in area landfills and waste treatment facilities. Operating impacts of the replacement reactors with respect to waste generation can also be expected to be virtually equivalent to impacts from the continued operation of the existing reactors. Overall, waste impacts of a new reactor at the Seabrook site would be SMALL.

8.3 Combination Alternative of Natural-Gas-Fired Combined-Cycle and Wind

This section presents the environmental impacts of a combination alternative to the continued operation of the Seabrook reactor consisting of an NGCC facility constructed at the Seabrook site and operating in conjunction with wind farms located in various locations within the ISO-NE service territory.

To serve as an effective baseload power alternative to the Seabrook reactor, this combination alternative must be capable of providing an equivalent amount of baseload power. For the purpose of this evaluation, half of the annual power producing potential of the Seabrook reactor—5,018,604 megawatt hours (MWh)—would come from an NGCC facility and the other half from wind farms. To produce its required share of power, the NGCC portion, operating at an expected capacity factor of 85 percent, would need to have a nameplate rating of 674 MWe (net). Design features and operating parameters of the NGCC portion of this combination alternative are presumed to be the same as those used to describe the discrete NGCC alternative in Section 8.1. The NGCC portion would use the existing electrical switchyards, substations, and transmission lines that now connect Seabrook to the ISO-NE grid. Existing intake and discharge structures of the existing cooling system would continue in service but would be connected to a new closed-cycle cooling system using either a mechanical draft or natural draft cooling tower.

The remainder of the power from this combination alternative would come from at least five wind farms, four of which are located on land somewhere within the ISO-NE service territory, with the last wind farm located offshore, in the Outer Continental Shelf (OCS) opposite the New Hampshire or Massachusetts coasts. To produce their share of the power—5,018,604 MWh annually—the five wind farms, operating at capacity factors of 35 percent each, would need a collective nameplate capacity rating of 1,636.86 MW, or an average individual nameplate rating of 327.37 MW.

Wind energy's intermittency affects its viability and value as a baseload power source; however, strategic and tactical options are under development to address this shortcoming. By using a combination of both onshore and offshore wind farms, producing a nameplate capacity of

1,636.86 MW is more reasonable than expecting a similar capacity to be produced on a wind farm in only one location. Having multiple locations (both onshore and offshore) ensures that the wind turbines experience varied wind conditions at each site rather than being subject to wind capacities at only one specific location. As a result, power is more likely to be produced at least some of the facilities at any given time, reducing the variability of wind-generated electricity. This variability can be lessened further if the proposed four onshore and one offshore wind farms are located at considerable distance from one another and allowed to operate as an aggregate, controlled from a central point. Because the energy produced from wind will service the entire ISO-NE area, the combination of siting wind farms at large distances from one another and developing both inland and offshore facilities would ensure a more constant source of energy. Energy storage is another possible way to overcome intermittency. Besides pumped-storage hydroelectricity, compressed air energy storage (CAES) is the technology most suited for storage of large amounts of energy; however, as noted earlier, no combination of wind and CAES has yet been proposed at the utility scale (EAC 2008). The American Wind Energy Association (AWEA) reports that more than 35,600 MW of wind energy capacity was operational at the end of 2009 nationwide, with 10,010 MW installed just in 2009 (AWEA 2010a). Installed capacity in ISO-NE states totals about 250 MW (AWEA 2010c). As is the case with other renewables, the feasibility of wind resources serving as alternative baseload power in the ISO-NE service area is dependent on the location, value, accessibility, and constancy of the resource. Wind energy must be converted to electricity at, or near, the point where it is extracted and there are limited energy storage opportunities available to overcome the intermittency and variability of wind resource availability. The highest wind-resource areas in the ISO-NE service territory are in remote locations, primarily along mountain ridgelines or in offshore areas. The Seabrook site would not be an appropriate location for the wind portion of this combination alternative, but, instead, each of the five wind farms will be located in remote or rural areas somewhere within the ISO-NE service territory or in an offshore location adjacent to the coasts of New Hampshire, Massachusetts, Rhode Island, or Maine. Thus, each wind farm will require a build-out of transmission lines to deliver its output to the nearest segment of the ISO-NE high-voltage grid.

At the current stage of wind energy technology development, wind resources of Category 3 (wind has a power density of 300 to 400 watts per square meter (W/m^2) with wind speeds of 15.7 to 16.8 mph (7.0 to 7.5 meters per second (m/s))) or better are required to produce utility-scale amounts of electricity. Land-based wind turbines have individual capacities as high as 3 MW, with the 1.67-MW turbine being the most popular size to have been installed in 2008. Offshore wind turbines being considered for commercial deployment have capacities between 3 MW and 5 MW (NREL 2008). In the analysis, it was assumed that 1.67-MW turbines would be used onshore and 5-MW turbines offshore. The capacity factors of wind farms are primarily dependent on the constancy of the wind resource and, while off-shore wind farms can have relatively high capacity factors due to high-quality winds throughout much of the day (resulting primarily from differential heating of land and sea areas), land-based wind farms typically have capacity factors less than 40 percent. Many hundreds of turbines would be required to meet the baseload capacity of the Seabrook reactor. Further, to avoid inter-turbine interferences to wind flow through the wind farm, turbines must be separated from each other, resulting in utility-scale wind farms requiring substantial amounts of land.

A study performed by the National Renewable Energy Laboratory (NREL) assessed offshore wind energy potential in the U.S.; the results show that New England has some of the best wind resources available (NREL 2010a). Analysis from the regional transmission operator in its renewable scenario development analysis report also suggests wind energy is a viable alternative for the New England area (ISO-NE 2009).

The anticipated environmental impacts of a combination alternative involving an NGCC facility on the Seabrook site operating in conjunction with four onshore and one offshore wind farms are summarized in Table 8–3.

Table 8–3. Environmental Impacts of NGCC and Wind Combination Alternative

	NGCC Portion of the Combination Alternative at the Seabrook Site	Wind Portion of the Combination Alternative at Various Onshore & Offshore Sites
Air quality	SMALL	SMALL
Groundwater	SMALL	SMALL
Surface water	SMALL	SMALL
Aquatic & terrestrial resources	SMALL	SMALL
Human health	SMALL	SMALL
Socioeconomics	SMALL	SMALL to LARGE
Historic & archaeological	SMALL to MODERATE	SMALL to MODERATE
Waste management	SMALL	SMALL

The types of environmental impacts of the NGCC portion of this combination alternative will be the same as those discussed in Section 8.1 for the discrete NGCC alternative. However, the smaller facility described here will have a proportionally reduced impact on air quality during operation. Construction-related impacts will be less due to a shorter construction period and a smaller construction workforce. In other respects, differences in impacts are incremental. Only those impacts thought to be significantly different from impacts associated with the NGCC alternative, discussed in Section 8.1, are discussed in the following sections.

Under the hypothetical alternative scenario described in Section 8.3, the 5 wind farms would need an average individual nameplate rating of 327.37 MW to replace half of the power expected to be produced by the Seabrook reactor. Assuming 1.67-MW turbines, each of the four onshore wind farms will require 196 turbines; the offshore wind farm will require 66 turbines, assuming 5-MW turbines. The onshore wind farms would likely be placed atop ridgelines where the wind potential is high, but such locations will result in greater visual impacts than if the wind farms were sited at lower elevations.

Although evidence of environmental impacts from land-based wind farms is extensive, there is very little empirical evidence of the impacts offshore wind farms along the Atlantic coast would have. However, extensive studies have been conducted on offshore wind farms in Europe and, together with an EIS recently published by Minerals Managements Services (MMS) (MMS 2009), these studies provide the basis for some of the conclusions below. The evaluation presented in the following sections for the onshore wind alternative was derived to the appropriate extent from impacts identified in the Wind Energy Programmatic EIS (BLM 2005).

While specific locations cannot be determined at this time, utility-scale wind farms extend over large land areas, although wind farm components will occupy only a small portion of that area. Nevertheless, it would not be feasible to locate any of the wind farms at the Seabrook site. NRC staff believes that it is likely that the offshore wind farm would be developed off the coasts of New Hampshire, Massachusetts, Rhode Island, or Maine, in the OCS.

The anticipated environmental impacts of a combination alternative involving an NGCC facility on the Seabrook site operating in conjunction with four on-shore and one off-shore wind farms are discussed in the following sections.

8.3.1 Air Quality

Section 8.1.1 discusses the various State and Federal regulations that would control the construction and operation of an NGCC facility. Although the NGCC facility of this alternative has one-half the rated capacity of the discrete NGCC alternative discussed in Section 8.1, the same regulatory controls would apply to pollutant releases.

Using data and algorithms published by EPA and EIA, and performance guarantees provided by pollution control equipment vendors, the NRC staff projects the following emissions for an NGCC alternative to the Seabrook reactor:

- SO_x—52 tons (47 MT) per year,
- NO_x—199 tons (180 MT) per year,
- CO—459 tons (416 MT) per year,
- PM_{10}—101 tons (92 MT) per year, and
- CO_2—1,682,263 tons (1,526,149 MT) per year.

8.3.1.1 Construction Impacts

Air quality impacts from construction of the NGCC portion would be similar to those resulting from construction of the discrete NGCC discussed in Section 8.1. However, this smaller facility will have a somewhat smaller footprint than the facility discussed in Section 8.1. As a result, relocation of existing facilities may not be required or may be required to a lesser extent. Likewise, the construction period for the NGCC facility of the combination alternative should be less, although the construction workforce could essentially be the same as for the larger facility discussed in Section 8.1.

GHGs will be produced during construction of the NGCC alternative, but the expected shorter time frame suggests that amounts of GHG will be less than the amount anticipated from the construction of the much larger NGCC facility discussed in Section 8.1. Because detailed construction schedules are not currently available, it is difficult to quantify the GHG emissions that would result. During operation, the primary source of GHGs will be the commuting workforce, which is expected to be slightly smaller than the workforce for the discrete NGCC alternative. NRC estimates that the 674 MW NGCC facility, operating at a capacity factor of 85 percent, would generate 1,682,263 tons of CO_2e per year (1,526,149 MMT/y). Assuming, as suggested by NETL (2007), that CCS can remove 90 percent of the CO_2 in the exhaust, this NGCC facility would release 0.15 MMT/yr of CO_2e if CCS controls were required in the future.

For the onshore wind farm portion, construction activities that could impact air quality include vehicle traffic from workers and equipment; construction of access roads; removal of vegetative cover; construction of laydown areas, staging areas, and pads; and concrete pouring for buildings and tower foundations. Construction activities would also generate fugitive dust from vehicle travel, movement, transport and stockpiling of soils, concrete batching, drilling, and pile driving. Worker and delivery vehicles and the operation of ancillary construction equipment would generate emissions. Construction of onsite buildings, electrical substations, and installation of electrical interconnections among turbines would also produce emissions. The above activities would be temporary and would cease once construction is complete. Most construction activities would occur during the day; therefore, nighttime noise levels probably would drop to background levels of the project area, and their potential impacts would be temporary and intermittent in nature.

For the offshore wind farm portion, construction activities would be different, in some respects, from those for onshore wind energy development projects. Air emissions would result from onshore activities of workforce commuting and delivery of components to staging areas, but the relatively small footprints of the land-based components of an offshore wind farm (cable landing and substation) suggest that little to no fugitive dust from ground disturbing activities would be associated with their construction. Air emissions unique to offshore wind farms would include exhaust gases from marine vessels and helicopters (if applicable) that would be used during construction. During the construction period, noise impacts could occur from vessels carrying equipment and construction crews to and from the offshore site. In the immediate vicinity of each turbine, noise could disrupt marine mammals, fish, and sea turtles. Vessels and barges involved with pile driving or the use of explosives to install foundations would create underwater noise and vibrations; whether or not it can be heard from shore would depend on distance and other factors such as meteorological conditions. Noise from pile driving of the turbine monopiles would be the principal noise impacts during construction. There would also be increased noise at the docks and onshore support facilities, as well as increased noise levels from helicopters, if used.

GHGs will be produced during the construction of both the onshore and offshore wind alternatives assumed in this analysis. Without a detailed construction plan, however, it is difficult to quantify total emissions. The emissions would come mainly from the exhausts of equipment and vehicles used by the commuting workforces and for delivery of construction materials and components, including vessels and work barges used in offshore facility construction or helicopters used in either onshore or offshore facility construction. Emissions from offshore construction may be slightly higher since both land- and water-based vehicles would be used. EPA estimates that CO_2 emissions from combustion of gasoline and diesel fuel would be 8.8 kg/gal (19.4 lb/gal) and 10.1 kg/gal (22.2 lb/gal), respectively (EPA 2005).

The overall air quality impacts associated with construction of an onshore and offshore wind alternative would be SMALL.

8.3.1.2 Additional Operating Impacts

EPA reported that, in 2008, the total amount of CO_2e emissions related to electricity production was 2,397.2 teragrams (2,363.5 MMT) (EPA 2010b). EIA reports that, in 2008, electricity production in New Hampshire was responsible for 6,777 thousand MTs (6.8 MMT), or 0.29 percent of the national total (EIA 2010d). The NRC staff estimates that uncontrolled emissions of CO_2e from operation of the NGCC portion of this combination alternative would amount to 1.68 MT/y (1.53 MMT/y). This amount represents 0.06 percent and 22.5 percent, respectively, of 2008 U.S. and New Hampshire CO_2e emissions. Although natural gas combustion in the combustion turbines would be the primary source of GHGs during operation, other miscellaneous ancillary sources—such as truck and rail deliveries of materials to the site and commuting of the workforce—would make minor contributions. During operation of an onshore wind alternative, noise sources would be mechanical and aerodynamic noise from wind turbines; transformer and switchgear noise from substations; corona noise from transmission lines; and vehicular traffic noise. Improvements in the design of large wind turbines have resulted in significantly reduced mechanical noise. As a result, aerodynamic noise (the flow of air over the blades) is the dominant noise source from modern wind turbines.

Impacts to air quality from the operation of the onshore wind turbines themselves are insignificant. There could be minor VOC emissions during routine changes of lubricating fluids and greases. Fugitive dust from road travel, vehicular exhaust, and brush clearing, in addition to the tailpipe emissions associated with vehicle travel, would occur during operations. However, all these activities would have limited scope and should have no significant air quality

impact. The overall air quality impacts associated with the operation of an onshore wind alternative would be SMALL.

During operation of an offshore wind alternative, minimal noise impacts to recreational boaters from wind turbines are expected, but vibrations transmitted down the tower could be disruptive to fish and aquatic mammals. The operation of wind turbines would not be audible from land; however, for navigation safety, the turbines closest to established shipping lanes could be equipped with foghorns that would be audible to ships during periods of fog. During operation, only emissions from the maintenance vessels are expected. The overall air quality impacts associated with the operation of an offshore wind alternative would be SMALL.

No GHG emissions are released during operation of a wind turbine, regardless of whether it were onshore or offshore; however, negligible amounts would be released from the vehicles used to transport maintenance personnel throughout the operating lives of either facility. Therefore, negligible impacts to climate are expected.

8.3.2 Groundwater Resources

Impacts to groundwater discussed in Section 8.1.2 would also occur for the NGCC portion of this alternative. Such impacts would be similar to, but smaller than, those described in Section 8.1.2 by virtue of the smaller NGCC facility that would be constructed and requiring less extensive ground disturbance and excavation work, along with associated dewatering under this alternative. The impact of the NGCC portion of the combination alternative on groundwater use and quality at Seabrook would be SMALL.

For construction of onshore wind turbine installations, the need for groundwater dewatering would likely be minimal at most sites due to the small footprint of foundation structures. For offshore installations, the impact on groundwater would be negligible. For all construction activities, appropriate BMPs—including spill prevention practices—would be employed during wind turbine construction and conducted in accordance with applicable permitting requirements to prevent or minimize impacts on groundwater quality.

Water would be required for the onshore wind farm construction for dust control to support access roads development, vegetative clearing, and grading. Water would also be used for concrete needed in the pad and piling foundations of wind towers, substations, control buildings, and other support facilities (onshore and offshore sites), as well as to provide for the potable and sanitary water needs of onsite workers. However, water needs for individual wind farm installations would be negligible compared to construction of the NGCC component under this alternative. Given the relatively short duration of construction, installation of new groundwater wells is unlikely. Water would more likely be procured and trucked or shipped in from offsite to the point of use or it could be obtained from local groundwater wells or surface water bodies. Use of ready-mix concrete would also reduce the need for onsite use of groundwater or other nearby water sources.

No impacts to groundwater are expected during wind farm operation. Very little water would be used during operation, as no water is required for cooling purposes, but it could be needed as part of routine servicing including cleaning turbine blades. Adherence to appropriate waste management and minimization plans, spill prevention practices, and pollution prevention plans during servicing of wind farm installations would minimize the risks to water quality from spills of petroleum, oil, and lubricant products and runoff. As a result, the impacts on groundwater quality and use from construction and operation of wind farm components under this alternative would be SMALL.

8.3.3 Surface Water Resources

The impacts to surface water resources from constructing and operating a new NGCC facility under this alternative would be a fraction of those described in Section 8.1.3 because the NGCC component has been scaled back to 674 MWe. Construction-related use and quality impacts will be of the same types, although the construction period would be shorter. All such activities would be subject to the same BMPs, controls, and permitting requirements identified in Section 8.1.3. During NGCC operation, the volume of ocean water that would be withdrawn to support closed-cycle cooling would be substantially less than that under the NGCC alternative or current Seabrook operations. Impacts on surface water quality and use from construction and operation of the NGCC portion of this alternative at Seabrook would be SMALL.

Construction impacts on surface water quality from onshore wind farms could include increased sediment in stormwater flowing across or from active construction areas and the incidental release of various petroleum products and chemicals, as noted in Section 8.3.2. Adherence to an EPA-issued Construction General Permit for stormwater discharges associated with construction activity and to an NHDES-issued Alteration of Terrain Permit would be expected to provide adequate controls to preempt adverse impacts. For the offshore wind component, potential impacts on surface water quality include ballast water discharge from vessels transporting crew and materials to the offshore sites and other water discharges from vessels (e.g., deck drainage, greywater discharge) as well as impacts resulting from installation of monopiles or pilings, undersea cables, and supporting onshore facilities. Once constructed, impacts on surface water resources from operation and maintenance of onshore and offshore wind farms would be negligible. The only potential discharges aside from stormwater runoff during operations would be those associated with work crews and vessels, as appropriate, performing maintenance activities. Such activities would be conducted in accordance with appropriate waste management and pollution prevention plans and procedures, as noted in Section 8.3.2. Impacts on surface water quality and use from construction and operation of the wind farm components under this alternative would be SMALL.

8.3.4 Aquatic and Terrestrial Ecology

8.3.4.1 Aquatic Ecology

Withdrawal rates for seawater used to cool the steam cycle of this smaller NGCC facility would be less than for the discrete NGCC facility discussed in Section 8.1.4. The NRC staff concludes that impacts to aquatic ecology would be SMALL.

For the onshore wind portion, construction activities could adversely affect wetlands and aquatic biota through habitat disturbance, mortality or injury of biota, erosion and runoff, exposure to contaminants, and interference with migratory movements. Construction within wetlands or other aquatic habitats would be largely prohibited, thus limiting potential direct impacts to aquatic ecology. Indirect impacts could occur as a result of surface water quality degradation or impacts from soil erosion. Aquatic ecology impacts for an onshore wind alternative would be SMALL.

Impacts to aquatic ecology could be more significant for offshore wind energy development. Construction activities will introduce noise sources that could be disruptive to aquatic and mammal populations in the area. Vessels bringing wind turbine components from overseas or other U.S. ports could lead to the introduction of invasive species to local waters. Construction activities could also disrupt fishing. However, while most construction related impacts—such as noise, seafloor disturbance, and increased amounts of suspended sediment—would be temporary, permanent alteration of habitat during construction could also occur. The presence

of monopile turbine foundations may act as fish attracting devices, which could potentially benefit aquatic communities. During operations, noise from maintenance vessels and vibration noise transmitted through the towers would continue to provide minimal impacts to the aquatic ecosystems. A recent report by the National Wildlife Federation (NWF) notes that studies performed in Europe have concluded that the ecological risks from offshore wind do not result in long-term or large-scale impacts. Mitigation measures to reduce noise and impact to aquatic habitats would be needed as well as additional studies to evaluate the effect of wind development on aquatic resources (NWF 2010). Impacts to aquatic ecology from an offshore wind alternative would be SMALL.

8.3.4.2 Terrestrial Ecology

Given the shorter construction period and the small footprint of the NGCC portion of this combination alternative, compared to the discrete NGCC alternative discussed in Section 8.1.4, terrestrial ecology impacts from construction and operation at the Seabrook site would be SMALL.

Terrestrial species may be affected by an onshore wind energy project operations through electrocution from transmission lines; noise; collision with turbines, meteorological towers, and transmission lines; site maintenance activities; disturbance associated with activities of the project workforce; and interference with migratory behavior. Bat, raptor, and migratory bird mortality from turbine collisions is a concern for operating wind farms; however, recent developments in turbine design have reduced the potential for bird and bat strikes. Impacts to terrestrial ecology from the construction and operation of an onshore wind alternative would be SMALL.

For the offshore wind portion, construction activities that could affect terrestrial ecology include vegetative clearing for, and construction of, the marine cable landing facility and substation and construction of the transmission line connecting to the existing grid. Impacts from these facilities and components during operations would be minimal, and areas disturbed during construction would be re-vegetated. Potential impacts to avian species include disturbances due to human and boating activities, operation of construction equipment, displacement due to habitat loss, and collision risk to birds during construction. During operations, similar impacts are possible, including loss or modification of habitat, creation of barriers to the flight paths for migrating birds from operating turbines, and collision risk to birds. Oil spills (from turbine transmissions and yaw control gear boxes), although unlikely, would adversely affect birds. The report by NWF acknowledges that offshore wind farms have significant environmental benefits over fossil fuel technologies, but it further notes that some data gaps still exist with respect to predicting impacts to ecosystems from offshore wind farms of the Atlantic coast (NWF 2010). Impacts to terrestrial ecology from the construction and operation of an offshore wind alternative would be SMALL.

8.3.5 Human Health

Human health impacts of this smaller NGCC facility will be proportionally the same as those for the NGCC facility discussed in Section 8.1.5 and would be SMALL.

Construction impacts to human health would resemble impacts from a typical construction project and include mostly work-related accidents and injury.

There are concerns that operation of onshore wind turbines could affect the health of individuals living near a wind development project. Possible impacts include low-frequency noise, turbine blade shadowing, and blade flicker. The extent of these impacts on human health has not been verified by clinical studies; however, since most wind farms would be expected to be located in

remote areas and since all such impacts would be expected to significantly decline with distance, very few members of the general population, if any, would be impacted. Turbines also could cause safety hazards to nearby airports and may cause interferences to radar operation. Overall, health risks to workers and members of the public from the construction and operation of an onshore wind alternative would be SMALL.

Although improbable, the following impacts to human health from the operation of offshore wind turbines are possible—blade throws (turbine blades becoming loose and flying off due to centripetal force) and, under specific weather conditions, ice could form on blades and release onto nearby boaters. As with onshore wind farms in remote areas, the number of individuals expected to be in the vicinity of a wind turbine at any given time is quite small, as is the likelihood of adverse impact to those individuals. Overall, health risks to workers and the public from the construction and operation of an offshore wind alternative would be SMALL.

8.3.6 Socioeconomics

8.3.6.1 Land Use

The footprint of the NGCC portion of the combination alternative will be somewhat smaller than the NGCC alternative discussed in Section 8.1.6. Onsite land use impacts from the construction and operation of the NGCC portion of this alternative will be SMALL. Offsite impacts will result from construction of a supporting pipeline and are also expected to be SMALL.

Because onshore wind turbines require ample spacing between one another to avoid inter-turbine air turbulence, the footprint of utility-scale wind farms could be quite large. Delivering heavy or oversized components to remote rugged areas along ridgelines are challenging and may require extensive road infrastructure modifications and construction of access roads that take circuitous routes to their destination. However, once construction is completed, many access roads can be reclaimed and replaced with more direct access to the wind farm for maintenance purposes. Likewise, land used for equipment laydown and turbine component assembly and erection would be returned to its original state. During operations, only 5 to 10 percent of the total acreage within the footprint is actually occupied by turbines, access roads, support buildings, and associated infrastructure while the remaining land areas can be put to other compatible uses, including agriculture. Overall, land use impacts from an onshore wind alternative would be SMALL to MODERATE.

Offshore wind turbines would be constructed in a grid pattern, with minimum spacing of 0.39 mi by 0.63 mi. The Cape Wind final EIS estimates a footprint of 25 square miles to generate a maximum of 454 MW (MMS 2009). A proportionally smaller, but comparable area requirement would be needed for the 327 MW offshore wind farm proposed in this SEIS. Marine cables would be installed on, or below, the seafloor interconnecting the turbines with a centrally located electrical service platform and connecting that service platform with an onshore cable landing facility and substation. Cable installation would result in only brief impacts to the seafloor. In addition, a small amount of land would be required for the cable landing and substation. Overall, land use impacts from an offshore wind alternative would be SMALL.

8.3.6.2 Socioeconomics

As previously discussed, socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics and social conditions of a region. For example, the number of jobs created by the construction and operation of the NGCC power plant and wind farm could affect regional employment, income, and expenditures. Two types of jobs are created by this alternative: (1) construction-related jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact; and (2) operation-related jobs in

support of power plant operations, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements of power plant construction and operations for the combination alternative were determined in order to measure their possible effect on current socioeconomic conditions.

Socioeconomic impacts would be less than those anticipated for the NGCC alternative discussed in Section 8.1.6, due primarily to the smaller construction workforce, the shorter construction period, and the smaller operating workforce. Socioeconomic impacts from the construction and operation of the NGCC portion of this alternative on the Seabrook site would be SMALL.

After construction, local communities may be temporarily affected by the loss of construction jobs and associated loss in demand for business services, and the rental housing market could experience increased vacancies and decreased prices. However, these effects would likely be spread over a larger area, as the wind farms may be constructed in more than one location. The combined effects of these two construction activities would be SMALL.

Job creation is the most prominent socioeconomic impact for both the onshore and offshore wind portion of this combination alternative. Many jobs would be created in the short term during the construction period. Fewer, but more long-term, jobs would be created during operations. Because the workforce for wind energy development projects is generally low, it is expected that impacts would be minor. The Cape Wind FEIS estimates that 391 full time jobs would be created during the 27-month construction period, and 50 workers would be required for operation; workforce numbers would be similar for an onshore wind alternative. Socioeconomic impacts would be SMALL for both the onshore and offshore portions of this combination alternative.

8.3.6.3 Transportation

Transportation impacts during the construction and operation of the NGCC portion of this alternative would be less than the impacts expected for the NGCC alternative, discussed in Section 8.1, because of a smaller construction workforce and smaller volume of materials and equipment would be needed to be transported to the site.

Construction and operation of a natural-gas-fired power plant and wind farm would increase the number of vehicles on the roads near these facilities. During construction, cars and trucks would deliver workers, materials, and equipment to the worksites. The increase in vehicular traffic would peak during shift changes resulting in temporary LOS impacts and delays at intersections. Transporting components of wind turbines could have a noticeable impact, but is likely to be spread over a large area. Pipeline construction and modification to existing natural gas pipeline systems could also have an impact. Traffic-related transportation impacts during construction could range from SMALL to MODERATE, depending on the location of the wind farm site, current road capacities, and average daily traffic volumes.

During plant operations, transportation impacts would not be noticeable. Given the small numbers of operations workers at these facilities, the LOS traffic impacts on local roads from the operation of the gas-fired power plant at the Seabrook site and at the wind farm would be SMALL. Transportation impacts at the wind farm site or sites would also depend on current road capacities and average daily traffic volumes but are likely to be SMALL given the low number of workers employed by that component of the alternative.

8.3.6.4 Aesthetics

The aesthetics impact analysis focuses on the degree of contrast between the surrounding landscape and the visibility of the power plant. In general, aesthetic changes would be limited to the immediate vicinity of the Seabrook site and the wind farm facilities.

Aesthetic impacts from the gas-fired power plant component of the combination alternative would be essentially the same as those described for the gas-fired alternative discussed in Section 8.1.6. Given the industrial character of the Seabrook site, the only new visual impact of an NGCC alternative would be the cooling tower and condensate plume. Power plant infrastructure would be generally smaller and less noticeable than the Seabrook containment and turbine buildings. Cooling towers would generate condensate plumes and operational noise. Noise during power plant operations would be limited to industrial processes and communications. In addition to the power plant structures, construction of natural gas pipelines would have a short-term impact. Noise from the pipelines could be audible offsite near compressors. In general, aesthetic changes would be limited to the immediate vicinity of the Seabrook site and would be SMALL.

The wind farms would have the greatest visual impact. The onshore wind turbines, which are over 300 ft (100 m) tall and spread across multiple sites, would dominate the view and would likely become the major focus of attention. Because onshore wind farms will be located in rural or remote areas, the introduction of wind turbines will be in sharp contrast to the visual appearance of the surrounding environment. The wind farms would likely be located along ridgelines, maximizing their visibility (BLM 2005). Impacts of construction and operation of an onshore wind alternative could be MODERATE to LARGE.

During construction of an offshore wind farm, visual impacts might result from nighttime work lighting. The impact from lighting is dependent on the distance of the observer and intensity of the lighting. During operations, flashing lights could be visible for approximately 2.5 mi. Wind farms located more than 4 mi from shore would appear small on the horizon from the shoreline (MMS 2009). Impacts of construction and operation from an offshore wind alternative on aesthetics could be MODERATE to LARGE.

8.3.6.5 Historic and Archaeological Resources

The same considerations, discussed in Section 8.1.6.5, for the impact of the construction of a NGCC plant on historic and archaeological resources apply to the construction activities that would occur on the Seabrook site for the NGCC portion of the combination alternative. As previously noted, the potential for historic and archaeological resources can vary greatly depending on the location of the proposed site. To consider a project's effects on historic and archaeological resources, any affected areas would need to be surveyed to identify and record historic and archaeological resources, identify cultural resources (e.g., traditional cultural properties), and develop possible mitigation measures to address any adverse effects from ground disturbing activities.

Based on a review of the Seabrook Cultural Resources Protection Plan, New Hampshire files for the region, published literature, and additional information provided by NextEra, the potential impacts of constructing and operating a new NGCC power plant at the Seabrook Site on historic and archaeological resources could be SMALL to MODERATE. This impact is based on the results of archaeological surveys. There is a high potential for additional archaeological sites and resource materials to be discovered during construction, including a high potential for encountering human remains. NextEra could mitigate MODERATE impacts by following the Seabrook Cultural Resources Protection Plan to ensure that any adverse impacts to archaeological resources at the Seabrook site are avoided.

Surveys would be needed to identify evaluate and address mitigation of potential impacts prior to the construction of any new wind farm. Studies would be needed for all areas of potential disturbance (e.g., roads, transmission corridors, or other right-of-ways). Areas with the greatest sensitivity should be avoided.

Construction activities of an onshore wind farm that have potential to impact cultural resources include earthmoving activities (e.g., grading and digging) and pedestrian and vehicular traffic. Visual impacts on significant cultural resources—such as viewsheds from other types of historic properties—may also occur.

Impacts to historic and archaeological resources for offshore wind development would be proportional to the land areas and seafloor areas disturbed during construction and would be based on whether or not those areas had been previously surveyed. Importantly, coastal and near-shore areas could have high concentrations of historic and archaeological resources.

Depending on the resource richness of the site chosen for the wind farms and associated infrastructure, the impacts could range between SMALL to MODERATE. Therefore, the overall impacts on historic and archaeological resources from the combination alternative could range from SMALL to MODERATE.

8.3.6.6 Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from the construction and operation of a new NGCC power plant at the Seabrook site and wind farms. Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant and exceeds the risk or exposure rate for the general population or for another appropriate comparison group. Disproportionately high environmental effects refer to impacts or risk of impact on the natural or physical environment in a minority or low-income community that are significant and appreciably exceeds the environmental impact on the larger community. Such effects may include biological, cultural, economic, or social impacts. Some of these potential effects have been identified in resource areas discussed in this SEIS. For example, increased demand for rental housing during power plant construction could disproportionately affect low-income populations.

Potential impacts to minority and low-income populations from the construction and operation of an NGCC power plant at Seabrook and wind farm would mostly consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts from construction would be short-term and primarily limited to onsite activities. Minority and low-income populations residing along site access roads would also be affected by increased commuter vehicle traffic during shift changes and truck traffic. However, these effects would be temporary during certain hours of the day and not likely to be high and adverse. Increased demand for rental housing during construction in the vicinity of the Seabrook Site and wind farms could affect low-income populations. Given the close proximity to the Boston metropolitan area, most construction workers would likely commute to construction sites, thereby reducing the potential demand for rental housing.

Based on this information and the analysis of human health and environmental impacts presented in this SEIS, the construction and operation of a NGCC power plant and wind farms (depending on location) would not have a disproportionately high and adverse human health and environmental effects on minority and low-income populations.

8.3.7 Waste Management

Wastes from the construction of the NGCC facility in this alternative will be less than construction wastes for the NGCC alternative discussed in Section 8.1.7. Operational wastes will also be less. Waste impacts from the construction and operation of the NGCC facility in this alternative will be SMALL.

In general, onshore wind farm waste management impacts could occur from the improper management or inadvertent release of hazardous materials—including fuels, lubricants, pesticides, and dielectric fluids in substation electrical equipment and from routine maintenance activities that would generate spent lubricating and hydraulic fluids and water-based coolants. Land clearing and other construction activities would generate waste that can be disposed of onsite or transported to a waste disposal site. During operation, generation of waste would be minimal and would fall under the control of various State and Federal regulations, depending on the nature of the waste. Waste impacts from an onshore wind alternative would be SMALL.

Waste types and impacts for an offshore wind farm would be similar to those for an onshore wind alternative; all waste would be expected to be brought back to shore for disposal. During construction, impacts could occur from mismanagement or improper disposal of oils and fluids, corrosion control coatings, or other chemicals used in construction. Since most components would be assembled elsewhere at onshore locations, waste-related impacts to the ocean would be confined to trash and debris accidently falling overboard from marine vessels or the electrical service platforms, which would wash up on shore, be carried out to the open ocean, or sink to the ocean floor. During operation, the generation of waste would be limited to wastes lubricating fluids resulting from routine maintenance. Waste impacts from an offshore wind alternative would be SMALL.

8.4 Closed-Cycle Cooling Alternative

This section presents the environmental impacts of a closed-cycle cooling system alternative at the Seabrook site. The NRC staff is examining this alternative in response to comments submitted by the EPA, U.S. National Marine Fisheries Service (NMFS), and NHDES on the draft SEIS. The purpose of this analysis is for the NRC staff to compare the closed-cycle cooling alternative with the proposed action to inform NRC's licensing decision as applicable under NEPA. The NRC does not have the regulatory authority to implement the requirements of the Clean Water Act (CWA), such as determining the best technology available or other permitting issues for which EPA or a delegated state has regulatory authority under CWA.

NextEra previously analyzed the environmental impacts of a closed-cycle cooling alternative in response to EPA's Supplemental Information Request pursuant to Section 308 of the CWA (ARCADIS 2008). The assessment was also used to support NextEra's application to renew Seabrook's NPDES permit from September 2006. ARCADIS (2008) summarizes the results of a conceptual study for a proposed retrofit closed-cycle cooling system for Unit 1. The study included a construction schedule, potential environmental effects, and loss of electric output during construction and operations. For this alternative, the NRC staff reviewed ARCADIS (2008) as part of its independent evaluation of the closed-cycle cooling system alternative. The closed-cycle cooling alternative would be located at the Seabrook site, and Unit 1 would be retrofitted to include closed-cycle cooling. A total of three saltwater mechanical draft cooling towers would be built, which would include two 15-cell, plume abated cooling towers at an area known as Snoopy's Head and one 24-cell, plume abated cooling tower at another site known at the 18-Acre Laydown Area. Each of the three separate strings of saltwater mechanical draft cooling tower cells would be 2,700 ft (823 m) in length. Cooling

tower cell arrays would occur within 700 ft (213 m) of currently occupied residential or commercial properties. Cooling towers would be 66 ft (20 m) tall (ARCADIS 2008). Other structures would be the same as that described for Unit 1. ARCADIS (2008) determined that there was sufficient space available at the Seabrook site to build the closed-cycle cooling alternative. Using the Seabrook site would maximize the availability of support infrastructure and reduce disruption to land and populations. For example, the alternative would use the site's existing Unit 1 power block, transmission lines, intake and discharge structures, and groundwater water wells (ARCADIS 2008).

The closed-cycle cooling system would use approximately 55,800 gpm, which is approximately 88 percent less water than the current once-through system for Unit 1 (ARCADIS 2008). Service water would remain the same as current operations for Unit 1 (21,000 gpm).

The majority of construction activities would occur near the currently existing Unit 1 turbine building area. At this site, NextEra would connect the new piping systems for the cooling towers into the condensers (ARCADIS 2008). NextEra estimated that the construction, including engineering, procurement and construction, would take 3.2 years (165 weeks) to complete (ARCADIS 2008).

Environmental impacts from the closed-cycle cooling alternative are summarized in Table 8–4.

Table 8–4. Environmental Impacts of Closed-Cycle Cooling Alternative

	Closed-Cycle Cooling Alternative
Air Quality	MODERATE
Groundwater	SMALL
Surface water	SMALL
Aquatic & Terrestrial Resources	SMALL
Human Health	SMALL to MODERATE
Socioeconomics	SMALL to MODERATE
Historic and Archaeological	SMALL to MODERATE
Waste Management	SMALL to MODERATE

Section 2.2.2 of this SEIS discusses the ambient air quality and regulatory framework that governs air pollutant emissions in Rockingham County, which encompasses Seabrook. In summary, Seabrook is located in the Merrimack Valley–Southern New Hampshire Interstate AQCR (40 CFR 81.11). Within New Hampshire, portions of Hillsborough, Merrimack, Rockingham, and Strafford counties are designated as moderate non-attainment areas in accordance with EPA's National Ambient Air Quality Standards (NAAQS) for 8-hour ozone (40 CFR 81.330). In addition to local emissions, many of the ozone exceedances in New Hampshire are associated with the transport of ozone and its precursors from upwind regions. The cities of Manchester and Nashua in Hillsborough County, which are about 30 mi (48 kilometers (km)) inland from Seabrook, are designated as maintenance areas for carbon monoxide(CO) in accordance with EPA's NAAQS. With these exceptions, all counties in New Hampshire are designated as unclassifiable/attainment areas for all other criteria pollutants.

Construction and operation of a closed-cycle cooling system at Seabrook could be subject to Federal and state regulations aimed at controlling air pollution. The closed-cycle cooling alternative would affect air quality by:

- the need to supply replacement power during construction-related outages and to replace the power lost due to the closed-cycle cooling during operation,
- emissions from construction activities and vehicles (including from worker vehicles and delivery traffic), and
- other emissions from cooling tower operations.

8.4.1 Air Quality

8.4.1.1 Replacement Power

Replacement power may be needed during both construction and operations of Seabrook's closed-cycle cooling system. Following cooling tower construction, Seabrook, Unit 1, would be offline for at least a short time during the switch over from open-cycle to closed-cycle cooling. However, while replacement power produced by existing generating facilities within the ISO-NE could result in increases in air emissions during this period, it is likely that the switch over could be scheduled to use available surplus power. This surplus power could be routed across electric grid areas to service areas where replacement power is needed without any net increase in air pollutant emissions.

Replacement power would be required once Seabrook's closed-cycle cooling system is online. Use of a closed-cycle cooling system would reduce Seabrook Unit 1's electrical output and efficiency due to increased turbine backpressure and introduction of new parasitic loads due to the additional power needed to operate cooling tower pumps and fans. These losses and additional demands account for approximately 51.5 MW of electric load or 416,000 MWh of annual generation. It is estimated that a reduction of 416,000 MWh in annual generation from Unit 1 would result in regional annual air emission increases of 154 to 7,180 tons (140 to 6,514 MT) of SO_x; 314 to 1,515 tons (285 to 1,374 MT) of NO_x; and 370,020 to 630,769 tons (335,680 to 572,230 MT) of CO_2 if replaced by fossil-fuel-fired power generation (ARCADIS 2008). Continuing air quality impacts would result from generation of the power that replaces these parasitic and efficiency losses during operation of Seabrook with closed-cycle cooling.

8.4.1.2 Construction Impacts

Air quality at or near Seabrook during the construction of the closed-cycle mechanical draft cooling towers would be affected mostly by exhaust emissions from internal combustion engines and fugitive dust emissions from site preparation and vehicular traffic on unpaved or disturbed areas. These emissions would include CO, NO_x, VOCs, SO_x, CO_2, and PM_{10} and $PM_{2.5}$ from operation of gasoline- and diesel-powered heavy-duty construction equipment, delivery vehicles, and workers' personal vehicles. The amount of pollutants emitted from construction heavy equipment and construction worker traffic would be relatively small compared to total vehicular emissions in the region.

A conformity determination is required under 40 CFR Part 93 to ascertain whether pollutant emissions resulting from a proposed Federal action in a non-attainment or maintenance area conform to the state implementation plan. Because Seabrook is located in a non-attainment area for ozone, a conformity analysis would need to be performed before construction.

Fugitive dust, a contributor to PM_{10} and $PM_{2.5}$, would be generated from site clearing and construction traffic and excavation work. Given the land area that would be affected and disturbed to some degree (about 18 ac (7.3 ha)), fugitive dust could be considerable. Fugitive dust management practices would be applied (e.g., watering, sediment fencing, covering soil

piles, re-vegetation, and related BMPs) during construction. Furthermore, the amount of road dust generated by vehicles traveling to and from the site transporting workers or hauling materials—including excavated and fill materials—would contribute to particulate concentrations. In total, construction impacts could be locally substantial but would be temporary.

8.4.1.3 Operating Impacts

During operations, potential impacts on ambient air quality could be significant. As previously discussed, the cooling towers would emit tower drift consisting of water, salt, and suspended solids. These emissions would be considered PM_{10} and could include $PM_{2.5}$. Seabrook is located in a non-attainment area for ozone, as previously discussed. However, operation of cooling towers would not emit ozone precursors such as NO_x and VOCs; thus, further conformity analysis for operation would not be required.

It is estimated that particulate matter emissions would be 3,807 tons (3,453 MT) per year from cooling tower operations at Seabrook. Accordingly, prevention of significant deterioration (PSD) requirements and permitting would be required, including modification of Seabrook's current Title V permit. PSD requirements are triggered when new major air pollutant sources or major modifications of sources located in areas that are attaining the NAAQS are proposed. Even with the most advanced control technologies in place, projected cooling tower emissions would exceed state emission standards for particulates. In addition, the potential exists for fogging and icing effects along with salt deposition associated with cooling tower operations. Although drift eliminators (baffles) would be included on the cooling towers to minimize drift, the NRC staff concludes that it would be difficult to avoid all offsite impacts given the distances from the proposed cooling tower locations to offsite properties and interests.

In summary, during construction, air quality impacts would be controlled by standard practices as specified in a state permit to construct an air pollutant source and by any additional measures shown necessary by a conformity analysis, if required. Should operational air emissions cause air quality to worsen and exceed ambient standards, the effect would be MODERATE or LARGE, though some level of emissions trading could limit this impact. Also, the need for replacement power from other generating facilities would generate air emissions. Overall, the impacts on air quality from construction and operation of the closed-cycle cooling alternative at Seabrook would be MODERATE.

8.4.2 Groundwater Resources

Construction of the three mechanical draft cooling tower installations would take place in two locations on the site property, as noted in Section 8.4. The need for groundwater dewatering would likely be minimal at the two sites as excavation depths would be limited to less than 10 ft (3 m) below ground surface (ARCADIS 2008). Construction in the areas closest to the marsh and lowest in elevation would have the greatest risk of requiring some dewatering of cooling tower basin excavations due to intrusion of brackish or shallow fresh groundwater. Open excavations create a potential pathway for groundwater contamination and may also establish communication between aquifers. Nevertheless, construction would be accomplished with the use of cofferdams, sumps, wells, or other methods as necessary to address high water-table conditions, as they exist at Seabrook. Any such discharges would be subject to controls and limitations of an EPA-issued NPDES DGP (EPA 2012a).

Facility construction would also increase the amount of impervious surface across the Seabrook site. While an increase in impervious surface would reduce infiltration and reduce groundwater recharge, the effects on water table elevations would likely be very small. In addition, BMPs and other controls (including appropriate waste management, water discharge, and spill

prevention practices) would be implemented in accordance with an NPDES Construction General Permit for stormwater discharges from EPA (EPA 2012b) and under an Alteration of Terrain Permit issued by the NHDES (NHDES 2012). These would serve to mitigate any impacts on groundwater quality.

During commissioning of the closed-cycle cooling system, Seabrook Unit 1 may be offline for a short period of time (see Section 8.4.1.1). The demand for potable water supplied by the Town of Seabrook well system for Seabrook Unit 1 operations would be unlikely to change appreciably during this time frame. Some additional water would be required to support cooling tower construction activities, including for such uses as worker potable and sanitary water needs, concrete production, dust suppression, and soil compaction. Water could be supplied via a temporary utility connection or trucked to the point of use. It is expected that total onsite (town groundwater-supplied) potable water use during the construction period would be much less than the 80 gpm (300 L/min) used during normal Seabrook operations. Onsite water demands to support cooling tower construction could be reduced by the use of ready-mix concrete and the use of portable sanitary facilities for construction workers that are serviced offsite.

No onsite groundwater or town-supplied groundwater would be used during operation of the Seabrook closed-cycle cooling system, as they would be continuously fed by seawater. Operation of Seabrook's mechanical draft cooling towers would not be expected to have any impact on soil, surface water, or groundwater quality. As discussed in the GEIS (NRC 1996), the effects of drift deposition are not a concern in humid regions, such as at Seabrook, where precipitation is sufficient to wash salts from the soil profile. The impacts to terrestrial ecology from salt drift during cooling tower operation are discussed in Section 8.4.4.2.

In consideration of the information above, the impacts on groundwater quality and use from construction and operation of the closed-cycle cooling alternative at Seabrook would be SMALL.

8.4.3 Surface Water Resources

Cooling tower construction could have some temporary impacts on surface water quality from increased sediment loading and from any pollutants in stormwater runoff from disturbed areas. During facility construction, runoff from the two construction sites would be controlled under permits issued by the EPA and NHDES, as noted in Section 8.4.2. These controls would include the requirement to develop and implement a stormwater pollution prevention plan and associated BMPs to prevent or significantly mitigate soil erosion and contamination of stormwater runoff that could impact soils, surface water, or groundwater.

Operation of cooling tower systems would require makeup water, which would be obtained from the Atlantic Ocean using the tunnel system currently used for the once-through cooling system (see Section 2.1.6 of this SEIS). However, operation of the closed-cycle cooling system would have the benefit of reducing flow at the ocean intake by 88 percent (ARCADIS 2008). Likewise, closed-cycle cooling would also result in a substantial reduction in the effluent discharged via Seabrook's ocean outfall structure, which is currently permitted for the discharge of up to 720 mgd (2.7 million m^3/day) of once-through cooling water and other plant wastewaters, as further described in Section 2.2.4.

Biocides are commonly used in cooling towers to control biofouling (Veil et al. 1997). Other chemical additives may also be needed to prevent scale build-up or corrosion in the closed-cycle system. Although Seabrook is currently permitted to use chlorine or the molluscicide EVAC or both, as noted in Section 2.2.4, use of cooling towers would be expected to increase the usage of such biocides and other additives. These additives would then be present in the cooling tower blowdown discharged from the system to Seabrook's ocean outfall

structure. This would require submitting a revised NPDES permit application and granting of the modified permit by the EPA. This may also require that NextEra obtain a new CWA Section 401 Water Quality Certification from the State of New Hampshire. Such permitting may also result in the imposition of revised monitoring requirements and in the need to provide treatment of the blowdown prior to discharge in order to meet water quality standards. In conclusion, the overall impacts on surface water quality and use from construction and operation of the closed-cycle cooling alternative at Seabrook would be SMALL.

8.4.4 Aquatic and Terrestrial Ecology

8.4.4.1 Aquatic Ecology

Construction activities for the closed-cycle cooling alternative (such as construction of cooling towers) could affect onsite aquatic features, including the Seabrook–Hampton Estuary and the Gulf of Maine. Minimal impacts on aquatic ecology resources are expected because NextEra would likely implement BMPs to minimize erosion and sedimentation. Stormwater control measures, which would be required to comply with NPDES permitting, would minimize the flow of disturbed soils into aquatic features.

During operations, the closed-cycle cooling system would use approximately 55,800 gpm, which is approximately 88 percent less water than the current once-through system for Unit 1 (ARCADIS 2008). The intake velocity at the velocity cap intake structures would decrease from a current maximum of 0.84 feet per second (fps) to less than 0.1 fps. The temperature of the discharged water would decrease from an average of 69.4 to 110.4 °F (20.8 to 44 °C) for the current once-through system to an average of 34 to 78 °F (1.1 to 26 °C) with a design maximum of 83 °F (28 °C) (ARCADIS 2008). Service water would remain the same as current operations for Unit 1 (21,000 gpm). Table 8–5 summarizes the cooling system specifications for the closed-cycle alternative and current operations.

Table 8–5. Summary of Cooling System Specifications for the Closed-Cycle Cooling Alternative and Current Operations

	Closed-Cycle Alternative	Current Operations
Cooling water intake	55,800 gpm	452,000 gpm
Intake velocity	0.1 fps	0.84 fps
Discharge temperature	34–78 °F	69.4–110.4 °F

Source: ARCADIS 2008

Consultation under several Federal acts, including the Endangered Species Act (ESA) and the Magnuson–Stevens Act, would be required to assess the occurrence and potential impacts to Federally protected aquatic species and habitats within affected surface waters. Coordination with state natural resource agencies would further ensure that NextEra would take appropriate steps to avoid or mitigate impacts to state-listed species, habitats of conservation concern, and other protected species and habitats. The NRC assumes that these consultations would result in avoidance or mitigation measures that would minimize or eliminate potential impacts to protected aquatic species and habitats.

The impacts on aquatic ecology would be minor because construction activities would require BMPs and stormwater management permits and because the surface water intake and discharge for this alternative would be 88 percent less than for current operations. Therefore, the staff concluded that impacts on aquatic ecology would be SMALL.

8.4.4.2 Terrestrial Ecology

The closed-cycle cooling alternative would be sited on one of two previously disturbed areas on the Seabrook site identified as “Snoopy’s Head” and the “18-Acre Laydown Area” in ARCADIS’s 2008 report. Though ARCADIS (2008) notes that installing mechanical draft cooling towers would require a significant level of complex construction activity, impacts to terrestrial habitat would be minor because all construction activity would occur on previously disturbed land. Implementation of BMPs would minimize erosion and fugitive dust. Construction noise could modify wildlife behavior; however, these effects would be temporary (3.2 years or less). Road improvements or construction of additional service roads, if needed to facilitate construction, could result in the temporary or permanent loss of terrestrial habitat.

Impacts from operation of the closed-cycle cooling alternative are expected to be of similar magnitude and intensity as those analyzed in the GEIS. The potential physical impacts from a cooling tower plume include salt drift and icing and fogging of surrounding vegetation during winter conditions. Icing can damage trees and other vegetation near the cooling towers. The salt content of the entrained moisture (drift) also has the potential to damage vegetation, depending on concentrations. However, the GEIS concludes such impacts would be SMALL. Cooling towers also have the potential to create a collision hazard for birds. This alternative would include mechanical draft cooling towers, which are shorter than natural draft cooling towers and, thus, pose less of a risk to birds. Additionally, the GEIS concludes that the potential impact to birds from collisions with cooling towers are SMALL.

As described above under aquatic ecology, consultation with the U.S. Fish and Wildlife Service under the ESA would ensure that the construction and operation of the closed-cycle cooling alternative would not adversely affect any Federally listed species or adversely modify or destroy designated critical habitat. Coordination with state natural resource agencies would further ensure that NextEra would take appropriate steps to avoid or mitigate impacts to state-listed species, habitats of conservation concern, and other protected species and habitats. Consequently, the impacts of construction and operation of the closed-cycle cooling alternative on protected species and habitats would be SMALL.

8.4.5 Human Health

Human health impacts for an operating nuclear power plant are identified in 10 CFR Part 51, Subpart A, Appendix B, Table B-1. Potential impacts on human health from the operation of closed-cycle cooling towers at nuclear power plants are evaluated in Section 4.3.6 of the GEIS.

During construction of the cooling towers, there would be risk to workers from typical industrial incidents and accidents. Accidental injuries are not uncommon in the construction industry, and accidents resulting in fatalities do occur. However, the occurrence of such events is mitigated by the use of proper industrial hygiene practices (e.g., use of protective hearing equipment and minimizing stay times), complying with worker safety requirements, and training. Occupational and public health impacts during construction are expected to be controlled by continued application of accepted industrial hygiene protocols, occupational health and safety controls, and radiation protection practices.

Seabrook would be expected to implement appropriate occupational safety and health and radiation protection practices to minimize the hazard to plant workers. Based on this information, the NRC staff concludes that the impact to plant and construction workers would be SMALL.

8.4.5.1 Noise

NextEra has not performed detailed studies of the potential noise levels from the cooling towers. However, preliminary studies show that there would be two sets of cooling towers located approximately 700 ft (213 m) from residential and commercial properties in the Town of Seabrook. For these locations, NextEra estimates that noise levels beyond the site would range from 55 to 75 dBA (ARCADIS 2008).

The evaluation of noise impacts in the GEIS found that noise level increases larger than 10 dBA would be expected to lead to interference with outdoor speech communication, particularly in rural areas or low-population areas where the background noise level is in the range of 45 to 55 dBA. Generally, a 3-dBA change over existing noise levels is considered to be a "just noticeable" difference, and a 10-dBA increase is subjectively perceived as a doubling in loudness and almost always causes an adverse community response (NWCC 2002). The Department of Housing and Urban Development (HUD) has established noise assessment guidelines and finds that noise level of 65 dBA Ldn [1] or less are acceptable (HUD 2013).

Because the cooling towers would be in operation most of the time, the continuous noise associated with their operation may be an issue to nearby residential and commercial properties. As a mitigation measure, NextEra has identified the use of externally mounted sound attenuators to reduce the noise levels to nearby residential and commercial properties (ARCADIS 2008). Based on the proximity of the potential cooling towers and the estimated offsite noise levels of up to 75 dBA on a mostly continuous basis, the staff concludes that the impact to members of the public would be SMALL to MODERATE.

8.4.5.2 Microbial Organisms

The GEIS evaluation of health effects from plants with cooling systems discusses the potential hazard to workers from microbiological organisms inhabiting the system whose presence might be enhanced by the thermal conditions found in the cooling system. The microbiological organisms of concern are freshwater organisms that are present at sites that use cooling ponds, lakes, or canals and that discharge to small rivers (NRC 1996). Because a closed-cycle system at Seabrook would operate using Gulf of Maine saltwater, thermal enhancement of microbiological organisms is not expected to be a concern to workers.

Because the cooling towers would not release heated water into the environment, and since the system would use saltwater, the NRC staff concludes that the impact to members of the public from microbiological organisms would be negligible.

8.4.6 Socioeconomics

8.4.6.1 Land Use

The analysis of land-use impacts focuses on land use changes caused by the construction and operation of new closed-cycle cooling towers at the Seabrook site. All power plant modifications related to the proposed closed-cycle cooling alternative would occur within existing structures or within previously disturbed areas on the industrially zoned Seabrook site.

As previously discussed, construction of the new cooling towers would take place at Snoopy's Head and the 18-acre Laydown Area. Land at Snoopy's Head was disturbed during the initial construction of Unit 1 and cancelled Unit 2. The 18-acre Laydown Area, a rectangular plot of

[1] Several different terms are commonly used to describe sounds that vary in intensity over time. The equivalent sound intensity level (Leq) represents the average sound intensity level over a specified interval, often one hour. The day-night sound intensity level (Ldn) is a single value calculated from hourly Leq over a 24-hour period, with the addition of 10 dBA to sound levels from 10 p.m. to 7 a.m. This addition accounts for the greater sensitivity of most people to nighttime noise.

land located immediately south of the south access road, was cleared for staging material, machinery, and equipment during the construction of Unit 1.

Removal and disposal of cooling tower construction and operational waste material from the Seabrook site could cause offsite land use impacts. However, some waste materials could be recycled or reused, thus reducing the impact.

Other than the activities described above, no new construction would occur outside of previously disturbed areas of the Seabrook site, and no expansion of existing buildings, roads, parking lots, or storage areas would be required to support the proposed closed-cycle cooling alternative. Existing parking lots, road access, equipment laydown areas, offices, workshops, and warehouses would be used during power plant modifications, cooling tower construction, and operations. Onsite land use would not change as the land occupied by the cooling towers is already in industrial use. Based on this information, overall land use impacts could range from SMALL to MODERATE, depending on the amount of waste material removed from Seabrook and the amount of land affected at offsite waste disposal sites.

8.4.6.2 Socioeconomics

Socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics and social conditions of a region. For example, the number of jobs created by the construction and operation of closed-cycle cooling towers could affect regional employment, income, and expenditures. Two types of job creation result from this alternative: (1) construction jobs, and (2) operations jobs, which have the greater potential for permanent, long-term socioeconomic impacts. Potential socioeconomic impacts include increased demand for housing, public services, and increased traffic in the region due to the temporary increase in the size of the workforce at Seabrook required to construct and operate the proposed closed-cycle cooling alternative.

Seabrook estimates construction of a closed-cycle cooling system to last approximately 3 years (ARCADIS 2008). No workforce estimates were provided; however, analysis of a similar closed-cycle cooling at the Oyster Creek Generating Station indicated that construction is likely to employ approximately 200 workers during peak construction months and 100 workers for the remainder of the 3-year construction period (NRC 2006). Based on previous refueling outages, most of the cooling tower construction workers would relocate temporarily to the Seabrook area, resulting in a short-term increase in the local population along with an increased demand for public services and housing. Because plant modification and construction work would be temporary, most workers would stay in available rental homes, apartments, mobile homes, and camper-trailers.

Once closed-cycle cooling tower construction and power plant modifications have been completed, the size of the workforce at Seabrook would return to normal levels and remain similar to pre-construction levels. Based on estimates from the analysis of the closed-cycle cooling system alternative at Oyster Creek Generating Station, approximately 25 employees would be added to the permanent workforce (NRC 2006).

As reported in Section 2.2.9, NextEra pays annual property taxes to seven local towns and to the State of New Hampshire. It is likely that the value of annual property tax payments to local taxing jurisdictions and state agencies would increase with changes in assessed valuation resulting from the construction of a new closed-cycle cooling system and other capital expenditures. Although emergency preparedness fees are paid to the Federal Emergency Management Agency (FEMA) and to the states of Maine, Massachusetts, and New Hampshire, it is unlikely the size of these fees would change with a change in the plant cooling system.

Based on this information, socioeconomic impacts caused by the construction and operation of new cooling towers at the site would be SMALL.

8.4.6.3 Transportation

Traffic-related transportation impacts during construction and operation of the closed-cycle cooling system would consist of commuting workers and deliveries of construction materials and equipment to the Seabrook site. During periods of peak construction activity, up to 200 workers could be commuting daily to the site. The increase in vehicular traffic would peak during shift changes, resulting in temporary LOS impacts and delays at intersections. Traffic volume in the area is heavy during certain hours of the day, and additional construction-related traffic would cause increased traffic delays, particularly along US Highway 1A and on secondary roads in the immediate vicinity of Seabrook.

During operations, the closed-cycle cooling system would have little to no effect on traffic conditions as the operations workforce at Seabrook would remain unchanged. Occasional shipments of waste cleaned out from cooling tower basins, deliveries of chemicals used to prevent fouling of the towers, and deliveries of replacement components would occur throughout the life of the cooling towers.

Based on this information, traffic-related transportation impacts during construction would range from SMALL to MODERATE, depending on traffic volume and time of day, and would be SMALL during cooling system operations.

8.4.6.4 Aesthetics

The Seabrook site is dominated by the 199-ft (61-m) containment structure and the 103-ft (31-m) high and 325-ft (99-m) long turbine and heater bay building north of the containment building (Section 2.2.9.4). The site is visible from Hampton Flats, US Highway 1A, and Hampton Harbor. During the winter season, the site is visible from elevated locations, such as Powwow Hill, located approximately 2 mi (3.2 km) southwest in Amesbury, Massachusetts. The addition of three cooling towers standing 66 ft (20 m) tall would make the facility more visible as the developed footprint of the facility would be expanded; the towers would also be clearly visible from offsite vantage points (ARCADIS 2008).

While the hybrid mechanical draft cooling towers under consideration are designed to reduce ground level fog and ice production in the local area, fog and ice could still occur during power plant operations. Analysis of hybrid mechanical draft cooling towers at Indian Point Generating Station shows a visible plume may occur under certain meteorological conditions during the year (NRC 2010). In most cases, these plumes would occur immediately over the tower and Seabrook property, though under extreme conditions, plumes may extend several hundred to thousands of meters (NRC 2010). Given tower design, the plume is likely to remain aloft and not occur at ground level thereby reducing the likelihood and severity of fog and ice. Less noticeable moisture and salt deposition from the plume may increase dampness and corrosion on surrounding property, which could affect the visual environment.

The NRC staff concludes that the impact of construction and operation of a closed-cycle cooling system at Seabrook on aesthetics would likely be SMALL to MODERATE, given the proximity to local visual resources. Impacts will be greater when atmospheric conditions result in large, visible plumes, and towers will always be clearly visible.

8.4.6.5 Historic and Cultural Resources

All lands needed to support construction of the mechanical draft cooling towers and their associated corridors would need to be surveyed for historic and archaeological resources. Constructing the mechanical draft cooling towers on previously disturbed land could reduce the

potential impact to historic and archaeological resources at Seabrook. However, archaeological surveys should still be conducted to verify the depth of disturbance and to evaluate the land for the potential discovery of historic and archaeological resources. Any resources found during these surveys would need to be evaluated for their eligibility for listing on the National Register of Historic Places, and any adverse effects would need to be mitigated. Nearby historic properties could also be impacted by the addition of the draft cooling towers to their view shed.

The level of impact at Seabrook would vary depending on the historic and archaeological resources present during construction of the cooling towers. Given the high potential for historic and archaeological resources to be discovered during construction, including the potential for encountering human remains, undisturbed portions of the power plant site should be avoided. Potential adverse impacts to historic properties could be avoided by limiting all construction activities to previously disturbed land. Additionally, early coordination with the State Historic Preservation Office, consultation with affected American Indian Tribes, and adherence to Seabrook's Environmental Compliance Manual for the protection of historic and archaeological resources would also reduce the likelihood of any adverse impacts. Therefore, the impacts on historic and archaeological resources at the Seabrook site from the construction and operation of closed-cycle cooling towers could range from SMALL to MODERATE.

8.4.6.6 Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from the construction and operation of a closed-cycle cooling system at Seabrook. As previously discussed, such effects may include human health, biological, cultural, economic, or social impacts. Some of these potential effects have been identified in resource areas previously discussed in this section. For example, increased demand for rental housing during construction could disproportionately affect low-income populations.

Potential impacts to minority and low-income populations from the construction and operation of a closed-cycle cooling system at Seabrook would mostly consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts during construction would be short-term and primarily limited to onsite activities. However, minority and low-income populations residing along site access roads could be directly affected by increased commuter vehicle and truck traffic. Because of the temporary nature of construction, these effects would only occur during certain hours of the day and are not likely to be high and adverse. Increased demand for rental housing during construction of the closed-cycle cooling system could also affect low-income populations. However, as Seabrook is located in a high population area and the number of available housing units exceeds demand, any increase in employment would have little or no noticeable effect on the availability of rental housing in the region. Also, given the close proximity to urban areas, workers could commute to the construction site, thereby reducing the need for rental housing.

As noted earlier in this section, replacement power required during the cooling tower construction outage could increase air quality impacts and human health effects in minority and low-income communities, depending on the location and characteristics of fossil-fueled power plants used to replace Seabrook output. These effects are likely to be short-lived (most will be no longer than the outage period) and may vary with time of year, scheduled outages at other power plant facilities, and pricing on the grid. Additionally, impacts would occur near the existing power plants and would result from incremental increases rather than new effects. Nonetheless, power generation may come from other sources to make up for parasitic and efficiency losses and could contribute to additional air quality and human health impacts.

However, it is assumed that emissions from these generator facilities would meet air quality standards.

Based on this information, and the analysis of human health and environmental impacts presented in this section, the construction and operation of the closed-cycle cooling system would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations living near Seabrook.

8.4.7 Waste Management

Construction of the closed-cycle cooling alternative at Seabrook would generate construction debris. NextEra has not evaluated the types or amounts of debris that would result from the development of the two parcels of land where the cooling towers would be sited—Snoopy's Head and the 18-ac Laydown Area. The Snoopy's Head location was formed with construction debris from initial plant construction (ARCADIS 2008). The site is uneven and contains a mixed composition of fill material. This location would require extensive preparation (i.e., soil compaction or additional fill material or both). Use of this previously disturbed land is likely to require removal and disposal or recycle of soil and fill material in order to accommodate the installation of the large diameter cooling tower supply and return lines. The Laydown Area is an 18-acre rectangular piece of land. Construction in this area would also require extensive excavation to install the large diameter cooling tower supply and return lines.

Based on the size of the two locations and the large amount of excavation needed to install the large supply and return lines, the staff estimates that a large amount of soil and construction debris would need to be disposed or recycled. The debris could be disposed of onsite as it did for other debris during initial construction of the plant or in a local municipal landfill if the material meets disposal criteria for the disposal facility. The staff is not aware of the potential to recycle the debris within the local area. Based on the information above, the staff concludes that the impacts would range from SMALL to MODERATE based on the types and amount of waste removed from the site. Since NextEra has not evaluated the excavation and disposition of the debris, it has not identified any mitigation measures that would be appropriate for waste disposed or recycled offsite.

8.5 Alternatives Considered but Dismissed

Alternatives to Seabrook license renewal that were considered and eliminated from detailed study are presented in this section. The order of presentation does not imply a priority. Wind is considered in combination with an NGCC facility in Section 8.3. The evaluation of wind technology appearing in this section is as a discrete alternative.

8.5.1 Wind

As with other intermittent renewable energy sources such as solar power, the feasibility of wind as a baseload power relies on the availability, accessibility, and constancy of the wind resource within the region of interest. Unlike solar thermal facilities that can capture and store relatively large amounts of solar energy as heat for delayed production of electricity to match the temporal profiles of electricity loads in their service areas, wind energy must be converted to electricity at, or near, the point where it is extracted and there are limited energy storage opportunities available to overcome the intermittency and variability of wind resource availability.

At the current stage of wind energy technology development, wind resources of Category 3 (wind has a power density of 300 to 400 W/m^2 with wind speeds of 15.7 to 16.8 mph (7.0 to 7.5 m/s)) or better are required to produce utility-scale amounts of electricity. The capacity

factors of wind farms are primarily dependent on the constancy of the wind resource and, while off-shore wind farms can have relatively high capacity factors due to high-quality winds throughout much of the day (resulting primarily from differential heating of land and sea areas), land-based wind farms typically have capacity factors less than 40 percent. Many hundreds of turbines would be required to meet the baseload capacity of the Seabrook reactor, and each wind farm would require a build-out of transmission lines to deliver its output to the nearest segment of the ISO-NE high-voltage grid. A significant challenge is that wind farms can be built more quickly than transmission lines. It can take a year to build a wind farm, but it can take up to 5 years to build the transmission lines needed to send power to cities. Further, to avoid inter-turbine interferences to wind flow through the wind farm, turbines must be separated from each other, resulting in utility-scale wind farms requiring substantial amounts of land.

In 2009, the average nameplate capacity of individual wind turbines was 1.74 MW while the average rotor diameter was almost 82 meters, increases of 40 percent and 69 percent, respectively, of those parameters from 1999-vintage wind turbines. Meanwhile, the average capacity of wind farms installed in 2009 was 91 MW, a decrease from the 121 MW capacity of wind farms installed in 2008. Land-based wind turbines have individual capacities as high as 3 MW, with the 1.67-MW turbine being the most popular size to have been installed in 2008. Offshore wind turbines being considered for commercial deployment have capacities between 3 MW and 5 MW (NREL 2008). While turbine size increases and other technological advancements (especially in wind forecasting) have generally improved the value and reliability of wind as a baseload power source, DOE's Office of Energy Efficiency and Renewable Energy (EERE) reports that among 260 wind farms built from 1999 to 2008, cumulative annual capacity factors generally increased over the period, varying from 24 percent in 1999 to a high of nearly 34 percent in 2008 (falling off to 30 percent in 2009) (DOE/EERE 2010). DOE further notes that some factors have slowed the increase in wind farm capacity factors, including forced curtailments of wind-generated power from Texas wind farms and installation of wind farms in wind resource areas of lesser quality.

Wind energy market penetrations have increased dramatically in recent years; 9,994 MW of capacity was installed in 2009, a 40 percent increase from 2008, bringing the cumulative nationwide installed wind capacity to more than 35,000 MW (DOE/ERE 2010). Within the ISO-NE service territory, over 20 onshore wind farms with a total installed capacity of 624 MW were operating as of March 2012 (NREL 2012).

As described above, wind turbines generally can serve as an intermittent power supply. Wind power might serve as a means of providing baseload power if:

- it is combined with energy storage mechanisms, such as pumped hydroelectric or CAES;
- many wind farms are interconnected to one another on the transmission grid, as described in Section 8.3; or
- another readily dispatchable power source is used when wind power is unavailable (e.g., natural gas, as described in Section 8.3).

EIA is not projecting any growth in pumped storage capacity through 2035 (EIA 2011). Furthermore, as described below, the potential for new hydroelectric development in New Hampshire is limited. Therefore, the NRC concludes that the use of pumped storage in combination with wind turbines to generate 1,245 MW is unlikely.

A CAES plant is another potential storage mechanism that could potentially serve as means for wind to provide baseload power. A CAES plant consists of motor-driven air compressors that use low cost off peak electricity to compress air into an underground storage medium. During

high electricity demand periods, the stored energy is recovered by releasing the compressed air through a combustion turbine to generate electricity (NPCC 2009). Only two CAES plants are currently in operation: a 290-MWe plant near Bremen, Germany, which began operating in 1978 and a 110-MWe plant located in McIntosh, Alabama, which has been operating since 1991. Both facilities use salt caverns (Succar and Williams 2008). A CAES plant requires suitable geology, such as an underground cavern for energy storage. A 268-MWe CAES plant coupled to a wind farm, the Iowa Stored Energy Park, had been proposed for construction near Des Moines, Iowa. The facility would have used a porous rock storage reservoir for the compressed air (Succar and Williams 2008). However, the project has been cancelled due to geologic concerns (ISEPA 2011). Other pilot, demonstration, prototype, and research projects involving CAES have been announced, and the U.S. Norton Energy Storage is proposing to construct a CAES plant that would provide up to 2,700 MWe of storage capacity in Norton, Ohio (OPSB 2011). Projects such as the Conoco-Phillips and General Compression venture may use compressed air storage directly without the combustion of fuel such as natural gas. However, the NRC is not aware of a CAES project coupled with wind generation that is providing baseload power. Therefore, the NRC concludes that the use of CAES in combination with wind turbines to generate 1,245 MWe in the ISO-NE service territory is unlikely.

8.5.1.1 Offshore Wind

The NREL issued a report that identified offshore wind potential in the U.S. (NREL 2010a). While NREL did not identify a significant amount of wind resources off the coast of New Hampshire, the report identified 200 gigawatts (GW) and 156.6 GW of potential wind energy off the coasts of Massachusetts and Maine, which are part of the ISO-NE service territory. However, these resource estimates do not consider any environmental, economic, or water-use considerations. Most of the highest wind potential areas off the New England coast are in the deep water (more than 60 mi (97 km)) and far from shore (12 to 50 nautical mi from shore). Capital costs generally increase with distance from land and water depth due to construction costs in deep water and length of new transmission required to be built (NREL 2010b).

Although no commercial-scale offshore wind projects are currently operating in the U.S., approximately 600 MW of offshore wind generation is connected to the electrical grid in Europe (BOEMRE 2012a; NREL 2010b). Several offshore wind farms are proposed within the U.S., including the ISO-NE service territory. Three of the largest proposed projects in the northeast, and furthest along in terms of permitting, are summarized below, including the Cape Wind Project and Block Island Wind Farm. The Cape Wind Project, located 4.7 mi (7.6 km) off the coast of Cape Cod, Massachusetts in the Nantucket Sound, would consist of 130 turbines with a maximum installed capacity of 468 MW. The project was initially proposed in 2001; however, due to significant delays related to permitting and the NEPA process, the project is currently scheduled to begin construction as soon as it completes its project financing phase (Cape Wind 2014). Cape Wind is the first and only U.S. offshore wind farm to have received all required Federal and state approvals, a commercial lease, and an approved construction and operations plan (BOEMRE 2012b). Deepwater Wind is proposing to build Block Island Wind Farm, a demonstration-scale wind farm that would be located 3 mi (4.8 km) southeast of Block Island, Rhode Island. The wind farm would primarily supply power to Block Island and would consist of 5 turbines with a total nameplate capacity of 30 MW. Deepwater Wind expects transmission line construction to begin in 2014 and wind turbine construction to begin in 2015(Deepwater Wind 2014). Deepwater Wind Energy Center (DWEC) would be located approximately 13 to 25 mi (21 to 40 km) off the coast of Rhode Island and Massachusetts. The project would include up to 200 turbines, with a maximum installed capacity of approximately 1,000 MW, which would make it the largest proposed offshore windfarm in the northeast. DWEC would distribute power from Long Island to New England. DWEC submitted a formal application to the U.S.

Department of the Interior's Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) in October 2011 (Deepwater Wind 2012).

In addition, the Department of Interior, New Hampshire, and several other New England and North Atlantic States signed a Memorandum of Understanding in 2010 to "create an Atlantic Offshore wind energy consortium to coordinate issues of regional applicability for the purpose of promoting the efficient, expeditious, orderly and responsible development of the wind resources of the Atlantic Outer Continental Shelf."

While wind data suggest there is potential for offshore wind farms along the coast of New England, project costs likely limit the future potential of large-scale projects (NREL 2010b). NREL (2010b) estimated that offshore project costs would run approximately 200 to 300 percent higher than land-based systems. Also, based on current prices for wind turbines, the 20-year levelized cost of electricity produced from an offshore wind farm would be above the current production costs from existing power generation facilities. In addition to cost, other barriers include the immature status of the technology, limited resource area, and high risks and uncertainty (NREL 2010b).

8.5.1.2 Conclusion

Despite the relatively high reliability demonstrated by modern turbines, the recent technological advancements in turbine design and wind farm operation, and wind energy's dramatic market penetrations of recent years, empirical data on wind farm capacity factors and wind energy's limited ability to store power for delayed production of electricity cause the NRC staff to conclude that wind energy—on shore, off shore, or a combination thereof—could not serve as a discrete alternative to the baseload power supplied by the Seabrook reactor. However, NRC also concludes that, when used in combination with other technologies with inherently higher capacity factors, wind energy can provide a viable alternative. NRC evaluated such a possible combination in Section 8.3.

8.5.2 Solar Power

Solar technologies, photovoltaic (PV) and solar thermal (also known as concentrating solar power (CSP)) use the sun's energy to produce electricity at a utility scale. In PV systems, the energy contained in photons of sunlight incident on special PV materials results in the production of direct current (DC) electricity, which is aggregated, converted to alternating current (AC), and connected to the high-voltage transmission grid. CSP technologies produce electricity by capturing the sun's heat energy. Two types of CSP technology that have enjoyed the greatest utility-scale applications are the parabolic trough and the power tower; both involve capturing the sun's heat and converting it to steam, which powers a conventional Rankine cycle steam turbine generator (STG). Although relatively benign in many respects, solar technology requires substantial land areas, and CSP technologies require roughly the same amount of water for cooling of the steam cycle as many other thermoelectric technologies. Establishing adequate cooling for CSP facilities is often problematic since geographic areas with the highest-value direct normal insolation (DNI) required for CSP are often in remote desert areas with limited, or no, water availability.

As with other forms of renewable energy, the potential of solar technologies to serve as reliable baseload power alternatives to the Seabrook reactor depends on the value, constancy, and accessibility of the solar resource. Both PV and CSP are enjoying explosive growth worldwide, especially for various off-grid applications or to augment grid-provided power at the point of consumption; however, discrete baseload applications still have technological limitations. Although thermal storage can markedly increase the value of CSP-derived power for baseload applications by providing energy storage capabilities, low energy conversion efficiencies and the

inherent weather-dependent intermittency of solar power limit its application as baseload power in all but geographic locations with the highest solar energy values.

Solar energy qualifies as a Class-I resource under New Hampshire's Renewable Portfolio Standard. Under that standard, investor-owned utilities and competitive power suppliers must obtain 11 percent of their power portfolio from Class-I renewables by 2020 and 16 percent by 2025. EIA reports the total solar generating capacity (solar thermal and solar PV) in the U.S. in 2008 was 536 MW, 0.005 percent of the total nationwide generating capacity of 1,010,171 MW. Solar power produced 864 MWh of power in 2008, 0.002 percent of the nationwide production of 4,119,388 MWh (EIA 2010A). In New Hampshire, in 2008, all renewables excluding hydroelectric were responsible for 1,174,984 MWh, 5.1 percent of the State's total generation of 22,876,992 MWh. In August 2010, the ISO-NE states generated 723,000 MWh of power (Connecticut—65, Massachusetts—108, Maine—395, New Hampshire—110, Rhode Island—13, and Vermont—32), approximately 5.6 percent of the nationwide total of 13,034 thousand MWh for that period (EIA 2010f).

DOE's NREL reports that all of the ISO-NE service territory has average solar insolation useful for PV applications on the order of 4.0 $kWh/m^2/day$ and DNI suitable for use in CSP applications averaging 3.5 $kWh/m^2/day$ (NREL 2010c). Both of these solar insolation values are well below the ideal for efficient and cost effective application of PV and CSP technologies. The modest levels of solar energy available throughout the ISO-NE service territory, the weather-dependent intermittency of solar power, and the inefficiency of solar technologies at their current stage (and for the foreseeable future) of technological development all argue against selecting solar power as a discrete alternative to the Seabrook reactor's baseload power. The relatively minor contributions of solar and other renewable technologies (excluding hydroelectric and pumped storage) to statewide power generation in New Hampshire, and most other ISO-NE states, are consistent with this conclusion.

8.5.3 Wood Waste

As noted in the GEIS (NRC 1996), the use of wood waste to generate utility scale baseload power is limited to those locations where wood waste is plentiful. Wastes from pulp, paper, and paperboard industries, and from forest management activities, can be expected to provide sufficient, reliable supplies of wood waste as feedstocks to external combustion sources for energy generation. Beside the fuel source, the technological aspects of a wood-fired generation facility are virtually identical to those of a coal-fired alternative; combustion in an external combustion unit such as a boiler to produce steam to drive a conventional STG. Given constancy of the fuel source, wood waste facilities can be expected to operate at equivalent efficiencies and reliabilities. Costs of operation would depend significantly on processing and delivery costs. Wood waste combustors would be sources of criteria pollutants and GHG, and pollution control requirements would be similar to those for coal plants, except that there is no potential for the release of HAPs such as mercury. Co-firing of wood waste with coal is also technically feasible. Processing the wood waste into pellets can improve the overall efficiency of such co-fired units. Although co-fired units can have capacity factors similar to baseload coal-fired units, such levels of performance are dependent on the continuous availability of the wood waste fuel. Among the ISO-NE states, 2008 electricity generating capacity from wood waste ranged from 26 MW (Massachusetts) to 76 MW (Vermont), to 140 MW (New Hampshire) to 612 MW (Maine) with zero generating capacity in Connecticut and Rhode Island; the largest amount of electricity generated from wood waste in 2008 occurred in Maine (EIA 2010g, 2010h, 2010i, 2010j, 2010k, 2010l). Given the limited capacity and modest actual electricity production, the NRC staff has determined that production of electricity from wood waste at levels equivalent to the Seabrook reactor would not be a feasible alternative to Seabrook license renewal.

8.5.4 Conventional Hydroelectric Power

Three technology variants of hydroelectric power exist—dam and release (also known as impoundment), run-of-the-river (also known as diversion), and pumped storage. In each variant, flowing water spins impellers of turbines of different designs to drive a generator to produce electricity. Dam and release facilities affect large amounts of land behind the dam to create reservoirs but can provide substantial amounts of power at capacity factors greater than 90 percent. Power generating capacities of run-of-the-river dams fluctuate with the flow of water in the river and the operation of such dams is typically constrained (and stopped entirely during certain periods) so as not to create undue stress on the aquatic ecosystems present. Pumped storage facilities use grid power to pump water from flowing water courses to higher elevations during off-peak load periods in order to release the water during peak load periods through turbines to generate electricity. Capacities of pumped storage facilities are dependent on the configuration and capacity of the elevated storage facility.

A comprehensive survey of hydropower resources in ISO-NE states was completed in 1997 by DOE's Idaho National Environmental Engineering Laboratory. All ISO-NE states had only modest hydroelectric potential, with Maine having the greatest capacity at 1042 MW (INEEL 1998). At the time of the study, the total hydroelectric generating potential for each of the ISO-NE states were as follows:

- Connecticut—44 MW,
- Massachusetts—132 MW,
- Maine—1,042 MW,
- New Hampshire—32 MW,
- Rhode Island—11 MW, and
- Vermont—174 MW.

More recently, EIA reports that, in 2008, conventional hydroelectric power (excluding pumped storage) was the principal electricity generation source among renewable sources in four of the ISO-NE states—Massachusetts, Maine, New Hampshire, and Vermont (EIA 2010g, 2010h, 2010i, 2010j, 2010k, 2010l). Nevertheless, only 5.9 gigawatt hours (GWh) of hydroelectric power were generated in the ISO-NE states from January to July 2010, 3.3 percent of the nationwide total of 179.5 GWh (EIA 2010m). As noted earlier, as of April 1, 2010, 1224 MW of new hydroelectric capacity was represented in the ISO-NE interconnection queue (ISO-NE 2010b). However, experience has shown that not all of the MW capacity represented in the Interconnection Queue materializes in power actually introduced into the grid. For planning purposes, ISO-NE expects attrition of projects on the Interconnection Queue to be as high as 40 percent (ISO-NE 2010a). If that were to be the case, the collective capacities of all hydroelectric facilities on the Queue that would ultimately inject electricity into the grid would fall well below the amount necessary to serve as a discrete technology replacement to Seabrook's reactor. Although hydroelectric facilities can demonstrate relatively high capacity factors, the relatively modest capacities and actual recent power generation of hydroelectric facilities in ISO-NE states, combined with the diminishing public support for large hydroelectric facilities because of their potential for adverse environmental impact, supports NRC's conclusion that hydroelectric power is not a feasible alternative to the Seabrook reactor.

8.5.5 Ocean Wave and Current Energy

Differential heating of the earth's water and land surfaces results in wind, which acts on the ocean's surface to create waves. The gravitational pull of the moon also helps to create waves. Ocean waves, currents, and tides represent kinetic and potential energies. The total annual average wave energy off the U.S. coastlines, at a water depth of 197 ft (60 m), is estimated at 2100 terawatt-hours (MMS 2006). Wave currents and tides are often predictable and reliable; ocean currents flow consistently, while tides can be predicted months and years in advance with well-known behavior in most coastal areas. Four principal wave energy conversion (WEC) technologies have been developed to date to capture the potential or kinetic energy of waves: point absorbers, attenuators, overtopping devices, and terminators. All have similar approaches to electricity generation but differ in size, anchoring method, spacing, interconnection, array patterns, and water depth limitations. Point absorbers and attenuators both allow waves to interact with a floating buoy, subsequently converting its motion into mechanical energy to drive a generator. Overtopping devices and terminators are also similar in their function. Overtopping devices trap some portion of the incident wave at a higher elevation than the average height of the surrounding sea surface, thus giving it higher potential energy, which is then transferred to power generators. Terminators allow waves to enter a tube, compressing air trapped at the top of the tube, which is then used to drive a generator.

Capacities of point absorbers range from 80 to 250 kW, with capacity factors as high as 40 percent; attenuator facilities have capacities of as high as 750 kW. Overtopping devices have design capacities as high as 4 MW, while terminators have design capacities ranging from 500 kW to 2 MW and capacity factors as high as 50 percent (MMS 2007).

The most advanced technology for capturing tidal and ocean current energy is the submerged turbine. Underwater turbines share many design features and functions with wind turbines but because of the greater density of water compared to air, have substantially greater power generating potential than wind turbines of comparable size blades. Only a small number of prototypes and demonstration units have been deployed to date, however. Underwater turbine "farms" are projected to have capacities of 2 to 3 MW, with capacity factors directly related to the constancy of the current with which they interact.

The environmental impacts of WEC technologies are still largely undefined and, while expected to be generally benign, could vary substantially with site-specific circumstances. Also, large-scale deployment of WEC technologies could compete with other activities already occurring in offshore locations, including commercial and recreational fishing and commercial shipping. Although real-world examples are limited, the potential cost of commercial-scale WEC-derived power is estimated to range from $0.09 to $0.11 per kilowatt-hour (MMS 2006). The relatively modest power capacities and relatively high costs of resulting power, coupled with the fact that all WEC technologies are in their infancy, support the NRC staff's conclusion that WEC technologies are not feasible substitutes for the Seabrook reactor.

8.5.6 Geothermal Power

Geothermal technologies extract the heat contained in geologic formations to produce steam to drive a conventional STG. The following variants of the heat exchanging mechanism have been developed:

- Hot geothermal fluids contained under pressure in a geological formation are brought to the surface where the release of pressure allows them to flash into steam (the most common of geothermal technologies applied to electricity production).

- Hot geothermal fluids are brought to the surface in a closed-loop system and directed to a heat exchanger where they convert water in a secondary loop into steam.
- Hot dry rock technologies involve fracturing a formation and extracting heat through injection of a heat transfer fluid.

Facilities producing electricity from geothermal energy can routinely demonstrate capacity factors of 95 percent or greater, making geothermal energy clearly eligible as a source of baseload electric power. However, as with other renewable energy technologies, the ultimate feasibility of geothermal energy serving as a baseload power replacement for the Seabrook reactor is dependent on the quality and accessibility of geothermal resources within or proximate to the region of interest—in this case, the ISO-NE service territory. As of October 2009, the U.S. had a total installed geothermal electricity production capacity of 3,153 MW, originating from geothermal facilities in nine states: Alaska, California, Hawaii, Idaho, Nevada, New Mexico, Oregon, Utah, and Wyoming. Additional geothermal facilities are being considered for Colorado, Florida, Louisiana, Mississippi, and Oregon. None of the ISO-NE states has adequate geothermal resources to support utility-scale electricity production (GEA 2010). NRC concludes, therefore, that geothermal energy does not represent a feasible alternative to the Seabrook reactor.

8.5.7 Municipal Solid Waste

MSW combustors use three types of technologies—mass burn, modular, and refuse-derived fuel. Mass burning is currently the method used most frequently in the U.S. and involves no (or little) sorting, shredding, or separation. Consequently, toxic or hazardous components present in the waste stream are combusted, and toxic constituents are exhausted to the air or become part of the resulting solid wastes. Currently, approximately 86 waste-to-energy plants operate in 24 states, processing 97,000 tons of MSW per day. Latest estimates are that 26 million tons of trash was processed in 2008 by waste-to-energy facilities. With a reliable supply of waste fuel, waste-to-energy plants have an aggregate capacity of 2,572 MW and can operate at capacity factors greater than 90 percent (ERC 2010). Currently, 19 waste-to-energy facilities are operating in the ISO-NE states with an aggregate capacity of 543.7 MW. The number of facilities in each state, statewide amounts of MSW processed in tons per day, and aggregate nameplate capacities include the following:

- Connecticut—6 facilities, 6,537 T/d, 194 MW;
- Massachusetts—7 facilities, 9,450 T/d, 265.9 MW;
- Maine—4 facilities, 2,800 T/d, 65.3 MW; and
- New Hampshire—2 facilities, 700 T/d, 18.5 MW.

EPA estimates that, on average, air impacts from MSW-to-energy plants are 3,685 lb/MWh of CO_2, 1.2 lb/MWh of SO_2, and 6.7 lb/MWh of NO_x. Depending on the composition of the municipal waste stream, air emissions can vary greatly and the ash produced may exhibit hazardous character and require special treatment and handling (EPA 2010d).

Estimates in the GEIS suggest that the overall level of construction impact from a waste-fired plant would be approximately the same as that for a coal-fired power plant. Additionally, waste-fired plants have the same, or greater, operational impacts than coal-fired technologies (including impacts on the aquatic environment, air, and waste disposal). The initial capital costs for municipal solid-waste plants are greater than for comparable steam-turbine technology at

coal-fired facilities or at wood-waste facilities because of the need for specialized waste separation and handling equipment (NRC 1996).

The decision to burn municipal waste to generate energy is usually driven by the need for an alternative to landfills rather than energy considerations. The use of landfills as a waste disposal option is likely to increase in the near term as energy prices increase (and especially since such landfills, of sufficient size and maturity, can be sources of easily recoverable CH_4 fuel); however, it is possible that municipal waste combustion facilities may become attractive again.

Regulatory structures that once supported MSW incineration no longer exist. For example, the Tax Reform Act of 1986 made capital-intensive projects such as municipal waste combustion facilities more expensive relative to less capital-intensive waste disposal alternatives such as landfills. Also, the 1994 Supreme Court decision C&A Carbone, Inc. *v.* Town of Clarkstown, NY, struck down local flow control ordinances that required waste to be delivered to specific municipal waste combustion facilities rather than landfills that may have had lower fees. In addition, environmental regulations have increased the capital cost necessary to construct and maintain municipal waste combustion facilities.

As expected, the operating waste-to-energy plants in New England are located near population centers. The NRC staff interprets the current array of operating facilities as representative what the current market and other counterbalancing factors will support. To meet the power equivalency of the Seabrook reactor, the aggregate capacity of waste-to-energy facilities in New England would need to expand nearly 230 percent from current activity levels. Given the small average installed size of MSW plants, additional stable streams of MSW are not likely to be available to support numerous new facilities. In addition, based on the increasingly unfavorable regulatory environment, especially with respect to expanding pollution control regulations, the NRC staff does not consider MSW combustion to be a reasonable alternative to Seabrook license renewal.

8.5.8 Biomass Fuels

When used here, “biomass fuels” include crop residues, switchgrass grown specifically for electricity production, forest residues, CH_4 from landfills, CH_4 from animal manure management, primary wood mill residues, secondary wood mill residues, urban wood wastes, and CH_4 from domestic wastewater treatment. The feasibility of the use of biomass fuels for baseload power is dependent on their geographic distribution, available quantities, constancy of supply, and energy content. A variety of technical approaches has been developed for biomass-fired electric generators, including direct burning, conversion to liquid biofuels, and biomass gasification. In a study completed in December 2005, Milbrandt of NREL documented the geographic distribution of biomass fuels within the U.S., reporting the results in MTs available (dry basis) per year (NREL 2005). Very limited amounts of potential biomass fuels are available in the ISO-NE states. Amounts of biomass fuels produced in the ISO-NE states range from a low of 174 MT/y in Rhode Island to a high of 3,489 MT/y in Maine, with a regional average of 1,374 MT/y. Power generating capacity from biomass fuels is very limited in the ISO-NE states, ranging from 3 MW in Vermont to 272 MW in Massachusetts (EIA 2010g, 2010h, 2010i, 2010j, 2010k, 2010l). Landfill gas is the only biomass fuel from which power is being derived in ISO-NE states in any appreciable amount, ranging from a high of 1,128 MWh in 2008 in Massachusetts to a low of 155 MWh in New Hampshire, with none being produced in Vermont. As of April 2010, of the total 3,515 MW represented in the ISO-NE Interconnection Queue, only 380 MW was for biomass-produced electricity (ISO-NE 2010a).

In the GEIS, the NRC staff indicated that none of these technologies had progressed to the point of being competitive on a large scale or of being reliable enough to replace a baseload plant such as Seabrook. After re-evaluating current technologies, and after reviewing existing state-wide capacities and the extent to which biomass is currently being used to produce electricity in the ISO-NE states (and the apparent limited supporting delivery infrastructures), the NRC staff finds biomass-fired alternatives are unable for the foreseeable future to reliably replace the Seabrook capacity and are not considered feasible alternatives to Seabrook license renewal.

8.5.9 Oil-Fired Power

Oil of various qualities, resulting from the refining of conventional crude oils or unconventional sources such as oil sands or tar sands, is combusted in a boiler where the steam thus produced is used to drive a conventional STG. Although oil has historically been used extensively in the northeast for comfort heating, EIA projects that oil-fired plants will account for very little of the new generation capacity constructed in the U.S. during the 2008 through 2030 time period. Further, EIA does not project that oil-fired power will account for any significant additions to capacity (EIA 2009f).

The variable costs of oil-fired generation tend to be greater than those of the nuclear or coal-fired operations, and oil-fired generation tends to have greater environmental impacts than natural gas-fired generation. In addition, future increases in oil prices are expected to make oil-fired generation increasingly more expensive (EIA 2009f). The high cost of oil has prompted a steady decline in its use for electricity generation. Thus, the NRC staff does not consider oil-fired generation as a reasonable alternative to Seabrook license renewal.

8.5.10 Fuel Cells

Fuel cells oxidize fuels without combustion and its environmental side effects. Power is produced electrochemically by passing a hydrogen-rich fuel over an anode and air (or oxygen) over a cathode and separating the two by an electrolyte. The only byproducts (depending on fuel characteristics) are heat, water, and CO_2. Hydrogen fuel can come from a variety of hydrocarbon resources by subjecting them to steam reforming under pressure. Natural gas is typically used as the source of hydrogen.

Currently, fuel cells are not economically or technologically competitive with other alternatives for electricity generation. EIA projects that fuel cells may cost $5,478 per installed kW (total overnight costs, 2008 dollars) (EIA 2010n), substantially greater than coal ($2,223), advanced (natural gas) combustion turbines ($648), onshore wind ($1,966), or offshore wind ($3,937), but cost competitive with solar PV ($6,171) or CSP solar ($5,132). More importantly, fuel cell units are likely to be small in size (the EIA reference plant is 10 MWe). While it may be possible to use a distributed array of fuel cells to provide an alternative to Seabrook, it would be extremely costly to do so and would require many units and wholesale modifications to the existing transmission system. Accordingly, the NRC staff does not consider fuel cells to be a reasonable alternative to Seabrook license renewal.

8.5.11 New Coal-Fired Capacity

Coal-fired generation accounts for a greater share of U.S. electrical power generation than any other fuel. Furthermore, the EIA projects that new coal-fired power plants will account for the greatest share of capacity additions through 2030—more than natural gas, nuclear, or renewable generation options. Integrated-gasification combined-cycle (IGCC) technology is an emerging coal option that uses coal gasification technology and is substantially cleaner than

before combustion. While coal-fired power plants are widely used and likely to remain widely used, the NRC acknowledges that future additions to coal capacity may be affected by perceived or actual efforts to limit GHG emissions.

Only a few IGCC plants are operating at utility scale. Although coal-fired generation is technically feasible and can supply baseload capacity similar to that supplied by Seabrook, to date, IGCC technologies have had limited application and have been plagued with operational problems such that their effective, long-term capacity factors are often not high enough for them to reliably serve as baseload units. For these reasons, the NRC does not consider the construction of a large, baseload coal-fired power plant as a reasonable alternative to continued Seabrook operation.

8.5.12 Energy Conservation and Energy Efficiency

Though often used interchangeably, energy conservation and energy efficiency are different concepts. Energy efficiency typically means deriving a similar LOS by using less energy, while energy conservation simply indicates a reduction in energy consumption. Both fall into a larger category known as demand-side management (DSM). DSM measures—unlike the energy supply alternatives discussed in previous sections—address energy end uses. DSM can include measures that do the following:

- Shift energy consumption to different times of the day to reduce peak loads.
- Interrupt certain large customers during periods of high demand.
- Interrupt certain appliances during high demand periods.
- Replace older, less efficient appliances, lighting, or control systems.
- Encourage customers to switch from gas to electricity for water heating and other similar measures that utilities use to boost sales.

Unlike other alternatives to license renewal, the GEIS notes that conservation is not a discrete power-generating source; it represents an option that States and utilities may use to reduce their need for power generation capability (NRC 1996).

In a 2008 staff report, the Federal Energy Regulatory Commission (FERC) outlined the results of the 2008 FERC Demand Response (DR) and Advanced Metering Survey (FERC 2008). Nationwide, approximately 8 percent of retail electricity customers are enrolled in some type of DR program. The potential DR resource contribution from all U.S. DR programs is estimated to be close to 41,000 MW, or about 5.8 percent of U.S. peak demand. A national assessment of DR potential, required of FERC by Section 529 of the Energy Independence and Security Act of 2007, evaluated potential energy savings in 5- and 10-year horizons for four development scenarios—Business As Usual, Expanded Business As Usual, Achievable Participation, and Full Participation. Each of these scenarios represents successively greater DR program opportunities and proportionally increasing levels of customer participation (FERC 2009). The greatest savings would be realized under the Full Participation scenario, with peak demand reductions of 188 GW by the year 2019, a 20 percent reduction of the anticipated peak load that would result without any DR programs in place. Under the Achievable Participation scenario, reflecting a more realizable voluntary participation level of 60 percent of eligible customers, peak demand would be reduced by 14 percent (138 GW) by 2019.

In New England, DR opportunities are offered in the wholesale electricity market (under provisions of ISO-NE's Forward Capacity Market (ISO-NE 2010a)) and to retail electricity customers by load-serving utilities in the region. Thus, in its modeled Business as Usual

scenario, FERC estimates that DR programs in the NE states could be among the most prolific in the country, capable of reducing peak load by as much as 10 percent overall. FERC also believes that the potential for peak reductions through DR is already largely realized in the NE states where DR programs are already collectively within 12 percent of meeting the peak demand reductions projections in FERC's Full Participation scenario (FERC 2009).

FERC's State-specific analyses for the NE states (FERC 2010a) indicates that by the year 2019, the Full Participation scenario would yield peak demand reductions ranging from 13.2 to 28.9 percent of statewide electricity consumption, from a 163 MW reduction in Vermont to a 2,458 MW reduction in Connecticut and a total reduction for all NE states of 6524 MW. If the potentials for DR reductions have already been largely realized, the Business as Usual scenario is a more realistic projection. Under that scenario, DR programs would yield an ISO-NE-wide reduction of 3,200 MW by 2019, ranging from 89 MW in Vermont (7.2 percent of the state's projected peak demand) to 1,369 MW in Connecticut (16 percent of the state's projected peak demand).

ISO-NE reports that, currently, 1,900 MW of DR programs are in place, and the largest reduction in a summer peak demand occurred in 2009 when DR programs provided a reduction of 682 MW from the peak of 28,770 MW (ISO-NE 2010a). However, in the latest Forward Capacity Auction completed by ISO-NE, 2,867 MW of DR was accepted and will count toward satisfying the Installed Capacity Requirement for the period 2012 through 2013. The 2,867 MW of accepted DR resources were composed of 1,072 MW of passive demand resources and 1,794 MW of active demand resources. ISO-NE determined that this amount of DR resources would be sufficient to satisfy the Installed Capacity Requirement but only if current generation resources, including the Seabrook reactor, remained in operation. Although NRC agrees that active DR programs will effectively serve to reduce peak demand, passive DR programs provide for continuous reductions in electricity consumption and, thus, offer a better measure of the feasibility of DR programs as a baseload power replacement. The 1,072 MW of passive DR resources most recently accepted by ISO-NE for interconnection, together with the FERC analysis that suggests only minor potential remains for significant DR program expansions in the NE states, allows the NRC staff to conclude that passive DR programs are not a feasible baseload power alternative to Seabrook.

8.5.13 Purchased Power

Under the purchased power alternative, no new generating capacity would necessarily be built and operated by NextEra but, instead, an equivalent amount to the electricity now being supplied by the Seabrook reactor would be purchased from other generators. Those generators could be located anywhere within or outside the ISO-NE service territory, although far-distant sources may not be immediately available to serve ISO-NE load centers without substantial transmission system build-outs.

Although wind energy development is expected to expand greatly in the New England states and neighboring areas in Canada, reliable schedules of development for those resources have not been announced nor has the proportion of power that would be exported to the load centers currently served by the Seabrook reactor. Further, regardless of the source of purchased power, substantial costs would be incurred in necessary expansions to the transmission infrastructure.

There is no guarantee that a sufficient amount of power from yet-to-be-developed renewable and other resources within, and outside of, the ISO-NE service territory would ultimately be available for purchase. Further, NextEra would be competing for those resources that do become available with generators subject to Renewable Portfolio Standard or RGGI

requirements or both. Incorporation of new generation sources from locations that are remote or distant from load centers would likely involve significant expenditures in transmission infrastructure expansions. NRC, therefore, concludes that a purchased power option is not a viable discrete alternative to extending the Seabrook reactor license.

8.6 No-Action Alternative

This section examines the environmental effects that would occur if NRC took no action. No action in this case means that NRC does not issue a renewed the operating license for Seabrook, and the license expires at the end of the current license term, on March 15, 2030. If NRC takes no action, the plant will shut down at, or before, the end of the current license. After shutdown, plant operators will initiate decommissioning in accordance with 10 CFR 50.82.

No-action is the only alternative that is considered in-depth that does not satisfy the purpose and need for this SEIS, as it does not provide power generation capacity nor would it meet the needs currently met by the Seabrook reactor or that the alternatives evaluated in Sections 8.1-8.5 would satisfy. Assuming that a need currently exists for the power generated by the Seabrook reactor, the no-action alternative would require the appropriate energy planning decision makers to rely on an alternative to replace the capacity of the Seabrook reactor or reduce the need for power.

This section addresses only those impacts that arise directly as a result of plant shutdown. The environmental impacts from decommissioning and related activities have already been addressed in several other documents, including the *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities*, NUREG-0586, Supplement 1 (NRC 2002); the license renewal GEIS (Chapter 7; NRC 1996); and Chapter 7 of this SEIS. These analyses either directly address or bound the environmental impacts of decommissioning whenever NextEra ceases to operate Seabrook.

Even with a renewed operating license, Seabrook will eventually shut down, and the environmental effects addressed in this section will occur at that time. Because these effects have not otherwise been addressed in this SEIS, the impacts are addressed in this section. As with decommissioning effects, shutdown effects are expected to be similar whether they occur at the end of the current license or at the end of a renewed license. Table 8–6 provides a summary of the environmental impacts of the no-action alternative.

Table 8–6. Environmental Impacts of No-Action Alternative

	No-Action Alternative
Air quality	SMALL
Groundwater	SMALL
Surface water	SMALL
Aquatic & terrestrial resources	SMALL
Human health	SMALL
Socioeconomics	SMALL to MODERATE
Historic & archaeological	SMALL
Waste management	SMALL

8.6.1 Air Quality

When the plant stops operating, there will be a reduction in air quality impacts; specifically, emissions of pollutants related to operation of the plant and emissions of criteria pollutants associated with commuting of the operating workforce will cease. Since it was determined that emissions during the renewal term would have a SMALL impact on air quality, if emissions decrease, the impacts to air quality from the no-action alternative will be SMALL.

8.6.2 Groundwater Resources

Chapter 4 discusses the impact to groundwater that is currently occurring as a result of operation of the Seabrook reactor. Groundwater wells installed onsite originally supplied a fraction of the fresh water used for sanitary and nonsafety-related purposes. However, those uses were discontinued in 1986, and no groundwater is currently used to support operation of the plant. Tritium contamination is known to exist in groundwater beneath the Seabrook site and remediation and mitigation activities are ongoing. Once operation of the reactor ceases, the potential for additional releases of tritium to the groundwater is expected to diminish. However, releases of tritium may not totally cease until decommissioning is completed. Remediation activities are expected to continue after reactor operation ceases. NRC concludes that impacts to groundwater from the no-action alternative will be SMALL.

8.6.3 Surface Resources

Chapter 4 discusses the impacts to surface water from plant operation. Operational impacts include withdrawals and discharges of seawater in association with operation of the once-through cooling system. Impacts also include stormwater runoff from industrial areas of the plant, which is currently controlled through provisions of an EPA-issued NPDES Multi-Sector General Permit for stormwater discharges associated with industrial activity and under Seabrook’s individual NPDES permit (No. NH0020338). Once reactor operation stops, impacts associated with seawater withdrawals and discharges will cease; however, stormwater discharges from industrialized portions of the site will continue largely unchanged until decommissioning activities commence. The current NPDES permits would be expected to continue in effect after reactor operation stops and would be replaced by new or revised permits, as appropriate, once decommissioning actions commence. The NRC staff concludes that impacts to surface water from the no-action alternative will be SMALL.

8.6.4 Aquatic and Terrestrial Resources

Chapter 4 discusses the impacts to aquatic and terrestrial resources from plant operation. Withdrawals and discharges of seawater associated with operation of the once-through cooling system will cease once reactor operation stops, thus eliminating the most significant impacting factors for aquatic resources. Impacts to terrestrial resources are expected to change slightly from the reduced human presence on the site once operations cease. Potentially new impacts to aquatic and terrestrial resources may be created once decommissioning commences. NRC concludes that impacts to aquatic and terrestrial resources from the no-action alternative will be SMALL.

8.6.5 Human Health

In Chapter 4 of this SEIS, the NRC staff concluded that the impacts of continued plant operation on human health are SMALL. After cessation of plant operations, the amounts of radioactive material released to the environment in gaseous and liquid forms, all of which are currently

within respective regulatory limits, would be reduced or eliminated. Therefore, the NRC staff concludes that the impact of plant shutdown on human health would also be SMALL. In addition, the potential for a variety of accidents will also be reduced to only those associated specifically with shutdown activities and fuel handling. In Chapter 5 of this SEIS, the NRC staff concluded that impacts of accidents during operation are SMALL. Impacts to human health from a reduced suite of potential accidents after reactor operation ceases would also be SMALL. Therefore, the NRC staff concludes that impacts to human health from the no-action alternative will be SMALL.

8.6.6 Socioeconomics

8.6.6.1 Land Use

Plant shutdown would not affect onsite land use. Plant structures and other facilities would remain in place until decommissioning. Most transmission lines connected to Seabrook would remain in service after the plant stops operating. Maintenance of most existing transmission lines would continue as before. The transmission lines could be used to deliver the output of any new power generating capacity additions made on the Seabrook site. Impacts on land use from plant shutdown would be SMALL.

8.6.6.2 Socioeconomics

Plant shutdown would have an impact on socioeconomic conditions in the region around Seabrook. Should the plant shut down, there would be immediate socioeconomic impacts from loss of jobs (some, though not all, of the approximately 1,100 employees would begin to leave), and tax payments may be reduced. These impacts, however, would not be considered significant on a regional basis given the close proximity to the Boston metropolitan area and because plant workers' residences are not concentrated in a single community or county. Revenue losses from Seabrook operations would directly affect Rockingham County and other local taxing districts and communities closest to, and most reliant on, the plant's tax revenue. The socioeconomic impacts of plant shutdown would, depending on the jurisdiction, range from SMALL to MODERATE. See Appendix J to NUREG 0596, Supplement 1 (NRC 2002) for an additional discussion of the potential socioeconomic impacts of plant decommissioning.

8.6.6.3 Transportation

Traffic volumes on the roads near the Seabrook site would be greatly reduced after plant shutdown due to the loss of jobs at the facilities. Deliveries of materials and equipment to Seabrook would also be reduced until decommissioning. Transportation impacts from the termination of plant operations would be SMALL.

8.6.6.4 Aesthetics

Plant structures and other facilities would likely remain in place until decommissioning. Noise caused by plant operation would cease. Aesthetic impacts of plant closure would be SMALL.

8.6.6.5 Historic and Archaeological Resources

Impacts from the no-action alternative on historic and archaeological resources would be SMALL. A separate environmental review would be conducted for decommissioning. That assessment would address the protection of historic and archaeological resources.

8.6.6.6 Environmental Justice

Impacts to minority and low-income populations when Seabrook ceases operations would depend on the number of jobs and the amount of tax revenues lost by the communities in the immediate vicinity of the power plant. Closure of Seabrook would reduce the overall number of

jobs (there are currently 1,100 employed at the facility) and tax revenue for social services attributed to plant operations. Minority and low-income populations in the township vicinity of Seabrook could experience some socioeconomic effects from plant shutdown, but these effects would not likely be high and adverse.

8.6.7 Waste Management

The impacts of waste generated by continued plant operation are discussed in Chapter 6 of this SEIS. The impacts of low-level and mixed waste from plant operation are characterized as SMALL. Once the Seabrook reactor stops operating, generation of high-level waste will cease and generation of low-level and mixed wastes will be diminished, limited only to those wastes associated with reactor shutdown and fuel handling activities. Therefore, the NRC staff concludes that the impacts of waste generation after shutdown will be SMALL.

8.7 Alternatives Summary

In this SEIS, NRC has considered alternative actions to license renewal of the Seabrook reactor, including in-depth evaluations of new generation alternatives (Sections 8.1 through 8.3), alternatives that the staff dismissed from detailed evaluation as infeasible or inappropriate (Section 8.4), and the no-action alternative in which the operating license is not renewed (Section 8.6). Impacts of all alternatives considered in detail are summarized in Table 8–7.

Table 8–7. Environmental Impacts of Proposed Action and Alternatives

Alternative	Air Quality	Groundwater	Surface Water	Aquatic & Terrestrial Resources	Human Health	Socioeconomics & Historic & Archaeological	Waste Management
License renewal	SMALL	SMALL	SMALL	SMALL to LARGE	SMALL	SMALL	SMALL
Natural gas-fired	SMALL to MODERATE	SMALL	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL
New nuclear	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL to LARGE	SMALL
Combination NGCC & wind	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL to LARGE	SMALL
No action	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL

The environmental impacts of the proposed action (issuing renewed Seabrook operating license) would be SMALL for all impact categories, except for aquatic resources where the impact level would be SMALL to LARGE. Based on the above evaluations, the gas-fired alternative is not an environmentally favorable alternative due to air quality impacts from NO_x, SO_x, PM_{10}, CO, and CO_2 (and their corresponding human health effects). NRC notes that while substantial quantities of high-value wind resources exist within, and near, the ISO-NE service territory, for intermittent renewable energy sources, such as wind, to serve as a reliable baseload alternative, they would need to be pursued in combination with conventional technologies. Such a combination was evaluated in depth and found to have less environmental impacts in most respects than would have resulted from pursuit of the conventional technology portion alone. Finally, the NRC concluded that under the no-action alternative, the act of shutting down the Seabrook reactor on or before its license expiration

date, would have only SMALL impact in all categories except socioeconomics where it could have a MODERATE impact in areas immediately adjacent to Seabrook.

In conclusion, there is no clear, environmentally-preferred alternative in this case. All alternatives capable of meeting the needs currently served by Seabrook entail impacts greater than or equal to the proposed action of Seabrook license renewal. Because the no-action alternative necessitates the implementation of one or a combination of alternatives, the no-action alternative would have environmental impacts greater than or equal to the proposed license renewal action.

8.8 References

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9.0 CONCLUSION

This supplemental environmental impact statement (SEIS) contains the environmental review of the NextEra Energy Seabrook, LLC (NextEra) application for a renewed operating license for Seabrook Station (Seabrook), as required by the *Code of Federal Regulations* (CFR), Part 51 of Title 10 (10 CFR Part 51) and the U.S. Nuclear Regulatory Commission's (NRC) regulations that implement the National Environmental Policy Act (NEPA). This chapter presents conclusions and recommendations from the site-specific environmental review of Seabrook and summarizes site-specific environmental issues of license renewal that were identified during the review. The environmental impacts of license renewal are summarized in Section 9.1; a comparison of the environmental impacts of license renewal and energy alternatives is presented in Section 9.2; unavoidable impacts of license renewal, energy alternatives, and resource commitments are discussed in Section 9.3; and conclusions and NRC staff recommendations are presented in Section 9.4.

9.1 Environmental Impacts of License Renewal

The NRC staff's review of site-specific environmental issues in this SEIS leads to the conclusion that, with two exceptions, issuing a renewed license would have SMALL impacts for the Category 2 issues applicable to license renewal at Seabrook, as well as environmental justice and chronic effects of electromagnetic fields (EMFs). In the area of aquatic resources, the NRC staff concluded that the impacts of license renewal at Seabrook would be SMALL for phytoplankton, zooplankton, invertebrates, and most fish species. However, the impact on winter flounder, rainbow smelt, and some kelp species is LARGE since the abundance of these species has decreased to a greater and observable extent near Seabrook's intake and discharge structures as compared to 3–4 miles (mi) (5–8 kilometers (km)) away. Similarly, in the Category 2 issue of protected species, the NRC staff concluded that the impacts of the license renewal at Seabrook would be SMALL for terrestrial and most aquatic species. However, the impact for the rainbow smelt, listed as a Species of Concern by the National Marine Fisheries Service (NMFS), would be LARGE because of the relatively high impingement rates and because the abundance of rainbow smelt has decreased to a greater and observable extent near Seabrook's intake and discharge structures as compared to further away.

Mitigation measures were considered for each Category 2 issue, as applicable. The NRC staff identified one potential measure that could mitigate potential impacts to threatened or endangered species. This measure would be for the Public Service Company of New Hampshire (PSNH) or National Grid, who own and operate the transmission lines associated with Seabrook, to report the existence of any Federally or state-listed endangered or threatened species within or near the transmission line rights-of-way (ROWs) to the New Hampshire Natural Heritage Bureau, Massachusetts Fish and Game Department, or U.S. Fish and Wildlife Service (FWS) if any such species are identified during the renewal term. In particular, if any evidence of injury or mortality of migratory birds, state-listed species, or Federally listed threatened or endangered species is observed within the corridor during the renewal period, coordination with the appropriate state or Federal agency would minimize impacts to the species and, in the case of Federally listed species, ensure compliance with the Endangered Species Act (ESA).

The NRC staff also considered cumulative impacts of past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes them. The NRC staff concluded that cumulative impacts of Seabrook's license renewal would be SMALL for all areas except aquatic resources. For aquatic resources, the NRC staff concluded

that the cumulative impacts would be MODERATE for most species and LARGE for winter flounder, rainbow smelt, and other species that would be adversely affected from climate change, such as lobster and Atlantic cod. The incremental impacts from Seabrook license renewal would be SMALL for most species and LARGE for winter flounder and rainbow smelt because the abundance of winter flounder and rainbow smelt has decreased to a greater and observable extent near Seabrook's intake and discharge structures compared to 3–4 mi (5–8 km) away. The local decrease suggests that, to the extent local subpopulations of winter flounder and rainbow smelt exist within 3–4 mi (5–8 km), they have been destabilized through operation of Seabrook's cooling water system.

9.2 Comparison of Environmental Impacts of License Renewal and Alternatives

In the conclusion to Chapter 8, the NRC staff determined that the impacts from license renewal would generally be equal to or less than the impacts to alternatives to license renewal. In comparing likely environmental impacts from natural gas-fired combined-cycle generation, new nuclear generation, a combination alternative consisting of a natural gas-fired combined-cycle component and a wind component, and the environmental impacts of license renewal, it was found that there is no clear environmentally preferred alternative to license renewal. All alternatives capable of meeting the needs currently served by Seabrook entail impacts greater than or equal to the proposed action of Seabrook license renewal. Additionally, because the no-action alternative necessitates the implementation of one or a combination of alternatives, the no-action alternative would have environmental impacts greater than or equal to the proposed license renewal action. Based on the analysis of alternatives to license renewal, the NRC staff has determined that the impacts of license renewal are reasonable when taken in the context of alternatives to the renewal of the Seabrook license.

9.3 Resource Commitments

9.3.1 Unavoidable Adverse Environmental Impacts

Unavoidable adverse environmental impacts are impacts that would occur after implementation of all feasible mitigation measures. Implementing any of the energy alternatives considered in this SEIS, including the proposed action, would result in some unavoidable adverse environmental impacts.

Minor unavoidable adverse impacts on air quality would occur due to emission and release of various chemical and radiological constituents from power plant operations. Nonradiological emissions resulting from power plant operations are expected to comply with U.S. Environmental Protection Agency (EPA) emissions standards, though the alternative of operating a fossil-fueled power plant in some areas may worsen existing attainment issues. Chemical and radiological emissions would not exceed the National Emission Standards for hazardous air pollutants (HAPs).

During nuclear power plant operations, workers and members of the public would face unavoidable exposure to radiation and hazardous and toxic chemicals. Workers would be exposed to radiation and chemicals associated with routine plant operations and the handling of nuclear fuel and waste material. Workers would have higher levels of exposure than members of the public, but doses would be administratively controlled and would not exceed standards or administrative control limits. In comparison, the alternatives involving the construction and operation of a non-nuclear power generating facility would also result in unavoidable exposure to hazardous and toxic chemicals to workers and the general public.

The generation of spent nuclear fuel and waste material, including low-level radioactive waste, hazardous waste, and nonhazardous waste would also be unavoidable. In comparison, hazardous and nonhazardous wastes would also be generated at non-nuclear power generating facilities. Wastes generated from plant operations during the renewal term would be collected, stored, and shipped for suitable treatment, recycling, or disposal in accordance with applicable Federal and state regulations. Due to the costs of handling these materials, power plant operators would be expected to conduct all activities and optimize all operations in a way that generates the smallest amount of waste possible.

9.3.2 The Relationship Between Local Short-Term Uses of the Environment and the Maintenance and Enhancement of Long-Term Productivity

The operation of power generating facilities would result in short-term uses of the environment as described in Chapters 4, 5, 6, 7, and 8. "Short-term" is the period of time that continued power generating activities take place.

Power plant operations require short-term use of the environment and commitment of resources, and they commit certain resources (e.g., land and energy) indefinitely or permanently. Most energy alternatives, including license renewal, would require certain short-term resource commitments because of the continued generation of electrical power and the continued use of generating sites and associated infrastructure. During operations, all energy alternatives require similar relationships between local short-term uses of the environment and the maintenance and enhancement of long-term productivity.

Air emissions from nuclear power plant operations introduce small amounts of radiological and nonradiological constituents to the region around the plant site. Over time, these emissions would result in increased concentrations and exposure, but they are not expected to impact air quality or radiation exposure to the extent that public health and long-term productivity of the environment would be impaired.

Continued employment, expenditures, and tax revenues generated during power plant operations directly benefit local, regional, and state economies over the short term. Local governments investing project-generated tax revenues into infrastructure and other required services could enhance economic productivity over the long term (beyond the period of extended operation).

The management and disposal of spent nuclear fuel, low-level radioactive waste, hazardous waste, and nonhazardous waste requires an increase in energy and consumes space at treatment, storage, or disposal facilities. Regardless of the location, the use of land to meet waste disposal needs would reduce the long-term productivity of the land.

Power plant facilities are committed to electricity production over the short term. After decommissioning these facilities and restoring the area, the land could be available for other future productive uses.

9.3.3 Irreversible and Irretrievable Commitments of Resources

This section describes the irreversible and irretrievable commitment of resources that have been identified in this SEIS. Resources are irreversible when primary or secondary impacts limit the future options for a resource. An irretrievable commitment refers to the use or consumption of resources that are neither renewable nor recoverable for future use. Irreversible and irretrievable commitment of resources for electrical power generation include the commitment of land, water, energy, raw materials, and other natural and man-made resources

required for power plant operations. In general, the commitment of capital, energy, labor, and material resources are also irreversible.

The implementation of any of the energy alternatives considered in this SEIS would entail the irreversible and irretrievable commitment of energy, water, chemicals, and in some cases, fossil fuels. These resources would be committed during the license renewal term and over the entire life cycle of the power plant (including construction, operations, and decommissioning) and would be unrecoverable.

Energy expended would be in the form of fuel for equipment, vehicles, and power plant operations and electricity for equipment and facility operations. Electricity and fuel would be purchased from offsite commercial sources. Water would be obtained from existing water supply systems. These resources are readily available, and the amounts required are not expected to deplete available supplies or exceed available system capacities.

9.4 Recommendations

The NRC staff's recommendation is that the adverse environmental impacts of license renewal for Seabrook are not great enough to deny the option of license renewal for energy-planning decisionmakers. This recommendation is based on the following:

- analysis and findings in the generic environmental impact statement (GEIS);
- Environmental Report (ER) submitted by NextEra;
- consultation with Federal, state, and local agencies;
- NRC staff's own independent review; and
- consideration of public comments received during the scoping process.

10.0 LIST OF PREPARERS

Members of the U.S. Nuclear Regulatory Commission's (NRC's) Office of Nuclear Reactor Regulation (NRR) prepared this supplemental environmental impact statement (SEIS) with assistance from other NRC organizations, as well as contract support from the Pacific Northwest National Laboratory (PNNL) and Sandia National Laboratory (SNL). Table 10–1 identifies each contributor's name, affiliation, and function or expertise.

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12.0 INDEX

NRC FORM 335 (12-2010) NRCMD 3.7 **BIBLIOGRAPHIC DATA SHEET** *(See instructions on the reverse)*	U.S. NUCLEAR REGULATORY COMMISSION	1. REPORT NUMBER (Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.) NUREG-1437, Supplement 46, Volume 1
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Division of License Renewal, Office of Nuclear Reactor Regulation
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9. SPONSORING ORGANIZATION - NAME AND ADDRESS (If NRC, type "Same as above", if contractor, provide NRC Division, Office or Region, U. S. Nuclear Regulatory Commission, and mailing address.)

Same as 8 above.

10. SUPPLEMENTARY NOTES

11. ABSTRACT (200 words or less)

This final supplemental environmental impact statement (SEIS) has been prepared in response to an application submitted by NextEra Energy Seabrook, LLC (NextEra) to renew the operating license for Seabrook Station (Seabrook) for an additional 20 years. This final SEIS includes the analysis that evaluates the environmental impacts of the proposed action and alternatives to the proposed action. Alternatives considered include replacement power from new natural-gas-fired combined-cycle generation; new nuclear generation; a combination alternative that includes some natural-gas-fired capacity, and a wind-power component; and the no-action alternative of not renewing the license.

The NRC's preliminary recommendation is that the adverse environmental impacts of license renewal for Seabrook are not great enough to deny the option of license renewal for energy planning decision makers. This recommendation is based on the following:

- analysis and findings in the generic environmental impact statement (GEIS);
- the Environmental Report (ER) submitted by NextEra;
- consultation with Federal, state, and local agencies;
- the NRC staff's own independent review, as documented in the 2011 draft SEIS and the 2013 supplement to the draft SEIS;
- the NRC staff's consideration of public comments received during the scoping process; and
- consideration of public comments received on the draft supplemental environmental impact statement and the 2013 supplement to the draft SEIS.

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Regarding Seabrook Station

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