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Vol. 1

Generic Environmental Impact Statement for License Renewal of Nuclear Plants

Supplement 29

Regarding
Pilgrim Nuclear Power Station

Final Report – Main Report

U.S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Washington, DC 20555-0001

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Office of Nuclear Reactor Regulation
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Abstract

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

This supplemental environmental impact statement (SEIS) has been prepared in response to an application submitted by Entergy Nuclear Operations, Inc. (Entergy), a subsidiary of Entergy Corporation, to the NRC to renew the OL for Pilgrim Nuclear Power Station (PNPS) for an additional 20 years under 10 CFR Part 54. This SEIS includes the NRC staff's analysis that considers and weighs the environmental impacts of the proposed action, the environmental impacts of alternatives to the proposed action, and mitigation measures available for reducing or avoiding adverse impacts. It also includes the staff's recommendation regarding the proposed action.

Regarding the 69 issues for which the GEIS reached generic conclusions, neither Entergy nor the staff has identified information that is both new and significant for any issue that applies to PNPS. In addition, the staff determined that information provided during the scoping process was not new and significant with respect to the conclusions in the GEIS. Therefore, the staff concludes that the impacts of renewing the OL for PNPS would not be greater than impacts identified for these issues in the GEIS. For each of these issues, the staff's conclusion in the GEIS is that the impact would be of SMALL(a) significance (except for collective off-site radiological impacts from the fuel cycle and high-level waste and spent fuel, which were not assigned a single significance level).

Regarding the remaining 23 issues, those that apply to PNPS are addressed in this SEIS. For each applicable issue, the staff concludes that the significance of the potential environmental impacts of renewal of the OL would be SMALL, with the exception of marine aquatic resources. Due to entrainment and impingement, the continued operation of the cooling water system would have MODERATE(b) impacts on the local winter flounder (*Pseudopleuronectes americanus*) population, and the Jones River population of rainbow smelt (*Osmerus mordax*).

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

(b) Environmental effects are sufficient to alter noticeably but not to destabilize important attributes of the resource.

Continued operation of the cooling water system would have SMALL to MODERATE impingement and entrainment impacts on other marine aquatic species as well. Cumulative impacts on the local winter flounder population and Jones River population of rainbow smelt would be MODERATE, and cumulative impacts on other marine aquatic species would be SMALL to MODERATE.

The NRC staff's recommendation is that the Commission determine that the adverse environmental impacts of license renewal for PNPS are not so great that preserving the option of license renewal for energy-planning decisionmakers would be unreasonable. This recommendation is based on (1) the analysis and findings in the GEIS; (2) the Environmental Report submitted by Entergy; (3) consultations with Federal, State, and local agencies; (4) the staff's own independent review; and (5) the staff's consideration of public comments.

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Executive Summary

By letter dated January 25, 2006, Entergy Nuclear Operations, Inc. (Entergy) submitted an application to the U.S. Nuclear Regulatory Commission (NRC) to renew the operating license (OL) for Pilgrim Nuclear Power Station (PNPS) for an additional 20-year period. If the OL is renewed, State regulatory agencies and PNPS will ultimately decide whether the plant will continue to operate based on factors such as the need for power or other matters within the State's jurisdiction or the purview of the owners. If the OL is not renewed, then the plant must be shut down on or before the expiration date of the current OL, which is June 8, 2012.

The NRC has implemented Section 102 of the National Environmental Policy Act of 1969, as amended (NEPA) (42 USC 4321), in Title 10 of the Code of Federal Regulations (CFR), Part 51 (10 CFR Part 51). In 10 CFR 51.20(b)(2), the Commission requires preparation of an environmental impact statement (EIS) or a supplement to an EIS for renewal of a reactor OL. In addition, 10 CFR 51.95(c) states that the EIS prepared at the OL renewal stage will be a supplement to the *Generic Environmental Impact Statement for License Renewal of Nuclear Plant*s (GEIS), NUREG-1437, Volumes 1 and 2.[(a)]

Upon acceptance of the PNPS application, the NRC began the environmental review process described in 10 CFR Part 51 by publishing a notice of intent to prepare an EIS and conduct scoping. The staff visited the PNPS site in May 2006 and held two public scoping meetings on May 17, 2006. In the preparation of the draft supplemental environmental impact statement (SEIS) for PNPS, the staff reviewed the PNPS Environmental Report (ER) and compared it to the GEIS, consulted with other agencies, conducted an independent review of the issues following the guidance set forth in NUREG-1555, Supplement 1, the *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal*, and considered the public comments received during the scoping process. The public comments received during the scoping process that were considered to be within the scope of the environmental review are provided in Appendix A, Part 1, of this SEIS.

The draft SEIS was published in December, 2006. The NRC held two public meetings in Plymouth, Massachusetts in January 2007, to describe the preliminary results of the NRC environmental review, to answer questions, and to provide members of the public with information to assist them in formulating comments on the draft SEIS. When the comment period ended, the staff considered and addressed all of the comments received. These comments are addressed in Appendix A, Part II of this SEIS.

This SEIS includes the NRC staff's analysis that considers and weighs the environmental effects of the proposed action, the environmental impacts of alternatives to the proposed action, and

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(a) 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.

mitigation measures for reducing or avoiding adverse effects. It also includes the staff's recommendation regarding the proposed action.

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

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

The evaluation criterion for the staff's environmental review, as defined in 10 CFR 51.95(c)(4) and the GEIS, is to determine:

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

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

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

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

The GEIS contains the results of a systematic evaluation of the consequences of renewing an OL and operating a nuclear power plant for an additional 20 years. It evaluates

92 environmental issues using the NRC's three-level standard of significance—SMALL, MODERATE, or LARGE—developed using the Council on Environmental Quality guidelines.

The following definitions of the three significance levels are set forth in footnotes to Table B-1 of 10 CFR Part 51, Subpart A, Appendix B:

> SMALL - Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.
>
> MODERATE - Environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.
>
> LARGE - Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

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

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

(2) A single significance level (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).

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

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

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

This SEIS documents the staff's consideration of all 92 environmental issues identified in the GEIS. The staff considered the environmental impacts associated with alternatives to license renewal and compared the environmental impacts of license renewal and the alternatives. The alternatives to license renewal that were considered include the no-action alternative (not renewing the OL for PNPS) and alternative methods of power generation. Based on projections made by the U.S. Department of Energy's Energy Information Administration (DOE/EIA), coal and gas-fired generation appear to be the most likely power-generation alternatives if the power from PNPS is replaced. These alternatives are evaluated assuming that the replacement power generation plant is located at either the PNPS site or some other unspecified alternate location.

Entergy and the staff have established independent processes for identifying and evaluating the significance of any new information on the environmental impacts of license renewal. Neither Entergy nor the staff has identified information that is both new and significant related to Category 1 issues that would call into question the conclusions in the GEIS. Therefore, the staff relies upon the conclusions of the GEIS for all of the Category 1 issues that are applicable to PNPS. However, the staff has identified the need for an essential fish habitat (EFH) consultation. NRC conducted an EFH consultation with the National Marine Fisheries Service (NMFS). NMFS has concluded the EFH consultation; such documentation is included in Appendix E of this SEIS. In addition, the staff considered the potential new issue of effects on aquatic habitat due to operation of the cooling system. The staff concluded that this issue, while new, would not be significant.

PNPS's license renewal application presents an analysis of the Category 2 issues plus environmental justice and chronic effects from electromagnetic fields. The staff has reviewed the PNPS analysis for each issue and has conducted an independent review of each issue. Six Category 2 issues are not applicable, because they are related to plant design features or site characteristics not found at PNPS. Four Category 2 issues are not discussed in this SEIS, because they are specifically related to refurbishment. PNPS has stated that its evaluation of structures and components, as required by 10 CFR 54.21, did not identify any major plant refurbishment activities or modifications as necessary to support the continued operation of PNPS for the license renewal period. In addition, any replacement of components or additional inspection activities are within the bounds of normal plant operation, and are not expected to affect the environment outside of the bounds of the plant operations evaluated in the U.S. Atomic Energy Commission's 1972 *Final Environmental Statement Related to Operation of PNPS*.

Eleven Category 2 issues related to operational impacts and postulated accidents during the renewal term, as well as environmental justice and chronic effects of electromagnetic fields, are discussed in detail in this SEIS. Five of the Category 2 issues and environmental justice apply to both refurbishment and to operation during the renewal term and are only discussed in this SEIS in relation to operation during the renewal term. For the 11 Category 2 issues and environmental justice, the staff concludes that the potential environmental effects are of SMALL and SMALL to MODERATE significance in the context of the standards set forth in the GEIS. A MODERATE impact was determined based on entrainment of the local population of winter flounder (*Pseudopleuronectes americanus*) and a MODERATE impact was determined based on impingement of the Jones River population of rainbow smelt (*Osmerus mordax*). The staff concluded that the potential site-specific impacts of the cooling intake system due to entrainment (local winter flounder population) and impingement (Jones River rainbow smelt) would be MODERATE. For all other marine aquatic species, the staff concluded that potential impacts due to entrainment and impingement would be SMALL to MODERATE. Additional mitigation to minimize the impacts of entrainment and impingement may be justified. EPA Region I is currently in the process of reviewing the National Pollutant Discharge Elimination System permit renewal application for PNPS. It is expected that this evaluation would evaluate the need for and feasibility of any additional mitigation measures.

The staff also determined that appropriate Federal health agencies have not reached a consensus on the existence of chronic adverse effects from electromagnetic fields. Therefore, no further evaluation of this issue is required. For severe accident mitigation alternatives (SAMAs), the staff concludes that a reasonable, comprehensive effort was made to identify and evaluate SAMAs. Based on its review of the SAMAs for PNPS and the plant improvements already made, the staff concludes that Entergy identified five potentially cost-beneficial SAMAs. The staff concludes that two additional SAMAs are potentially cost-beneficial. However, these SAMAs do not relate to adequate managing of the effects of aging during the period of extended operation. Therefore, they do not need to be implemented as part of the license renewal pursuant to 10 CFR Part 54.

Cumulative impacts of past, present, and reasonably foreseeable future actions were considered, regardless of what agency (Federal or non-Federal) or person undertakes such other actions. For purposes of this analysis, the staff concluded that the cumulative impacts resulting from the incremental contribution of PNPS operation and maintenance of the transmission line right-of-way would be SMALL for all resources with the exception of marine aquatic resources, which would experience SMALL to MODERATE cumulative impacts.

If the PNPS operating license is not renewed and the unit ceases operation on or before the expiration of its current operating license, then the adverse impacts of likely alternatives would not be smaller than those associated with continued operation of PNPS. The impacts may, in fact, be greater in some areas.

The recommendation of the NRC staff is that the Commission determine that the adverse environmental impacts of license renewal for PNPS are not so great that preserving the option of license renewal for energy planning decisionmakers would be unreasonable. This recommendation is based on (1) the analysis and findings in the GEIS; (2) the ER submitted by

Entergy; (3) consultations with other Federal, State, and local agencies; (4) the staff's own independent review; and (5) the staff's consideration of public comments.

Abbreviations/Acronyms

°	degree(s)
μm	micron(s)
ac	acre(s)
AC	alternating current
ACC	averted cleanup and decontamination costs
ADS	automatic depressurization system
AEC	U.S. Atomic Energy Commission
ALARA	as low as reasonably achievable
AOC	averted off-site property damage costs
AOE	averted occupational exposure
AOG	augmented off-gas
AOSC	averted on-site cost
APE	averted public exposure
ASME	American Society of Mechanical Engineers
ASMFC	Atlantic States Marine Fisheries Commission
ATWS	anticipated transient without scram
BA	biological assessment
BRW	boiling water reactor
BTU	British thermal unit(s)
BWROG	boiling water reactor owners group
C	Celsius
CAA	Clean Air Act
CAIR	Clean Air Interstate Rule
CAPB	collapsed accident progression bins
CCDP	conditional core damage probabilities
CDF	core damage frequency
CDS	Comprehensive Demonstration Study
CET	containment event tree
CEQ	Council on Environmental Quality
CFR	*Code of Federal Regulations*
cfs	cubic foot (feet) per second
Ci	curie(s)
cm	centimeter(s)
CO	carbon monoxide
CO_2	carbon dioxide
COE	cost of enhancement
CST	condensate storage tanks
CWA	Clean Water Act

DBA	design-basis accidents
DC	direct current
DCH	direct containment heating
delta T	change in temperature
DFO	Department of Fisheries and Oceans
DMR	discharge monitoring report
DO	dissolved oxygen
DOE	U.S. Department of Energy
DSM	demand side management
DTV	direct torus vent
EA	environmental assessment
ECCS	emergency core cooling system
EDG	emergency diesel generator
EEZ	exclusive economic zone
EFH	essential fish habitat
EIA	Energy Information Administration (of DOE)
EIS	environmental impact statement
ELF-EMF	extremely low frequency-electromagnetic field
EN-EV	environmental review and evaluation procedure
Entergy	Entergy Nuclear Operations, Inc.
EOP	emergency operating procedure
EPA	U.S. Environmental Protection Agency
EPH	extractable petroleum hydrocarbons
EPRI	Elecrtical Power Research Institute
ER	Environmental Report
ESA	Endangered Species Act of 1976, as amended
ETE	evacuation time estimate
F	Fahrenheit
FES	Final Environmental Statement
FIVE	fire-induced vulnerability evaluation
FMP	fishery management plan
fps	foot (feet) per second
FR	*Federal Register*
FSAR	Final Safety Analysis Report
ft	foot (feet)
FWS	U.S. Fish and Wildlife Service
fy	fiscal year

GL	generic letter
GARM	Groundfish Assessment Review Meeting
GEIS	*Generic Environmental Impact Statement for License Renewal of Nuclear Plants, NUREG-1437*
GIS	geographic information system
gpm	gallon(s) per minute
HAPC	habitat area of particular concern
HCLPF	high confidence low probability of failure
HLW	high-level waste
hp	horsepower
HPCI	high pressure coolant injection
ICRP	International Commission on Radiological Protection
in.	inch(es)
IPE	individual plant examination
IPEEE	individual plant examination external events
ISLOCA	interfacing system LOCA
km	kilometer(s)
kV	kilovolt(s)
kW	kilowatt(s)
kWh	kilowatt hour(s)
L	liter(s)
LLRWSF	low level radwaste storage facility
LOCA	loss of coolant accident
LOOP	loss of off-site power
LPCI	low pressure coolant injection
m	meter(s)
m/s	meter(s) per second
mA	milliampere(s)
MA DEM	Massachusetts Department of Environmental Management
MAAP	modular accident analysis program
MACCS2	MELCOR Accident Consequence Code System 2
MAFMC	Mid-Atlantic Fishery Management Council
MassGIS	Massachusetts Geographic Information System
MBDS	Massachusetts Bay Disposal Site
MCC	motor control centers
MDEP	Massachusetts Department of Environmental Protection

MDFW	Massachusetts Division of Fisheries and Wildlife
MDMF	Massachusetts Division of Marine Fisheries
MDPH	Massachusetts Department of Public Health
MEOEA	Massachusetts Executive Office for Environmental Affairs
mg/L	milligram(s) per liter
MHC	Massachusetts Historical Commission
mi	mile(s)
min	minute(s)
MISER	Massachusetts Institute for Social and Environmental Research
mL	milliliter(s)
MLW	mean low water
mm	millimeter(s)
mrem	millirem(s)
MRI	Marine Research, Inc.
MSA	Magnuson-Stevens Act
MSIV	main steam isolation valve
MSL	mean sea level
MTU	metric ton of uranium
MWd	megawatt-days
MW(e)	megawatt(s) electric
MW(h)	megawatt hour(s)
MWRA	Massachusetts Water Resource Authority
MW(t)	megawatt(s) thermal
NAFO	Northwest Atlantic Fisheries Organization
NAS	National Academy of Sciences
NEFMC	New England Fishery Management Council
NEFSC	Northeast Fisheries Science Center
NEPA	National Environmental Policy Act of 1969, as amended
NESC	National Electric Safety Code
NHESP	Massachusetts Natural Heritage and Endangered Species Program
NHPA	National Historic Preservation Act
NIEHS	National Institute of Environmental Health Sciences
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide
NO_x	nitrogen oxide(s)
NOAA	National Oceanic and Atmospheric Administration
NOV	notice of violation
NPDES	National Pollutant Discharge Elimination System
NPSH	net positive suction head
NRC	U.S. Nuclear Regulatory Commission

OCPC	Old Colony Planning Council
ODCM	Offsite Dose Calculation Manual
OL	operating license
PAH	polycyclic aromatic hydrocarbon
PCB	polychloronated biphenyl
PDS	plant damage state
PGA	peak ground acceleration
PILOT	payments in lieu of taxes
$PM_{2.5}$	particulate matter, 2.5 microns or less in diameter
PM_{10}	particulate matter, 10 microns or less in diameter
PNPS	Pilgrim Nuclear Power Station
ppm	parts per million
ppt	parts per thousand
PSA	probabilistic safety assessment
psi	pound(s) per square inch
RAI	request for additional information
RAMAS	risk analysis management alternative system
RBCCW	reactor building closed cooling water
RCIC	reactor coolant injection cooling
RCRA	Resource Conservation and Recovery Act
REMP	radiological environmental monitoring program
REWD	Radioactive Effluent and Waste Disposal Report
RHR	residual heat removal
ROW	right-of-way
RPC	replacement power costs
RPV	reactor pressure valve
RRW	risk reduction worth
s	second(s)
SAFE	Stock Assessment and Fishery Evaluation
SAMA	severe accident mitigation alternative
SAR	Safety Analysis Report
SARC	Stock Assessment Review Committee
SBO	station blackout
SCR	selective catalytic reduction
SEIS	supplemental environmental impact statement
SER	Safety Evaluation Report
SGTS	standby gas treatment system
SLC	standby liquid control

SMHS	Southeastern Massachusetts Health Study
SO_2	sulfur dioxide
SO_x	sulfur oxide(s)
SPRA	seismic probabilistic risk assessment
SRV	steam release valve
SSB	spawning stock biomass
SSW	salt service water
Sv	sievert(s)
TBCCW	turbine building closed cooling water
TDS	total dissolved solids
TPH	total petroleum hydrocarbons
TRC	total residual chlorine
U.S.	United States
USACE	U.S. Army Corps of Engineers
USC	United States Code
USCB	U.S. Census Bureau
USI	unresolved safety issue
V	volt(s)
VDC	volts direct current
VIMS	Virginia Institute of Marine Science
yr	year(s)

1.0 Introduction

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

Entergy Nuclear Operations, Inc. (Entergy), a subsidiary of Entergy Corporation, operates Pilgrim Nuclear Power Station (PNPS) in Plymouth, Massachusetts under OL DPR-35, which was issued by the NRC. This OL will expire on June 8, 2012. On January 25, 2006, Entergy submitted an application to the NRC to renew the PNPS OL for an additional 20 years under 10 CFR Part 54 (Entergy 2006a). Entergy is a licensee for the purposes of its current OL and an applicant for the renewal of the OL. Pursuant to 10 CFR 54.23 and 51.53(c), Entergy submitted an Environmental Report (ER) (Entergy 2006b) in which Entergy analyzed the environmental impacts associated with the proposed license renewal action, considered alternatives to the proposed action, and evaluated mitigation measures for reducing adverse environmental effects.

This report is the facility-specific supplement to the GEIS (the supplemental EIS [SEIS]) for the PNPS license renewal application. This SEIS is a supplement to the GEIS because it relies, in part, on the findings of the GEIS. The staff also prepared a separate safety evaluation report in accordance with 10 CFR Part 54.

1.1 Report Contents

The following sections of this introduction (1) describe the background for the preparation of this SEIS, including the development of the GEIS and the process used by the staff to assess the environmental impacts associated with license renewal, (2) describe the proposed Federal

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(a) 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.

action to renew the PNPS OL, (3) discuss the purpose and need for the proposed action, and (4) present the status of Entergy's compliance with environmental quality standards and requirements that have been imposed by Federal, State, regional, and local agencies that are responsible for environmental protection.

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

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

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

1.2 Background

The following sections discuss use of the GEIS, which examines the possible environmental impacts that could occur as a result of renewing individual nuclear power plant OLs under 10 CFR Part 54. The established license renewal evaluation process supports the thorough evaluation of the impacts of OL renewal.

1.2.1 Generic Environmental Impact Statement

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

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

The NRC's standard of significance for impacts was established using the Council on Environmental Quality (CEQ) terminology for "significantly" (40 CFR 1508.27, which requires consideration of both "context" and "intensity"). Using the CEQ terminology, the NRC established three significance levels – SMALL, MODERATE, or LARGE. The definitions of the three significance levels are set forth in the footnotes to Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, as follows:

> SMALL – Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.
>
> MODERATE – Environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.
>
> LARGE – Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

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

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

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

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

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

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

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

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

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

The NRC staff has identified a new issue that was not previously addressed in the GEIS related to essential fish habitat (EFH). The consultation requirements of Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act, as amended by the

Sustainable Fisheries Act of 1996, provide that Federal agencies must consult with the Secretary of Commerce on all actions or proposed actions authorized, funded, or undertaken by the agency that may adversely affect EFH. NRC conducted an EFH consultation with the National Marine Fisheries Service (NMFS). NMFS has concluded the EFH consultation; such documentation is included in Appendix E of this SEIS. Another new issue (effects on aquatic habitat) was identified but was determined not to be significant.

1.2.2 License Renewal Evaluation Process

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

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

- provide an analysis of the Category 2 issues in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B in accordance with 10 CFR 51.53(c)(3)(ii) and

- discuss actions to mitigate any adverse impacts associated with the proposed action and environmental impacts of alternatives to the proposed action.

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

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

- consider the need for power and other issues not related to the environmental effects of the proposed action and the alternatives,

- discuss any aspect of the storage of spent fuel within the scope of the generic determination in 10 CFR 51.23(a) in accordance with 10 CFR 51.23(b), or

- contain an analysis of any Category 1 issue unless there is significant new information on a specific issue — this is pursuant to 10 CFR 51.23(c)(3)(iii) and (iv).

New and significant information is (1) information that identifies a significant environmental issue not covered in the GEIS and codified in Table B-1 of 10 CFR Part 51, Subpart A,

Appendix B or (2) information that was not considered in the analyses summarized in the GEIS and that leads to an impact finding that is different from the finding presented in the GEIS and codified in 10 CFR Part 51.

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

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

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

The NRC prepares an independent analysis of the environmental impacts of license renewal and compares these impacts with the environmental impacts of alternatives. The evaluation of the Entergy license renewal application began with the publication of a notice of acceptance for docketing and notice of opportunity for a hearing in the *Federal Register* (FR) (71 FR 15222; NRC 2006a) on March 27, 2006. The staff published a notice of intent to prepare an EIS and conduct scoping (71 FR 19554; NRC 2006b) on April 14, 2006. Two public scoping meetings were held on May 17, 2006, in Plymouth, Massachusetts. Comments received during the scoping period were summarized in the *Environmental Impact Statement Scoping Process: Summary Report - Pilgrim Nuclear Power Station* (NRC 2006c) dated September 26, 2006. Comments that are applicable to this environmental review are presented in Part 1 of Appendix A.

The staff followed the review guidance contained in NUREG-1555, Supplement 1 (NRC 2000). The staff and contractor retained to assist the staff visited the PNPS Site on May 1 through May 5, 2006, to gather information and to become familiar with the site and its environs. The staff also reviewed the comments received during scoping, and consulted with Federal, State, regional, and local agencies. A list of the organizations consulted is provided in Appendix D. Other documents related to PNPS were reviewed and are referenced within this SEIS.

This SEIS presents the staff's analysis that considers and weighs the environmental effects of the proposed renewal of the OL for PNPS, the environmental impacts of alternatives to license renewal, and mitigation measures available for avoiding adverse environmental effects. Chapter 9, "Summary and Conclusions," provides the NRC staff's preliminary recommendation to the Commission on whether or not the adverse environmental impacts of license renewal are so great that preserving the option of license renewal for energy-planning decisionmakers would be unreasonable.

On December 8, 2006 the NRC published the Notice of Availability of the draft SEIS. A 75-day comment period began on the date of publication of the U.S. Environmental Protection Agency Notice of Filing of the draft SEIS to allow members of the public to comment on the preliminary results of the NRC staff's review. The comment period ended on February 28, 2007. During the comment period, two public meetings were held in Plymouth, Massachusetts on January 24, 2007. During these meetings, the NRC staff described the preliminary results of the NRC environmental review and answered questions related to the environmental review to provide members of the public with information to assist them in formulating their comments. Comments made during the 75-day comment period, including those made at the two public meetings, are presented in Appendix A, Part 2, of this SEIS.

1.3 The Proposed Federal Action

The proposed Federal action is renewal of the OL for PNPS. The PNPS facility is located in eastern Massachusetts on the western shore of Cape Cod Bay, approximately 38 miles (mi) southwest of Boston, Massachusetts, and 44 mi east of Providence, Rhode Island. The plant has one General Electric-designed boiling water reactor with a design power level of 1,998 megawatts thermal (MW[t]). In 2003, PNPS implemented a Thermal Power Optimization of 1.5 percent to achieve the current electrical rating of 715 megawatts electric (MW[e]). Plant cooling is provided by a once-through heat dissipation system that withdraws cooling water from and discharges it to Cape Cod Bay. PNPS produces electricity to supply the needs of more than 550,000 homes. The current OL for PNPS expires on June 8, 2012. By letter dated January 25, 2006, Entergy submitted an application to the NRC (Entergy 2006a) to renew this OL for an additional 20 years of operation (i.e., until June 8, 2032).

1.4 The Purpose and Need for the Proposed Action

Although a licensee must have a renewed license to operate a reactor beyond the term of the existing OL, the possession of that license is just one of a number of conditions that must be met for the licensee to continue plant operation during the term of the renewed license. Once an OL is renewed, State regulatory agencies and the owners of the plant will ultimately decide whether the plant will continue to operate based on factors such as the need for power or other matters within the State’s jurisdiction or the purview of the owners.

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

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

The purpose and need for the proposed action (renewal of an operating license) is to provide an option that allows for power generation capability beyond the term of a current nuclear power plant operating license to meet future system generating needs, as such needs may be determined by State, utility, and where authorized, Federal (other than NRC) decision makers. This definition of purpose and need reflects the Commission’s recognition that, unless there are findings in the safety review required by the Atomic Energy Act of 1954, as amended or findings in the NEPA environmental analysis that would lead the NRC to reject a license renewal application, the NRC does not have a role in the energy-planning decisions of state regulators and utility officials as to whether a particular nuclear power plant should continue to operate.

From the perspective of the licensee and the state regulatory authority, the purpose of renewing an OL is to maintain the availability of the nuclear plant to meet system energy requirements beyond the current term of the plant's license.

1.5 Compliance and Consultations

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

The staff has reviewed the list and consulted with the appropriate Federal, State, and local agencies to identify any compliance or permit issues or significant environmental issues of concern to the reviewing agencies. These agencies did not identify any new and significant environmental issues. However, as of the publication of this SEIS, NRC is in consultation with the NMFS regarding threatened and endangered species, and NMFS concluded the EFH consultation. The ER states that Entergy is in compliance with applicable environmental standards and requirements for PNPS. The staff has not identified any environmental issues that are both new and significant.

1.6 References

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

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

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

Atomic Energy Act of 1954, as amended, 42 USC 2011, et seq.

Entergy Nuclear Operations, Inc. (Entergy). 2006a. *License Renewal Application, Pilgrim Nuclear Power Station*, Docket No. 50-293, Facility Operating License Number DPR-35, Plymouth, Massachusetts.

Entergy Nuclear Operations, Inc. (Entergy). 2006b. *Applicant's Environmental Report – Operating License Renewal Stage, Pilgrim Nuclear Power Station*. Docket Number 50-293, Plymouth, Massachusetts.

National Environmental Policy Act of 1969, as amended (NEPA) 42 USC 4321, et seq.

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

Nuclear Regulatory Commission (NRC). 1999. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants Main Report*, "Section 6.3 – Transportation, Table 9.1, Summary of findings on NEPA issues for license renewal of nuclear power plants," Final Report. NUREG-1437, Volume 1, Addendum 1, Washington, DC.

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

Nuclear Regulatory Commission (NRC). 2006a. "Notice of Acceptance for Docketing of the Application and Notice of Opportunity for a Hearing Regarding Renewal of Facility Operating License Number DPR-35 and for an Additional 20-Year Period." *Federal Register*: Volume 71, Number 58, pgs. 15222-15223. March 27, 2006.

Nuclear Regulatory Commission (NRC). 2006b. "Notice of Intent to Prepare an Environmental Impact Statement and Conduct Scoping Process." *Federal Register*: Volume 71, Number 72, pgs. 19554-19556. April 14, 2006.

Nuclear Regulatory Commission (NRC). 2006c. *Environmental Impact Statement Scoping Process: Summary Report – Pilgrim Nuclear Power Station, Plymouth, Massachusetts*. Washington, DC. September 26, 2006.

2.0 Description of Nuclear Power Plant and Site and Plant Interaction with the Environment

Entergy's Pilgrim Nuclear Power Station (PNPS) is located on the rocky western shore of Cape Cod Bay in the Town of Plymouth, Plymouth County, Massachusetts. The nearest large cities are Boston, Massachusetts, approximately 38 miles (mi) to the northwest and Providence, Rhode Island, approximately 44 mi to the west.

The facility consists of one boiling water reactor producing steam that turns a turbine to generate electricity. Facility cooling is provided by a once-through system using water from Cape Cod Bay. The plant and its environs are described in Section 2.1, and the plant's interaction with the environment is presented in Section 2.2.

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

Prior to development as a power facility, the site of PNPS was part of the Greenwood estate. The site was purchased in 1967 for the main purpose of constructing PNPS. The PNPS facility occupies approximately 140 acres (ac). Entergy also owns an additional 1500 ac adjacent to the plant site that is in a forest management trust (Entergy 2006a). The generating station is situated near the northeast end of Pine Hills, a ridge of low lying hills approximately 4 mi long. These hills reach a maximum height of 395 feet (ft) and form the major drainage divide in the area. Major plant structures are situated approximately 23 ft above mean sea level (MSL), but site elevation rises rapidly as distance from Cape Cod Bay increases. The maximum elevation within 3 mi of the site is 395 ft MSL at Manomet Hill. The terrain within 6 mi of the PNPS area is rolling forested hills, predominately hardwoods, interspersed with urban areas and a small number of agricultural areas, the majority of which are cranberry bogs.

More than 60 percent of the area within a 50-mi radius of the site is open water (Massachusetts Bay, Cape Cod Bay, Buzzards Bay, and Nantucket Sound). The area within 6 mi of PNPS is located entirely within Plymouth County, primarily within the Town of Plymouth. The community of Plymouth is the nearest urbanized area. The area within 2 mi of PNPS includes Priscilla Beach, White Horse Beach, and part of the community of Plymouth, which supports both permanent and seasonal residences (Entergy 2006a). Figures 2-1 and 2-2, show the site location and features within 50-mi and 6-mi, respectively.

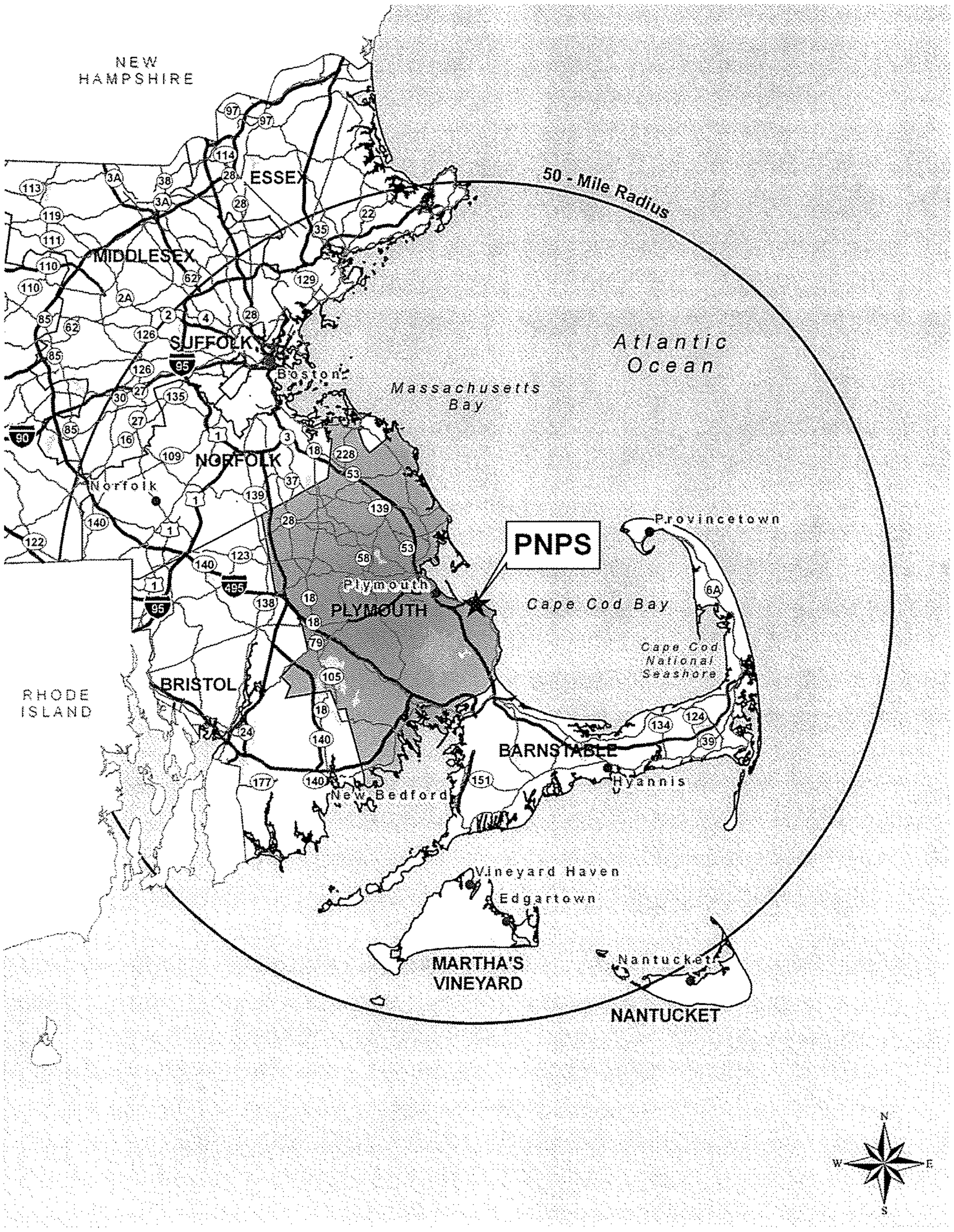

Figure 2-1. Location of PNPS, 50-mi Radius

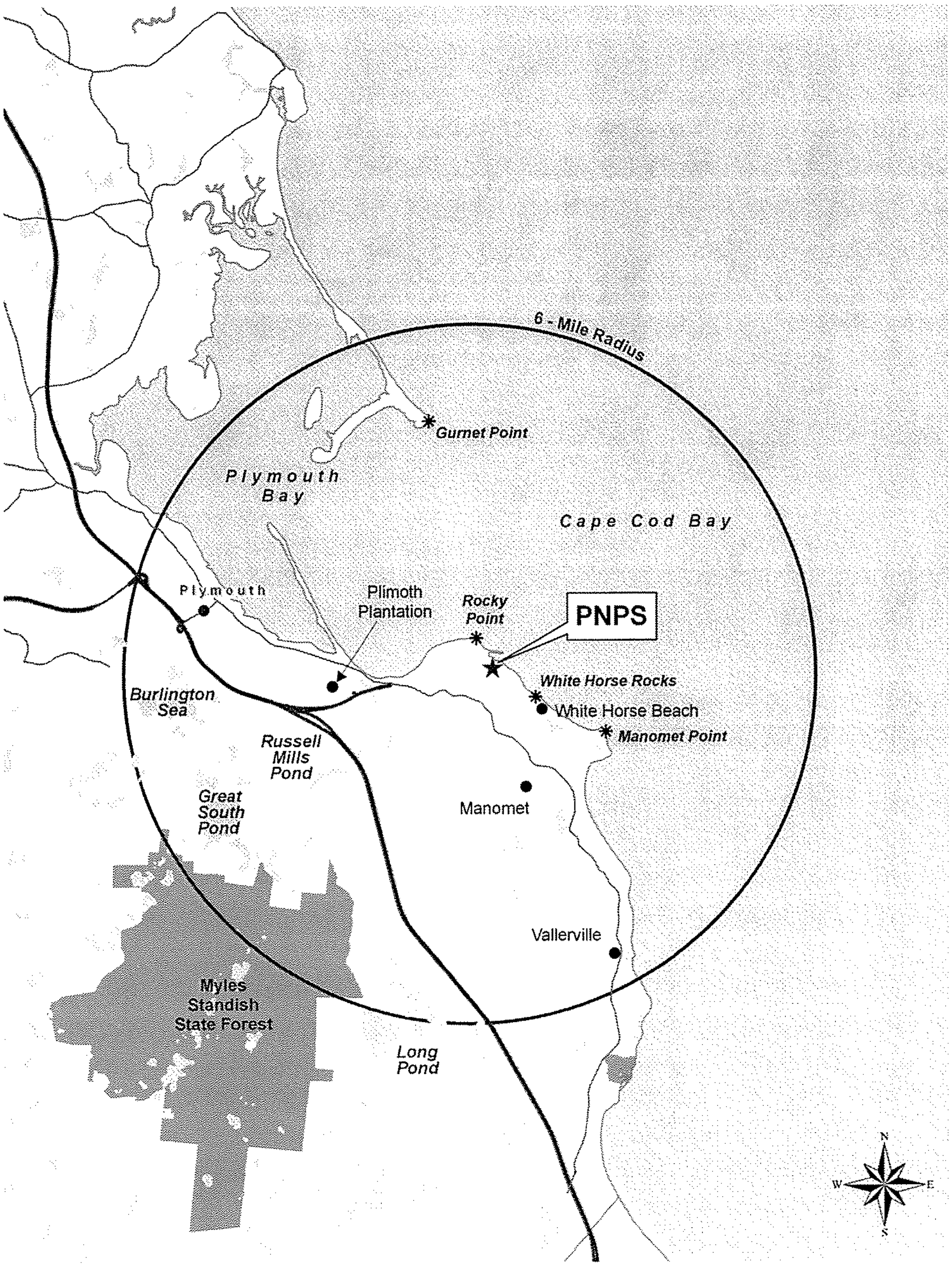

Figure 2-2. Location of PNPS, 6-mi Radius

2.1.1 External Appearance and Setting

As mentioned above, PNPS is located on the western shoreline of Cape Cod Bay and has 1 mi of continuous shoreline frontage. The site can be accessed by land or from Cape Cod Bay. Access by land is via Power House Road, which connects the site to Rocky Hill Road, approximately 0.25 mi southwest of the site, and Route 3A, approximately 1.25 mi to the south. A boat landing providing waterside access to the site is located immediately south of the facility's cooling water intake canal (Entergy 2006a).

The major features of the PNPS site are the reactor and turbine buildings, the off-gas retention building, the radwaste building, the diesel generator building, the intake structure, the switchyard, the main stack, administration buildings, and the former recreational facilities. A nature area consisting of hiking trails and an observation deck with a view of Cape Cod Bay formerly was located immediately northwest of the site. However, the recreational facilities and nature area have been closed to the public since shortly after September 11, 2001 and are not currently maintained as a recreation or nature area. Limited use is allowed to employees of PNPS. The nearest residence is over 2000 ft northwest of the reactor building (Entergy 2006a). Single-family houses are also located approximately 2500 ft southeast of the site. The two transmission lines that connect PNPS to the New England power grid are owned, operated, and maintained by NSTAR Electric and Gas Corporation (NSTAR). The transmission lines share a single right-of-way (ROW), which is bordered by forested swaths. The transmission lines ROW extends southeast from the switchyard approximately 800 ft and then south across Rocky Hill Road and Route 3A. The site boundary and general facility layout are depicted on Figures 2-3 and 2-4, respectively.

2.1.2 Reactor Systems

PNPS has one boiling water reactor unit and a steam-driven turbine generator manufactured by General Electric Company. Bechtel was the architect/engineer and construction manager of the project. The unit was originally licensed for an output of 1998 megawatts-thermal [Mw(t)], and commercial operation began in December 1972. In 2003, PNPS underwent a Thermal Power Optimization, which increased the electrical rating to the current 715 gross megawatts-electric [Mw(e)]. The PNPS fuel is a low-enriched uranium dioxide with maximum enrichments of 4.6 percent by weight uranium-235 and fuel burnup levels of 48,000 megawatt-days per metric ton uranium.

The primary containment for the reactor is a pressure suppression system, which includes a drywell, pressure suppression chamber, vent system, isolation valves, containment cooling

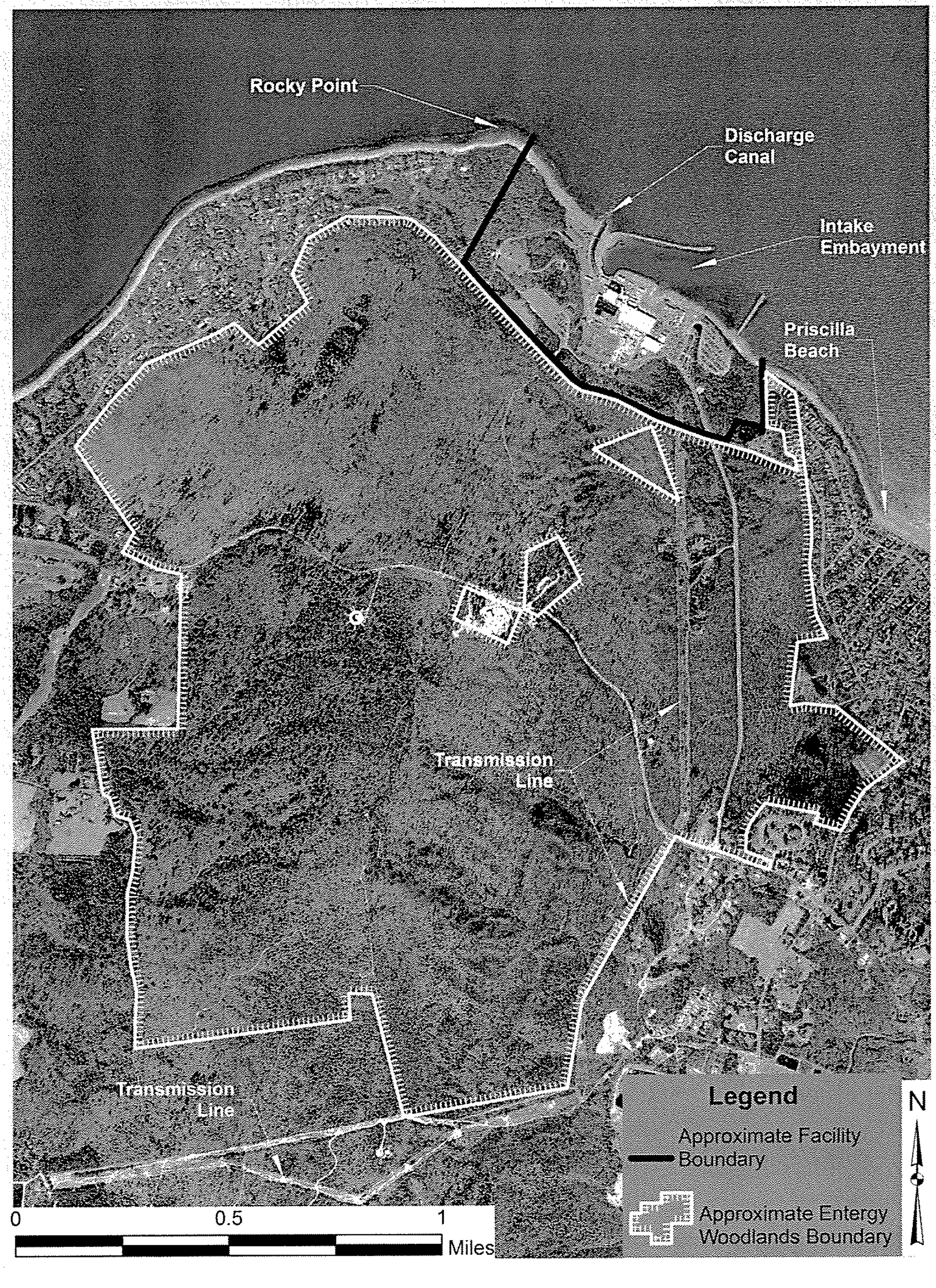

Figure 2-3. Aerial Photograph Showing PNPS Property Boundaries and Environs.

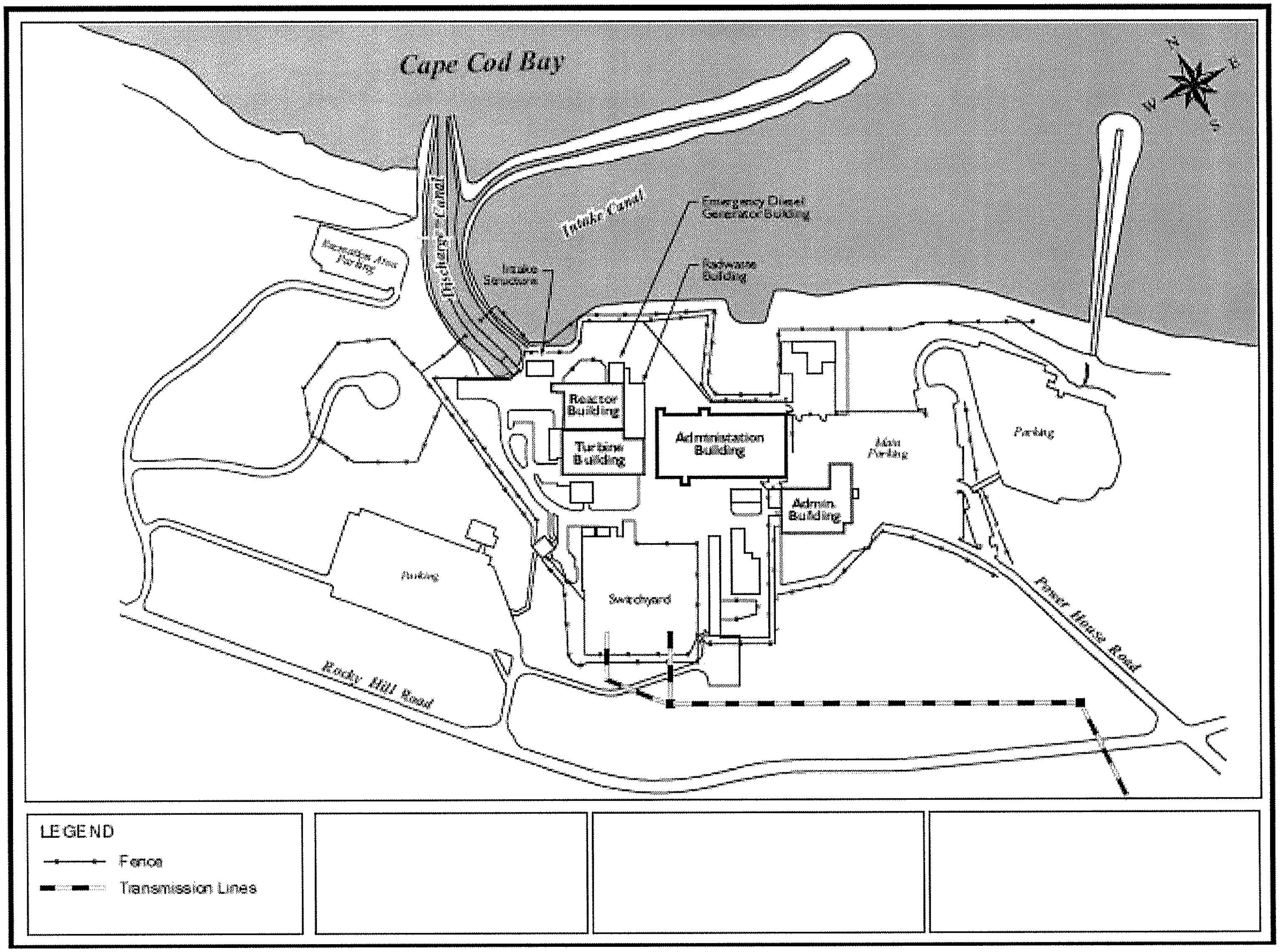

Figure 2-4. Facility Layout (Source: Entergy 2006a)

system, and other service equipment, and is designed to withstand an internal pressure of 62 pounds per square inch (psi) above atmospheric pressure. The containment is also designed to act as a radioactive materials barrier. A secondary containment completely encloses both the primary containment and fuel storage areas and acts as a radioactive materials barrier, as well (Entergy 2006a).

2.1.3 Cooling and Auxiliary Water Systems

The cooling and service water systems at PNPS operate as a once-through cooling system, with Cape Cod Bay being the water source. Seawater is withdrawn from the bay through an intake embayment formed by two breakwaters (Figure 2-4). The intake structure consists of wing walls, a skimmer wall that functions as a submerged baffle, slanted vertical bar racks that capture large debris, vertical traveling screens to prevent entrainment, fish-return sluiceways, condenser cooling water pumps, and service water pumps (Figure 2- 5). The two wing walls are constructed of concrete, and guide flow into four separate intake bays. Each wing wall extends from the face of the intake structure at a 45-degree angle, one to a distance of 130 ft to the northwest and the other one to a distance of 63 ft to the northeast. The entrance of the intake measures 62 ft wide at the stop log guide, and extends to the floor of the intake structure at 24 ft below MSL. The skimmer wall at the front of the intake removes floating debris, with the bottom of the wall extending to 12 ft below MSL. Fish are able to escape the system by way of approximately 6 to 12 10-inch (in.) circular openings that are located in the skimmer walls and at each end of the intake structure. According to the applicant, divers have visually verified that the escape openings are effective. Bar racks behind the skimmer wall intercept large debris. The racks are constructed of 3-in.-by-3/8-in. rectangular bars, with a 3-in. opening between each bar. Divers remove debris and large, impinged organisms from the bar racks.

Located in the seawater pump wells of the intake structure, two vertical, mixed-flow, wet-type pumps provide a continuous supply of condenser cooling water. Each 1450-horsepower pump has a capacity of 155,500 gallons per minute (gpm) [346.5 cubic ft per second (cfs)]. The water is pumped from the intake structure to the condensers via two buried concrete pipes measuring 7.5 ft in diameter. Measurements taken at the breakwaters during mid-tide level with both pumps running indicate that the average intake velocity is 0.05 ft per second (fps). At the intake, before the screens, the velocity is about 1 fps during all tidal conditions. Through the traveling screens, the velocity is about 2 fps. The velocity is approximately 0.15 fps near the east fish-return sluiceway, which is located in the intake embayment just east of the intake structure.

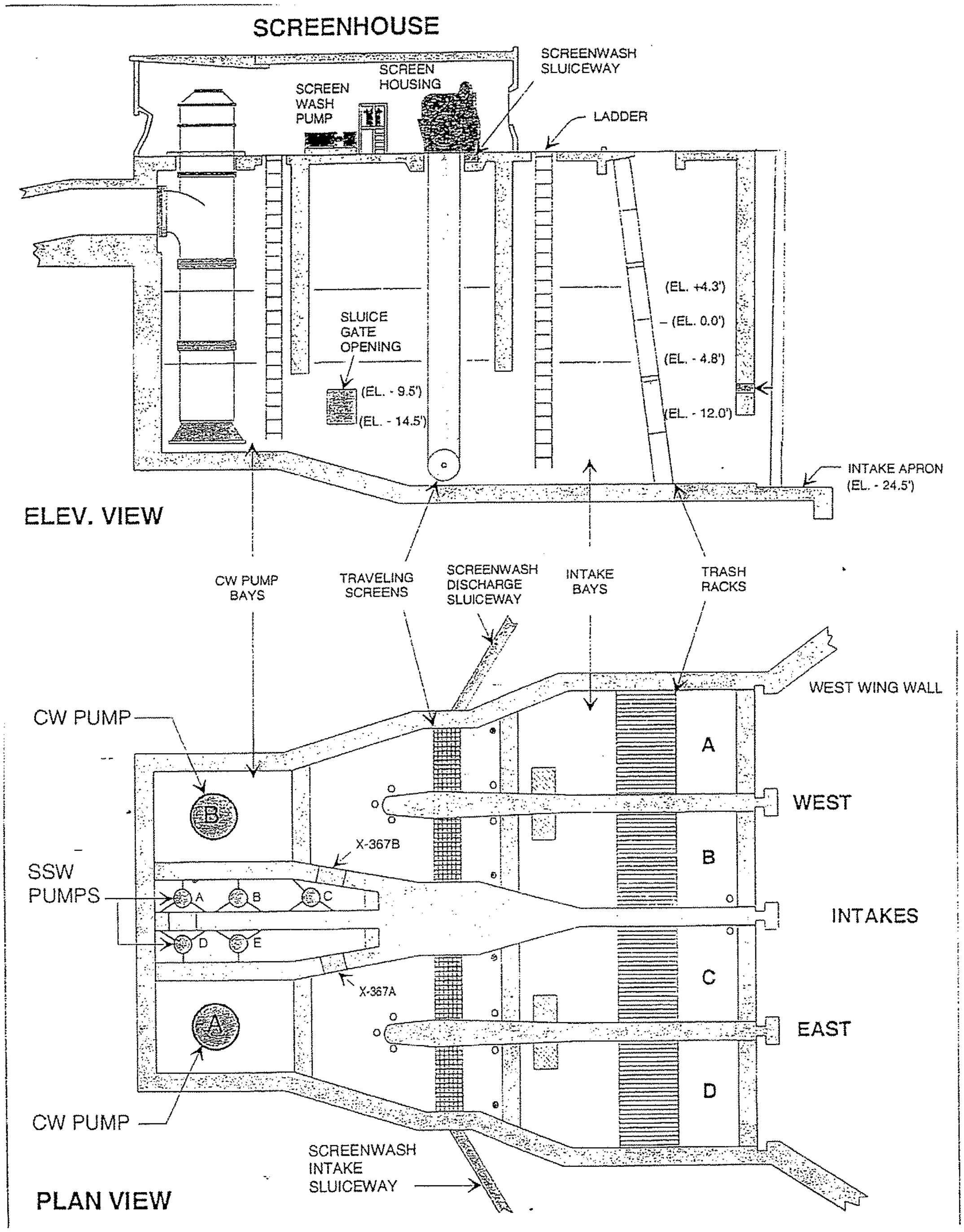

Figure 2-5. PNPS Intake Structure (Source: ENSR 2000)

Located in the central wet well of the intake structure are five service water pumps that supply the service water system. Generally, four pumps run while one is kept on standby. Each pump has a capacity of 2500 gpm, providing a combined capacity at normal operation of approximately 10,000 gpm. The service water system is continuously chlorinated in order to control nuisance biological organisms, such as mollusks, barnacles, algae and other organisms, in the service water system. Diffusers located downstream of the racks deliver a 12-percent sodium hypochlorite and seawater mixture to each intake bay. The mixture is used to ensure the total residual chlorine discharge concentration does not exceed a maximum daily concentration of 1.0 parts per million (ppm) and an average monthly concentration of 0.5 ppm in the service water discharge and 0.1 ppm maximum daily and 0.1 ppm average monthly concentration in the condenser cooling water.

Chlorination of the main cooling water system also takes place, but not on a continuous basis. Hypochlorination events occur during spring, summer, and fall, when the circulating water system is chlorinated for up to two hours per day (one hour for each pump). A chlorine solution is added inboard of the bar rack to control fouling.

From intake to discharge, the travel time for water to move through the system varies from 5 to 10 minutes, depending upon whether one or two intake pumps are in service. The tidal stage affects pump output, also causing changes in the transit time. In addition to dye dilution studies conducted in the 1980s, the transit time has been estimated during chlorination events. During these chlorination events, chlorine is added outboard of the intake screens, and monitored readings are taken in the discharge canal. Residual chlorine is typically detected approximately 5 minutes into the cycle. Condenser chlorination is usually conducted only when both circulating water pumps are running.

Prior to water flowing through either the cooling water pumps or the service water pumps, water passes through one of four 10-ft-wide traveling screens. The screens work to prevent small debris and small aquatic organisms from being entrained into the cooling water or service water systems. Each screen is constructed of 53 segments with ¼ in. by ½ in. stainless steel wire mesh. Each segment has a stainless steel lip that is used to lift debris and organisms and direct them into a fish-return sluiceway.

The traveling screens are not operated continuously but are operated during any of the following scenarios:

- When the difference in water level on each side of the screen reaches a specified threshold at an alarm set point. The threshold is typically set at 6 in. This level difference signifies that too much debris has collected on the screen. Level differences are rare and usually the result of a storm event.

- When there is an indication that fish are being impinged at a rate exceeding 20 fish per hour, at which time the traveling screens are turned continuously until the impingement rate drops below 20 fish per hour for two consecutive sampling events. Each impingement sampling event is conducted for a minimum of 30 minutes, 3 times per week.

- During marine life monitoring. The screen wash, which occurs during screen rotations, is scheduled for eight hours prior to each of the three weekly sampling events.

- During hypo-chlorination, which occurs each day for two hours when the main cooling water system is chlorinated inboard of the trash rack to control fouling.

- Whenever water temperatures are less than 30 degrees Fahrenheit (°F).

- At a minimum, once per each 12-hour shift. This usually occurs at the beginning and end of each shift, and will usually last for a few hours.

On average, the traveling screens rotate 3 to 4 times each day. The screens normally operate at 5 fps, but can be accelerated to 20 fps during storm events that are causing extreme debris loading.

The screens are washed when they are in operation, using a dual-level spray wash. Service water is used as the source for the spray wash. Sodium thiosulfate is added to the wash water to remove chlorine and protect organisms returned to the intake embayment. The screens are washed from the side that faces the approaching flow at the splash housing, which is located about 46 ft above the bottom of the intake structure. Low-pressure spray, about 20 psi, removes light fouling and organisms from the screen. Subsequently, a high-pressure wash, about 100 psi, is applied to remove heavy fouling. The low- and high-pressure spray nozzles are about 18 to 24 in. apart. The screen rotation rate is kept slow during high impingement events.

Impinged fish are washed into a seamless concrete fish-return sluiceway and usually returned to the intake embayment approximately 300 ft east of the intake structure. The original west sluiceway was installed in 1972 and was connected to the discharge canal. In 1979, the east sluiceway was installed and connected to the intake embayment. During storms, the wash is discharged via the original sluiceway to the discharge canal. An interchangeable baffle plate is utilized to divert the flow to one sluiceway or the other from the screenhouse. The baffle plate directs organisms and debris; however, some water flows over this structure and into the alternate sluiceway. The new sluiceway was designed to maintain a minimum 6-in. depth and a water velocity of less than 8 fps and is covered with galvanized wire screen. Though there are several turns in the sluiceway, none appear to be greater than 23 degrees. The discharge point of the east sluiceway is at the mean low water (MLW) level. On occasion, the end of the east sluiceway has been seen above the water level, causing an actual "free fall" scenario. The west sluiceway discharge is above the MLW level in the discharge canal.

Under normal operation, seawater is heated in the condensers to approximately 27 to 30°F above the intake temperature. This is within the plant's National Pollutant Discharge Elimination System (NPDES) permit, which allows for as much as a 32°F temperature change. With the cooling water flow being relatively constant at 311,040 gpm (693 cfs) throughout the year, the discharge temperature is almost entirely a function of the intake water temperature. From the condensers, water flows through buried concrete conveyance to the discharge canal. The conveyance consists of 235 ft of a 13-ft-by-17-ft reinforced concrete box culvert, followed by 250 ft of a concrete pipe that is 10.5 ft in diameter.

Three to five times each year, the plant is reduced to 50 percent power, and a thermal backwash is conducted to control biological fouling. During the backwash, water is heated to about 105°F, and two of the four traveling screens are rotated in reverse, allowing heated, non-chlorinated seawater from the condensers to flow back over the screens and to the intake embayment. The treatment is maintained for about 35 minutes. Scheduling of the thermal backwash treatments is coordinated with the highest tide to achieve maximum coverage, preventing mussels from growing in the upper elevations of the intake structure.

Upon exiting the concrete pipe, discharged water enters a 900-ft-long trapezoidal discharge canal separated from the intake embayment by a breakwater. The discharge canal was created by two breakwaters that are oriented perpendicular to the shoreline, one of which is shared with the intake embayment. The channel sides are sloped at a 2:1 horizontal-to-vertical ratio. The bottom is 30 ft wide at an elevation of 0 ft MLW, or 4.8 ft below MSL. The channel bottom remains at this elevation until it converges with the shore, which has a slope of approximately 40:1 at the channel mouth. At low tide, the water in the discharge canal is several feet higher than sea level, and the discharge is rapid and turbulent (estimated at 8.1 fps). At high tide, the velocity is much lower (estimated at 1.4 fps) because the cross sectional area of flow in the channel is greater. Discharge of the heated water creates a thermal plume in the nearshore area of PNPS. A detailed discussion of the extent and characteristics of this plume is presented in Section 4.1.3.

Dredging of the discharge canal has never been conducted. The intake embayment has been dredged twice, once in 1982 and again in the late 1990s. The purpose of dredging in the 1990s, though unsuccessful, was to bring colder water into the cooling water system. Each dredging event was individually permitted through the U.S. Army Corps of Engineers (USACE). The potential dredged material was tested as part of the permit application process, undergoing chemical, biological, and radiological analyses (see Section 2.2.5.2). The sediments were described as having no detected polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), or pesticides, and relatively low concentrations of petroleum hydrocarbons and heavy metals. Thus, they were considered to be Category One material under the Massachusetts Department of Environmental Protection (MDEP) dredged material classification guidelines and suitable for disposal (BSC Group 1996). Of the three potential categories of dredged material, a Category One classification has the lowest amount of contaminants. The dredged material was disposed of in open water, at the Massachusetts Bay Disposal Site, north of Boston. There are no current plans for future dredging of the discharge canal or the intake embayment at PNPS.

2.1.4 Radioactive Waste Management Systems and Effluent Control Systems

PNPS processing systems are designed and operated to meet the dose design objectives of Title 10 of the Code of Federal Regulations (CFR) Part 20 and 10 CRF Part 50, Appendix I ("Numerical Guides for Design Objectives and Limiting Conditions for Operations to Meet the Criterion 'As Low As is Reasonably Achievable' for Radiological Material in Light-Water-Cooled Nuclear Power Reactor Effluents"). Radioactive wastes produced as a by-product of plant operations are collected and treated within the liquid, gaseous and/or solid waste processing systems before they are released to the environment or shipped to offsite disposal facilities. Liquid and gaseous effluents containing radioactive materials are reduced to levels as low as reasonably achievable (ALARA) prior to release. All liquid and gaseous releases are monitored and controlled to ensure compliance with the authorized limits. The radionuclides removed from the liquid and gaseous processing systems are converted to a solid waste form and disposed with other generated solid radioactive wastes (Entergy 2006a).

Radioactive materials produced from the fission of uranium-235 and from neutron activation of metals in the primary coolant system are the main source of liquid, gaseous and solid radioactive waste. The radioactive fission products build up within the fuel and are contained within the sealed fuel rods; however, small quantities of fission products are released from the fuel rods into the reactor coolant under normal operating conditions. In addition, neutron activation of trace concentrations of metals contained within the reactor coolant, such as zirconium, iron, and cobalt, creates radioactive isotopes of these metals and these activation products also enter the radioactive waste processing stream (Entergy 2006a).

Treating and separating these radionuclides from gases and liquids and removing contaminated material from various reactor areas produces nonfuel solid wastes. Nonfuel solid radioactive waste consists of contaminated tools and equipment, components removed from service, solidified liquid waste, and spent filtration media. It also includes dry active waste such as contaminated protective clothing, paper, rags and other trash generated from plant operations, during design modification, and during routine maintenance activities. Some solid waste is temporarily stored on-site prior to disposal off-site at a licensed disposal facility (Entergy 2006a).

Spent fuel solid waste consists of reactor fuel assemblies that have exhausted a certain percentage of their fissile fuel material. Spent fuel assemblies are removed from the reactor core and replaced by fresh fuel during routine refueling outages, typically every 24 months. These spent fuel assemblies are stored on-site in the spent fuel pool in the reactor building (Entergy 2006a).

The site's PNPS Offsite Dose Calculations Manual (ODCM) specifies radioactive waste sampling and analysis requirements and describes the methods used for calculating the concentrations of radioactive material in effluents and the estimated offsite doses. The ODCM also provides guidelines for operating radioactive waste treatment systems and instrumentation in a manner so as to attain offsite doses that are ALARA (Entergy 2003c). Radioactive Effluent and Waste Disposal (REWD) Reports for 2001 through 2005 were reviewed by the Staff (Entergy 2002b, 2003b, 2004b, 2005b, 2006c). These data were used to develop information for a representative year for capacity factors and operational events that impact the volume and activity of liquid, gaseous, and solid waste.

2.1.4.1 Liquid Waste Processing Systems and Effluent Controls

The function of the liquid radioactive waste system is to collect, treat, store, and/or dispose of all radioactive liquid wastes. Liquid waste is collected in sumps and drain tanks at various locations throughout the plant and is then transferred to the appropriate receiving tank for processing. The liquid radioactive waste control system is designed to segregate and then process liquid radioactive waste from various sources separately. The liquid radioactive waste is classified, collected, and processed as either clean (liquids having a varying amount of radioactivity and low conductivity), chemical (liquids having low concentrations of radioactive impurities and high conductivities), or miscellaneous radwastes (liquids having a high detergent or contaminant level, but with a low radioactivity concentration) (Entergy 2006a).

Very low levels of radioactivity may be released in plant effluents if they meet the limits specified in the U.S. Nuclear Regulatory Commission (NRC) regulations. These releases are closely monitored and evaluated for compliance with NRC restrictions in accordance with the PNPS ODCM (Entergy 2003c).

Clean liquid radioactive waste is collected from the equipment drain sumps located in the drywell, the reactor building, the turbine building, the radioactive waste building, and the retention building. The liquid wastes are then transferred to the clean waste receiver tank for processing. The clean waste receiver tank also receives resin transfer water and ultrasonic resin cleaner flush water. Flatbed filters and/or a mix of demineralizer, TherMix ®, and/or radwaste filter demineralizers are used to treat the clean liquid radioactive waste prior to its collection in the treated water holding tanks. Liquid waste within the holding tanks is sampled and analyzed and usually returned to the condensate storage tanks or the main condenser hot well for reuse within the facility. If the analysis of the clean liquid waste indicates high contaminants or high radioactivity, the clean liquid waste may be reprocessed. Clean liquid waste with abnormally high conductivity may be reprocessed in the chemical waste system or evaluated for controlled release into the circulating water discharge canal through the liquid radioactive waste header (Entergy 2006a).

Chemical liquid radioactive wastes are collected from the floor drain sumps of the drywell, reactor building, turbine building, radioactive waste building, and the retention building. Collected liquid wastes are primarily from minor equipment leaks, tank overflows, equipment drains, and floor drainage. The liquid wastes are automatically transferred to the chemical waste receiver tanks when the sump is filled to a preset level. After decay and storage, the chemical liquid wastes are evaluated for discharge or reprocessing (Entergy 2006a). Miscellaneous liquid radioactive wastes are collected from floor drains within the turbine washdown area, personnel decontamination areas, fuel cask decontamination area, reactor head washdown area, truck decontamination area, machine shop wastes, and retube building decontamination area. Miscellaneous liquid radioactive wastes primarily consists of water collected from equipment washdown and decontamination solution wastes, radiochemistry laboratory solution wastes, miscellaneous water waste, and personnel decontamination waste. The wastes are sampled and analyzed for radioactivity to evaluate them for controlled release or for transfer to the chemical waste receiver tank for reprocessing.

If it is determined that the liquid radioactive waste meets the ODCM criteria for controlled release, it can be discharged on a controlled basis into the circulating water discharge canal through the liquid radioactive waste discharge header. As the liquid waste passes through the discharge header, the radioactivity level is continuously monitored. Accidental discharge is protected against by instrumentation for detection and alarm of abnormal conditions and administrative controls. The radioactivity level is monitored during the discharge; the discharge is automatically terminated if the activity exceeds preset levels (Entergy 2006a).

A review of the liquid effluents reported in the annual PNPS REWD Reports for the years 2001 through 2005 (Entergy 2002b, 2003b, 2004b, 2005b, 2006c) was performed to estimate the annual releases that would be expected during the license renewal period. No liquid releases were made in 2004 or 2005; the largest liquid releases during this five-year period occurred in 2003. There were 11 batch discharges of liquid effluents in 2003 containing a total of 0.02 Ci of fission and activation products and 38 Ci of tritium. All liquid discharges were well within the NRC regulatory limits. No significant increases in liquid waste effluents are expected during the license renewal term.

During this 5-year period, PNPS initiated an aggressive liquid radioactive waste management program to reprocess and reuse water. The REWD Report for 2002 notes that liquid effluent releases were significantly lower than in past years (Entergy 2003b). The REWD Reports for 2004 and 2005 recorded zero liquid releases (Entergy 2005b, 2006c).

See Section 2.2.7 for a discussion of the theoretical doses to the maximally exposed individual as a result of liquid effluent releases.

2.1.4.2 Gaseous Waste Processing Systems and Effluent Controls

The sources of gaseous releases from PNPS are the 330-ft plant stack, the reactor building vents, and the turbine building vents. The sources of releases to the stack are the main condenser steam jet air ejectors, the gland seal off-gases, and the exhausts from the augmented off-gas (AOG) charcoal absorber building, the radioactive waste building ventilation system, and the mechanical vacuum pumps during startup. The releases from the reactor building and turbine building vents are from steam leakage through valve stems, pump seals, and flanged connections within these areas. The PNPS ventilation systems are designed to maintain gaseous effluents to levels ALARA by a combination of holdups for decay of short-lived radioactive material, filtration, and monitoring (Entergy 2006a).

Non-condensible gases from the main condenser air ejectors, the startup mechanical vacuum pumps, and the gland condensers are processed through the air ejector and AOG system. The AOG system also controls recombination of radiolytic hydrogen and oxygen that are continuously removed from the reactor coolant to maintain turbine efficiency. After recombination, the off-gas is routed to a condenser to remove moisture, and then through a 30-minute delay pipe before entering the AOG charcoal absorber system. AOG charcoal absorbers provide for holdup of krypton and xenon radioactivity. The holdup time allows decay of the short-lived radioactive material which reduces the concentration of these materials such that the site boundary concentration of gaseous effluent is maintained ALARA (Entergy 2006a).

The noncondensable exhaust from the main turbine gland seal condenser is collected and processed by the gland seal holdup system. Saturated air-water vapor mixture with trace amounts of hydrogen, oxygen, and radioactive gases are exhausted from the turbine generator gland seal condenser. The exhaust enters into a 16-in. diameter holdup line and is delayed for approximately 1.75 minutes. The effluent is routed to the main stack and mixed with the AOG system effluent for discharge through the main stack (Entergy 2006a).

These streams are ultimately exhausted through the main stack. Two full capacity fans located at the base of the main stack are designed to thoroughly mix all of the gas inlet streams and to facilitate accurate radiation monitoring of the effluent (Entergy 2006a). This approach minimizes release points to the environment, provides for continuous monitoring of the effluent, and takes advantage of additional atmospheric dispersion (Entergy 2006a).

Ventilation from the administration building, machine shop, battery room and lube oil compartments, recirculation pump motor-generator set area, diesel generator building, and reactor auxiliary bay are listed as having negligible potential for the release of radioactive effluents. Ventilation from the turbine building operating floor and switchgear area are classified as having a low potential for release with airborne radiation concentration levels being monitored by the turbine building effluent monitoring system (Entergy 2006a).

Primary containment venting, steam leakage outside the primary containment, hood vents, and high pressure coolant injection testing are potential sources of low-level radioactive contaminants at PNPS. Gaseous effluents from these areas are monitored and discharged through either the main stack or the reactor building exhaust vent. The ventilation systems from these areas are designed to exhaust the air through process radiation monitoring equipment (Entergy 2006a).

Gaseous effluents were reported in the PNPS REWD Reports for the years 2001 through 2005 (Entergy 2002b, 2003b, 2004b, 2005b, 2006c). During this 5-yr period, the average annual releases of gaseous radioactive effluents were as follows:

- 90.0 Ci/yr of noble gases
- 1.69×10^{-3} Ci/yr of radioiodines
- 1.22×10^{-3} Ci/yr of beta and gamma emitters as particulates
- 435 Ci/yr of tritium

All gaseous discharges were well within the NRC regulatory limits. No significant increases in gaseous waste effluents are expected during the license renewal term.

See Section 2.2.7 for a discussion of the theoretical doses to the maximally exposed individual as a result of gaseous releases.

2.1.4.3 Solid Waste Processing

The solid waste processing system processes both wet solid wastes (reactor cleanup sludge; spent resins and charcoal from radwaste, spent fuel pool, and condensate demineralizers; and TherMix ® and radwaste filter/demineralizer) and dry solid waste (rags, paper, small equipment parts, and solid laboratory wastes). Solid waste is processed at the radwaste building, the radwaste trucklock, low level radwaste storage facility (LLRWSF) and/or the trash compaction facility (Entergy 2006a).

Solid waste is segregated, separated, consolidated, and analyzed for disposal in the trash compaction facility hazardous material area. The LLRWSF is utilized for interim storage for up to 5 years of solid radioactive waste and for temporary storage of bulk dewatered waste for shipment to a processing facility. Dewatered solid wastes are contained in high integrity containers and are placed in cylindrical, concrete storage modules within the LLRWSF. Dry radioactive waste are contained in steel containers and are stored in rectangular, concrete storage modules within the LLRWSF (Entergy 2006a).

Disposal and transportation of radioactive waste at PNPS are performed in accordance with the U.S. Nuclear Regulatory Commission (NRC) and U.S. Department of Transportation (DOT) requirements. The amount and type of solid radioactive waste generated and shipped from PNPS varies from year to year (Entergy 2006a). Based on a review of the PNPS REWD Reports for the period 2001 through 2005, the annual average of solid radioactive waste shipped from PNPS was 698 m^3/yr containing 725 Ci/yr (Entergy 2002b, 2003b, 2004b, 2005b, 2006c). No significant increases in radioactive waste shipments are expected during the license renewal term.

2.1.5 Nonradioactive Waste Systems

The principal nonradioactive waste streams from PNPS consist of heating boiler blowdown, filter backwash, sludges and other wastes, floor and yard drains, and stormwater runoff. Nonradioactive waste streams are produced from plant maintenance and cleaning activities. Nonradioactive wastes, specifically chemical and biocide wastes, are also produced while controlling the pH in the coolant, controlling scale and corrosion and while cleaning the main condenser. Nonradioactive waste liquids are generally discharged with the cooling water discharges. An onsite septic system collects the sanitary wastewater, which is transferred to an onsite wastewater treatment facility and discharged to a leach field in accordance with the Groundwater Discharge Permit # 2-389 issued by MDEP.

During operation of the oil-fired boilers, nonradioactive gases are discharged to the atmosphere. By limiting fuel usage and hours of operation of the oil-fired boilers, emissions of regulated pollutants is within the MDEP's air quality standards (Entergy 2006a).

Entergy has a corporate policy and a plan for waste minimization at its nuclear power plants, including PNPS (Entergy 2006a). The plan provides a hierarchy of waste minimization options that emphasize (1) source reduction, (2) resuse/recycling, (3) treatment to reduce volume and/or toxicity, and (4) disposal, in that order. It is expected that Entergy would continue to maintain and implement its waste minimization policy and plan during the license renewal period at PNPS.

2.1.6 Plant Operation and Maintenance

PNPS utilizes various programs and activities to maintain, inspect, test and monitor the performance of plant equipment and to manage aging effects. The programs and activities are implemented to comply with the requirements of 10 CFR Part 50, Appendix B (Quality Assurance), Appendix R (Fire Protection), and Appendices G and H, Reactor Vessel Materials; 10 CFR Part 50.55a, American Society of Mechanical Engineers (ASME) Code, Section XI, In-service Inspection and Testing; 10 CFR Part 50.65, the maintenance rule, including the structures monitoring; and to maintain water chemistry (Entergy 2006a).

Some programs and activities are performed during the operation of the nuclear unit, while others are performed during scheduled refueling outages. Additional programs are implemented in response to NRC generic communications and to meet technical specification surveillance requirements.

2.1.7 Power Transmission System

As presented in Table 2-1, the applicant identified two 345-kilovolt (kV) transmission lines, the 342 line and the 355 line, that connect PNPS to the power grid. The two lines share a single 300-ft-wide ROW that extends from the PNPS switchyard approximately 5.0 mi to the Jordan Road Tap and then an additional 2.2 mi to the Snake Hill Road substation (Entergy 2006a; AEC 1972) (Figure 2-6). Over its 7.2-mi length, the ROW covers approximately 260 ac. The transmission line ROW does not cross any State or Federal parks, wildlife refuges, or wildlife management areas (Entergy 2006a), nor does it cross any major lakes, ponds, or streams. However, the transmission line ROW crosses a small stream near Old Sandwich Road.

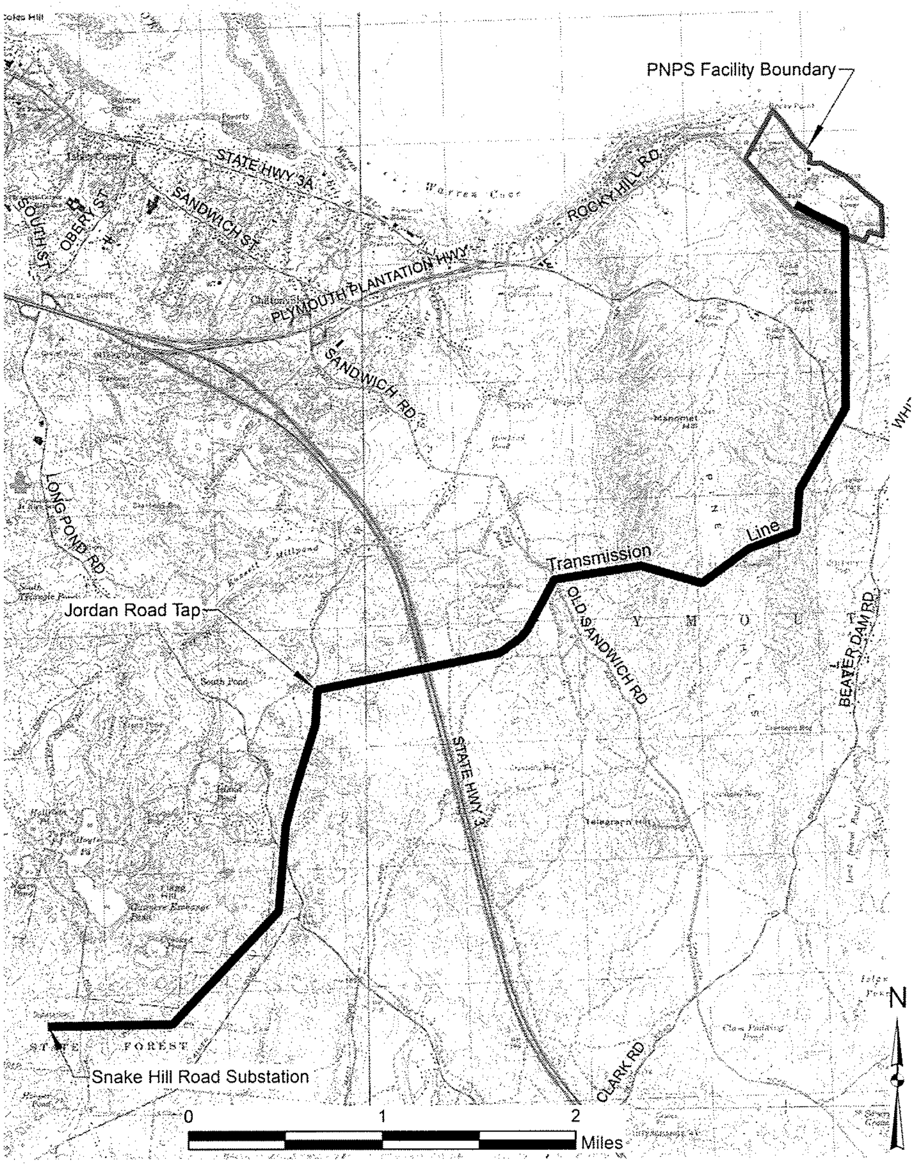

Figure 2-6. PNPS Transmission Line ROW

Table 2-1. PNPS Transmission Line ROWs

Destination	Line	Number of lines	kV	Approximate Distance		ROW Width		ROW Area	
				km	**(mi)**	**m**	**(ft)**	**hectares**	**acres**
PNPS to Jordan Road Tap	342,355	2	345/ line	8.05	5	91.4	300	73.6	181.8
Jordan Road Tap to Snake Hill Road Substation	342,355	2	345/ line	3.5	2.2	91.4	300	32.3	80.0
Total				11.6	7.2			105.9	261.8

Source: Entergy 2006a

Entergy does not own, operate, or maintain the PNPS-to-Snake Hill Road ROW or transmission lines. The lines are owned and maintained by NSTAR, which provides electricity and natural gas to businesses and residents in eastern Massachusetts (Entergy 2006a; NSTAR 2006). NSTAR maintains the transmission line ROW in accordance with a Vegetation Management Plan (NSTAR 2006) approved by the Massachusetts Department of Agricultural Resources and the Natural Heritage and Endangered Species Program (NHESP). Under this plan, NSTAR maintains the PNPS ROW from the station to the Snake Hill Road substation, as well as the rest of their system, using an integrated vegetation management program. The ROW is managed by NSTAR to encourage the natural development of low-growing woody shrubs and herbaceous plant communities while controlling tall-growing trees and undesirable shrub species that may interfere with the operation of the transmission lines.

2.2 Plant Interaction with the Environment

Sections 2.2.1 through 2.2.8 provide general descriptions of the environment near PNPS as background information. They also provide detailed descriptions where needed to support the analysis of potential environmental impacts of operation during the renewal term, as discussed in Sections 3 and 4. Section 2.2.9 describes the historic and archaeological resources in the area, and Section 2.2.10 describes possible impacts associated with other Federal project activities.

2.2.1 Land Use

The PNPS facility occupies 140 ac, located northeast of Rocky Hill Road. The site includes a central developed area surrounded by a security fence that contains the generating facilities, switchyard, warehouses, office buildings, and parking lots. The remainder of the site, surrounding the developed area to the north, west, and south, is primarily undeveloped and wooded. The Cape Cod Bay shoreline borders the site to the east. The properties along the shoreline north and south of the site, which also are situated between Rocky Hill Road and the bay, are residential except for the parcel immediately north of the site, which is used for nonprofit/conservation purposes. PNPS is located in the Town of Plymouth and Entergy has a payments in lieu of taxes (PILOT) agreement with the Town. The site is zoned LI/Light Industrial by the town. The parcels immediately north and south of the site are zoned RR/Rural Residential[a].

Entergy also owns a large tract of undeveloped land, over 1530 ac, located predominantly across Rocky Hill Road south and west of the 140-ac PNPS site. The majority of this property has been placed in a forest land trust under Chapter 61 of the General Laws of Massachusetts, Classification and Taxation of Forest Lands and Forest Products. The majority of this woodlands property is zoned RR/Rural Residential; a small portion east of Power House Road is zoned R-25/Residential[b]. The Entergy-owned property boundary, including the PNPS site and the woodlands tract, is shown in Figure 2-3.

A 300-ft-wide transmission line ROW, containing two transmission lines built to connect PNPS to the power grid, runs from the PNPS site to the Snake Hill Road substation approximately 7.2 mi to the southwest (Entergy 2006a; AEC 1972). The corridor extends from the PNPS switchyard, crosses Rocky Hill Road, and traverses almost 2 mi within the Entergy woodlands and along its southeastern property boundary. The corridor then turns west, leaving the Entergy woodlands property, and continues southwest approximately 5 mi to where it connects to a previously existing corridor. Lands traversed by the transmission lines ROW are primarily undeveloped woodland and are zoned RR/Rural Residential by the Town of Plymouth. At its southern end, approximately 1.3 mi of the corridor are within Myles Standish State Forest.

PNPS is within Massachusetts's coastal zone for purposes of the Coastal Zone Management Act. Section 307(c)(3)(A) of the Coastal Zone Management Act [16 USC 1456(c)(3)(A)] requires that applicants for federal licenses to conduct an activity in a coastal zone provide to the licensing agency a certification that the proposed activity is consistent with the enforceable policies of the State's coastal zone program. A copy of the certification is also to be provided to

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(a) The RR zoning district has a minimum lot size of 120,000 ft^2 (Rural Residential). (Town of Plymouth 2004c).

(b) The R-25 district has a minimum lot size of 25,000 ft^2 (Medium Lot Residential).

the State. Within six months of receipt of the certification, the State is to notify the Federal agency whether the State concurs with or objects to the applicant's certification.

Entergy's certification that renewal of the PNPS license would be consistent with the Massachusetts coastal zone management program is provided in Attachment D of its Environmental Report (Entergy 2006a), which was submitted on January 27, 2006, as part of the license renewal application for PNPS. Correspondence related to the certification is in Appendix E of this SEIS. By letter dated July 11, 2006, the Massachusetts Office of Coastal Zone Management concurred with the applicant's consistency certification.

2.2.2 Water Use

Cape Cod Bay, with a surface area of approximately 430 square nautical mi, or about 365,000 ac, is the source of cooling and service water for PNPS. The facility uses a once-through cooling system in which seawater is withdrawn from the bay via an embayment formed by two breakwaters and is discharged into a 900-ft-long discharge canal immediately adjacent to the intake embayment. The intake structure provides 311,000 gpm of condenser cooling water and can provide up to 13,500 gpm of cooling water to the service water system.

As designated in the PNPS NPDES Permit Number MA003557 (Federal) and Number 359 (State), the monthly average and daily maximum discharge limitations for condenser cooling water (outfall no. 001) are 447 million gallons per day (mgd) and 510 mgd, respectively (EPA 1994). The monthly average discharge limitation for service cooling water (outfall no. 010) is 19.4 mgd (there is no daily maximum limitation specified in the NPDES permit). According to the applicant's April 2005 to March 2006 Discharge Monitoring Reports (DMRs) for the NPDES permit, flow for both the condenser and service cooling water systems did not exceed the permit requirements during that time period (Entergy 2006d).

The PNPS facility obtains its potable and reactor makeup water from the Town of Plymouth municipal water system (Entergy 2006a). The town water supply is derived solely from groundwater. Estimated annual potable water consumption for a non-outage year at PNPS is approximately 39.1 million gallons per year or 74.4 gpm (Town of Plymouth 2004b). The usage represents approximately 2.3 percent of the town's total yearly consumption (Town of Plymouth 2004a). There is no direct groundwater use at the PNPS facility. The site has one groundwater well (installed in 2000), which has been used in the past for irrigation purposes only. The well is no longer in use and it is not anticipated that the well will be returned to service at anytime in the future (Entergy 2006a). The Town of Plymouth Water Division obtains its drinking water supply from 10 groundwater wells at nine locations throughout the town. The Plymouth-Carver aquifer, which provides water for Plymouth and neighboring communities, is composed of saturated glacial sand and gravel. The aquifer is designated by EPA as a Sole Source Aquifer, the second largest in Massachusetts. This aquifer provides at least 50 percent of the communities' water supply (Town of Plymouth 2006a).

2.2.3 Water Quality

2.2.3.1 Surface Water

Pursuant to the Federal Water Pollution Control Act [also known as the Clean Water Act (CWA)], PNPS effluent discharges are regulated by a NPDES permit. EPA Region I administers the NPDES permit program in Massachusetts. The NPDES permit was issued to PNPS on April 29, 1991, and the current NPDES permit (which is a modification of the permit issued in 1991) was issued August 30, 1994 (Federal Permit Number MA0003557) in conjunction with the Commonwealth of Massachusetts (Massachusetts Permit Number 359) (EPA 1994). A provision of the CWA allows facilities to continue to operate under an expired permit provided the permittee makes a timely renewal application. The PNPS NPDES permit, which expired April 29, 1996, remains in effect while EPA Region I and the Commonwealth review Entergy's application for renewal of the permit. The quantitative effluent limitations regulated under the PNPS NPDES permit are shown in Table 2-2.

Based on a review of the discharge data presented in the applicant's April 2005 to March 2006 monthly DMRs for the PNPS facility, an effluent limitation was outside of the permit requirement on three occasions. During April 2005, there was one permit exceedance. Analytical results for total suspended solids of 38.2 milligrams/liter (mg/L) at stormwater outfall 007 exceeded the monthly average limit (30 mg/L), but not the daily maximum limit (100 mg/L). The DMR attributed this to the unusually large amount of road sand used that winter. On one occasion in January 2006 and another in February 2006, there was a problem with the screenwash dechlorination system (outfall 003) in which chlorine was detected in the screenwash sluiceway.

In each instance, one of the dechlorination pumps was not pumping adequately. One pump was repaired and the other replaced, and the system was restored to normal operation. These exceedances were not significant enough to result in issuance of a Notice of Violation (NOV) by EPA (Entergy 2006d).

2.2.3.2 Groundwater

According to the April 26, 1999, MDEP Groundwater Discharge Permit (Southeast Region, Permit #2-389), the PNPS sanitary wastewater treatment facility is authorized to discharge treated wastewater effluent into a leach field in compliance with specified discharge limitations (MDEP 1999). Groundwater flow at this site is toward Cape Cod Bay (Entergy 2006a). The parameters regulated under the MDEP groundwater discharge permit are shown in Table 2-3.

Table 2-2. Effluent Limitations - NPDES Permit for PNPS

	Flow (mgd)		Total Residual Oxidants (mg/L)		Max. Temp. (°F)		Temp. Rise (°F)		Total Suspended Solids (mg/L)		Oil and Grease (mg/L)		pH
Outfall No.(Outfall Description)	Avg. Monthly	Max. Daily	Avg. Monthly	Max. Daily	Avg. Monthly	Max. Daily	Avg. Monthly	Max. Daily	Avg. Monthly	Max. Daily	Avg. Monthly	Max. Daily	
001 (Condenser Cooling Water)	447	510	0.1	0.1	NA	102	NA	32	NA	NA	NA	NA	0.5 units*
002 (Thermal Backwash for Bio-fouling Control)	NA	255	NA	NA	NA	120	NA	NA	NA	NA	NA	NA	0.5 units*
003 (Intake Screen Wash)	4.1	4.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.5 units*
004,005,006,007 (Yard Drains)	NA	NA	NA	NA	NA	NA	NA	NA	30	100	NA	15.0	6.0 to 8.5
008 (Sea Foam Suppression)	0.73	0.73	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.5 units*
010 (Service Cooling Water)	19.4	NA	0.50	1.00	NA	NA	NA	NA	NA	NA	NA	NA	NA
011 (Makeup Water and Demineralizer Waste Discharge)	0.015	0.06	NA	NA	NA	NA	NA	NA	30	100	NA	NA	6.1 to 8.4

*For these outfalls, the pH shall not be greater than or less than 0.5 standard units of the influent.
There is no Outfall No. 009 (number 009 was not assigned).
Source: EPA 1994.

Table 2-3. Effluent Limitations – MDEP Groundwater Discharge Permit for PNPS Wastewater Treatment Facility

Effluent Characteristic	Discharge Limitation
Flow (gallons/day)	37,500 daily average
Biochemical Oxygen Demand, 5-day @ 20°C	30.0 mg/L
Total Suspended Solids	30.0 mg/L
Chloride	250.0 mg/L
Oils and Greases	15.0 mg/L
Total Dissolved Solids	1000 mg/L
pH	6.5 to 8.5

Source: MDEP 1999

Based on a review of the groundwater data presented in the applicant's January 2005 to March 2006 monthly DMRs for the facility, two effluent limits were exceeded over a three-month period. During January, February, and March 2005, total dissolved solids (TDS) and chloride concentrations exceeded the permit limits. The TDS effluent limit of 1000 mg/L was exceeded by 100 to 400 mg/L, and the chloride limit of 250 mg/L was exceeded by 10 and 80 mg/L. In order to determine the source of these elevated TDS and chloride levels in the treated wastewater effluent, PNPS sampled all three lift stations and the raw water coming into the facility. The conclusion was reached that runoff containing road salt, which was used extensively due to adverse weather conditions, as well as softener chemicals from the cafeteria may have contributed to the high readings over those months. During May 2005, TDS exceeded the permit limit by 100 mg/L, which was attributed to a contaminated sample. These exceedances were not significant enough to result in issuance of an NOV by MDEP (Entergy 2006e).

A site contamination assessment was conducted for PNPS in 1999. This assessment was performed to identify any radioactive contamination in the vicinity of the PNPS facility. The types of samples collected include shallow soil samples, deep soil samples, catch basin sediment samples, and groundwater samples. Analytical results from these samples indicate that radioactive contamination in the vicinity of the process buildings is minimal and, thus, would not pose any significant effect on decommissioning efforts. In compliance with 10 CFR Part 50.75(g)(1) recordkeeping requirements, PNPS maintains a file that documents spill events at the facility and describes associated remediation and any residual concentrations remaining.

Information in this file was used to guide the sampling for the site contamination assessment (Boston Edison 1999).

Impacts to site groundwater were evaluated after more than 15,000 gallons of transformer oil were spilled from the main transformer at the PNPS site in March 1997. A response action was conducted in 1997, and a completion and outcome statement was subsequently prepared for submittal to MDEP. It documents the details of the release and cleanup, provides the analytical results of the soil and groundwater samples collected, and presents the results of the risk characterization conducted at the affected area. Total petroleum hydrocarbons (TPH) and extractable petroleum hydrocarbons (EPH) were detected above screening criteria in subsurface soil samples collected from the area around the transformer. Contaminated trap rock and soil were excavated and removed from the site, and soil samples were collected to confirm removal of the source of contamination. Analytical results indicated that elevated concentrations of select EPH carbon chains and TPH remained in the soil. Three rounds of groundwater samples were collected in the vicinity of the transformer following the removal of trap rock and soil. EPH were detected above screening criteria in September 1997; however, no exceedances were detected in the April or December 1997 samples. A risk characterization was conducted for soil and groundwater to determine the level of risk to human health, safety, welfare, and the environment at the PNPS site based on the transformer oil spill. Despite the elevated concentrations of contaminants present, the risk characterization determined that a condition of no significant risk of harm exists at the site. In addition, a background feasibility evaluation was conducted, which determined that it is technologically infeasible to remediate the impacted soil to background levels. Based on the results of the risk characterization and the background feasibility evaluation, the response action was considered complete (RAM Environmental 1998).

2.2.4 Air Quality

PNPS is situated on the western shoreline of Cape Cod Bay in Plymouth, Massachusetts on a ridge of low hills running in a north-south direction reaching a height of 395 ft. Approximately 60 percent of the area within a 50-mi radius is open water (AEC 1972). Thus, the site has a continental climate influenced by the sea. In these mid latitudes of the United States (U.S.), the weather is influenced mostly by large-scale air masses and storm systems which enter the area from southwesterly through northwesterly directions. The prevailing winds are likely to be from the west, with a northwest component in the winter and spring, tending to be more southwesterly during the remainder of the year (NOAA 2004).

The average annual temperature at Plymouth is 50° F with a high monthly average of 71° F in July and monthly average of 27° F in January (Entergy 2006a). The Atlantic Ocean moderates the climate on local scales, with air temperatures along the coast being less extreme than those inland. For example, western Massachusetts is generally colder than the eastern part of the state. In the west, Pittsfield averages 68° F in July and 21° F in January. Worcester, in the central portion of the state, has a July average of 70°F and a January average of 24°F. The highest temperature ever recorded in the state was 107°F at New Bedford and Chester, on August 2, 1975. The lowest recorded temperature, -35°F, occurred at Chester on January 12, 1981 (World Book 2006).

Hurricanes occasionally strike New England from the south and deliver strong winds and heavy rains to these coastal locations in the summer and autumn months. Destructive hurricanes hit the state in 1938, 1944, and 1945. Tornado activity in eastern Massachusetts is uncommon. The relatively warm ocean waters off the east coast in winter can provide the energy for extra tropical cyclones, many producing "northeasters" in the winter and spring, leading to strong winds and heavy precipitation. Thunderstorms occur in the late spring and summer. Monthly averages for precipitation at Plymouth vary from about 3 to 4.5 in. Although snowfall amounts typically average 42 in. per year, the Plymouth area is subjected to a wide range of snowfall since it is located in the northeastern part of the U.S. The State's precipitation (rain, melted snow, and other forms of moisture) ranges from approximately 47 in. a year in the west to about 43 in. near the east. From 55 to 75 in. of snow falls in the western mountains each year. The central part of the State averages about 49 in. a year and the coastal area about 42 in. (World Book 2006).

PNPS is within the MDEP Southeast Region. Ozone is the only pollutant for which Massachusetts monitors indicate violation of the National Ambient Air Quality Standards. Massachusetts is in attainment for the other pollutants, including carbon monoxide, lead, nitrogen dioxide, sulfur dioxide, and particulate matter with a mean aerodynamic diameter of less that 10 micrometers (PM_{10}) and less than 2.5 micrometers ($PM_{2.5}$). The term “attainment” means that the State-run ambient air quality network has verified that the air quality for various pollutants is within established EPA Standards. Likewise, the term “non-attainment” is used to indicate instances wherein key pollutants demonstrated monitoring values that exceed the EPA Standards. Massachusetts has been in attainment for sulfur dioxide, nitrogen dioxide, and lead based on decades of monitoring. With the adoption of numerous control programs, Massachusetts has been in attainment for carbon monoxide since 1986 and was redesignated as "in attainment" for carbon monoxide in 2002 (MDEP 2005).

Massachusetts has been classified as in "serious non-attainment" for the 1-hour ozone standard since the early 1990s. However, with greater controls there has been a reduction in the severity of the 1-hour exceedances. Massachusetts has been designated as being in "moderate non-attainment" of the 8-hour ozone standard (EPA 2004).

There are no designated Class I Federal areas within a 50-mi radius of PNPS. The closest non-attainment area for particulate matter is New Haven, Connecticut, approximately 135 mi from PNPS. The closest non-attainment area for sulfur dioxide is Mansfield, New Jersey, approximately 250 mi from PNPS (EPA 2003).

PNPS has heating boilers and diesel generators located onsite. Emissions from these sources are regulated by an emissions cap approved by the MDEP in July 2005. This cap limits facility emissions to less than 50 percent of the major source category emissions.

2.2.5 Marine Aquatic Resources

2.2.5.1 Water Body Characteristics

Cape Cod Bay (Figure 2-1) is a large embayment in southeastern Massachusetts that is open to the north, and enclosed by the mainland to the west and Cape Cod to the south and east. The Commonwealth of Massachusetts has designated Cape Cod Bay as an Ocean Sanctuary, a status intended to protect the ecology and appearance of this area by prohibiting a variety of activities.

Cape Cod Bay constitutes the southern end of Massachusetts Bay and the Gulf of Maine. Cape Cod is a hook-shaped, glacially deposited peninsula whose northern tip extends about 6.2 mi north of PNPS. Cape Cod Bay is approximately 18.6 mi wide at the latitude of PNPS. The surface area of Cape Cod Bay is approximately 360,000 ac, and the volume is approximately 36 million ac ft (Stone and Webster 1975, in ENSR 2000).

Water depths in the vicinity of PNPS are typically 10 ft and up to 120 ft within 5 mi offshore of the site. The nearshore waters and coastline in the immediate vicinity of PNPS are shown in an aerial photograph in Figure 2-3. The nearshore depths to the north of PNPS average approximately 12 ft. The greatest depth, approximately 180 ft, occurs at the mouth of Cape Cod Bay. Approximately half of the surface area of Cape Cod Bay has depths greater than 100 ft (Stone and Webster 1975 in ENSR 2000), with depths increasing as the bay floor slopes toward deeper water at its northern connection with Massachusetts Bay and the Gulf of Maine.

The bottom is mainly unconsolidated sediment, finer in deeper waters than near shore (Bridges and Anderson 1984, in ENSR 2000). The sea floor in the vicinity of PNPS is generally sandy, with depths of approximately 21 ft offshore and to the south of PNPS. Two shallow rocky ledges bracket the PNPS area. One ledge extends northward from Rocky Point near the northern tip of the PNPS property. The other ledge also extends northward for several hundred meters from the vicinity of Manomet Point (ENSR 2000; Davis and McGrath 1984) (Figure 2-2).

The movement of water within Cape Cod Bay is controlled mainly by ocean circulation patterns, tidal fluctuations, and wind. These factors affect the hydrodynamics of the bay to varying degrees and result in currents that jointly control the exchange of water between Cape Cod Bay and the much larger Massachusetts Bay. The waters of Cape Cod Bay exchange with water from Massachusetts Bay through the processes of tidal exchange, the counterclockwise pattern of ocean circulation, and wind-induced motion. Tidal fluctuations largely control this exchange. The intertidal volume represents approximately 9.3 percent of the mean volume of the bay. The total bay flushing rate is approximately 7.2 percent per day, which corresponds to a mean residence time in Cape Cod Bay of 13.9 days (Stone and Webster 1975, in ENSR 2000).

Ocean currents in the vicinity of PNPS are generally toward the south and are part of the large-scale, counterclockwise circulation pattern within Massachusetts Bay. In contrast, tidal currents tend to rotate clockwise, completing one revolution per tide cycle (EG&G 1995, in ENSR 2000). Tide heights in Massachusetts Bay are predominantly semidiurnal with a typical range of 9.1 ft. The maximum tidal range at spring phase is 10.6 ft. At PNPS, the estimated average yearly maximum astronomical high tide is 11.7 ft MLW, and the estimated average yearly minimum astronomical low tide is 2.3 ft MLW (Stone and Webster 1975, in ENSR 2000).

Water temperatures in Cape Cod Bay fluctuate seasonally and due to processes such as upwelling, downwelling, and turbulence. Seasonal temperature variations are significantly greater near the surface of the bay than on the bottom, although seasonal climatic changes produce temperature stratification during the summer months. Generally, during the summer and early fall, bay temperatures exhibit a two-layer structure in which a very strong temperature gradient exists at the interface of the layers, with temperatures decreasing with increasing water depth. More gradual temperature changes generally occur over the entire depth of the water column within this two-layer structure (Stone and Webster 1975, in ENSR 2000).

Water temperature measurements have been collected by the Massachusetts Water Resource Authority (MWRA) in Boston Harbor, Massachusetts Bay, and Cape Cod Bay from 1989 through 2004. Over the 15-year period, temperatures have remained fairly consistent, ranging from approximately 2 degrees Celsius (°C) (35.6°F) (in mid-winter) to 22°C (71.6°F) (in mid-summer) in the near-surface water and approximately 3°C (37.4°F) (in mid-winter) to approximately 12°C (53.6°F) (in mid-summer) in the near-bottom water (Libby et al. 2006). Large fluctuations during the summer are typical, resulting from upwelling/downwelling fluctuations as well as short-lived wind-mixing events (Libby et al. 2006).

Salinity becomes vertically uniform throughout the water column during late winter. As the snow melts in the spring and surface water runoff increases, the fresh water enters the bay at the surface, and because it is less dense than saltwater, the fresh water stays at the surface. As a result of the relative decrease in surface water salinity, a density gradient develops. At the same time the additional solar warming increases the surface temperature and further enhances the density gradient (Libby et al. 2006).

Dissolved oxygen (DO) concentrations in the water column of Cape Cod Bay are highest during the winter and early spring when oxygen is well mixed throughout the water column. DO measurements have been collected throughout the Massachusetts/Cape Cod Bay system since

1992 by the MWRA (Libby et al. 2006). Monitoring results from this program indicate that the DO varies significantly throughout the year, with values in 2004 ranging from approximately 11 mg/L in March 2004 to a low of approximately 7.5 mg/L in Cape Cod Bay during early fall (Libby et al. 2006). In general, the DO at the bottom is 1 to 2 mg/L less than at the surface throughout the year (Galya et al. 1997 in ENSR 2000). This general cycle of mid-winter highs and early-fall lows has been repeated during each of the monitoring years and suggests a fairly regular pattern of steady decline through the period of increased algal production and a subsequent increase during destratification and reduced algal production (Libby et al. 2006).

2.2.5.2 Chemical Contaminants near PNPS

At the site audit in May of 2006, the NRC staff was informed that analytical data for surface water and sediment have not been collected regularly by Entergy or its predecessor, Boston Edison, at the PNPS facility. However, sediment has been collected and analyzed in support of a dredging permit application. Such data were collected from the cooling water intake embayment at PNPS on four occasions between October 1992 and July 1996. These analytical data are available in the report *Maintenance Dredging of Pilgrim Nuclear Power Station Intake Channel Report* (BSC Group 1996).

In 1992 and 1994, sediment samples were collected and analyzed for several physical and chemical parameters. Eight inorganics (cadmium, chromium, copper, lead, mercury, nickel, sodium, and zinc), the chloride ion, volatile organics, and total petroleum hydrocarbons were detected at relatively low concentrations based on comparison to MDEP dredging material classification guidelines. PAHs, pesticides, and PCBs were not detected in any sediment sample. Samples were also analyzed for radionuclides, and results indicated that the concentrations detected would not pose any significant risk. Results of this sampling indicated that sediment dredged from the PNPS intake embayment would be suitable for disposal at the Massachusetts Bay Disposal Site (MBDS) without bioassay or bioaccumulation testing of the samples (BSC Group 1996).

Sediment samples from the PNPS site were collected in 1996 to determine the environmental impacts of proposed dredge spoils on the marine benthic populations using toxicological and bioaccumulation tests. For comparison, control sediment samples were collected from a contaminant-free area of the Hampton Harbor, and reference sediment samples were collected outside the MBDS. Toxicological studies indicated that the PNPS intake embayment sediment had no impact on the survival of the mysid shrimp *Mysidopsis bahia*, tidewater silverside minnow (*Menidia beryllina*), the polychaete worm *Nereis virens*, or the bivalve clam *Macoma nasuta*.

These tests indicated that sediment from the intake embayment would have a significant impact on the survival of the amphipod *Ampelisca abdita* and the development of the larval stage of the blue mussel (*Mytilus edulis*). Bioaccumulation tests found no significant uptake of any of the parameters tested (cadmium, cobalt, cobalt-60, and mercury) in either *Macoma nasuta* or *Nereis virens* after exposure to the PNPS intake embayment sediment for 28 days (BSC Group 1996).

A follow-up study on the January 1996 toxicological and bioaccumulation study was conducted in July 1996 to assess potential acute impacts to the marine benthic populations exposed to dredged sediment from the PNPS intake embayment. Toxicological studies indicated that the sediment had a significant effect on the survival of the amphipod in only one location after 10 days exposure and that the observed toxicity in the previous tests may have resulted from ammonia levels unrelated to PNPS operations (BSC Group 1996).

Data are also available to evaluate overall contaminant distribution in Massachusetts Bay. As part of a study conducted by Shea et al. (1991), sediment chemical contaminant data from a total of 18 studies were compared. The studies included analytical results of metals, PAHs, PCBs, pesticides, and radionuclides in Massachusetts Bay sediments. The study concluded that Massachusetts Bay sediments were no more contaminated than those of other urban estuarine and coastal regions on the east coast, and that based on comparison of the observed data to the National Oceanic and Atmospheric Administration (NOAA) sediment toxicity effects levels, the sediments in Massachusetts Bay are healthy (Shea et al. 1991).

2.2.5.3 Biological Communities

The marine biological communities in the waters of Cape Cod Bay surrounding PNPS include fish, pelagic invertebrates, plankton, benthic invertebrates, marine aquatic plants, marine mammals, and Federally listed marine species (including some marine mammals and sea turtles).

2.2.5.3.1 Fish

The species composition of the fish community found in western Cape Cod Bay reflects a transition between the Gulf of Maine and the Mid-Atlantic Bight (Lawton et al. 1995 in ENSR 2000). Due to the warm water intrusion from the Cape Cod Canal into the cold waters from the Gulf of Maine current, Cape Cod Bay maintains a seasonally diverse composition of finfish. Cape Cod serves as the southern boundary for several northern Atlantic fish species and the northern boundary for several fish species that inhabit the warmer waters south of Cape Cod, resulting in a wide variety of fish species (ENSR 2000). PNPS is situated on an open part of the coast and the biota in the vicinity of the station is more typical of marine than of estuarine environments (ENSR 2000).

Monitoring

Marine finfish populations in the vicinity of PNPS have been monitored since the initiation of station operations to determine if the station has had any effect on local populations. These studies have been conducted by independent researchers, State agencies, and consultants under contract with PNPS or its parent companies (Boston Edison, Entergy). These studies have been conducted in response to the NPDES permitting requirements, in response to advisory committee concerns, or due to PNPS concerns only. The results of these studies are published at least annually through the Marine Ecology Reports or are issued as special reports.

A variety of methods has been employed to sample the fish populations that inhabit the waters in the vicinity of the station. These methods have included:

- Bottom trawls
- Gill nets
- Haul seines
- Diver surveys
- Recreational creel surveys
- Ichthyoplankton surveys
- Impingement and entrainment monitoring

Bottom trawling gear was used to sample demersal fish species inhabiting inshore waters, gill nets were set to sample pelagic species, and haul seining was employed to sample other inshore species. In addition, visual transects were surveyed by divers in complex habitat areas that could not be surveyed with typical sampling equipment in order to assess habitat-seeking fish species such as the tautog *(Tautoga onitis*) and cunner (*Tautogolabrus adspersus*). Recreational creel surveys also were conducted to assess the sport fisheries adjacent to PNPS. In addition, ichthyoplankton studies were initiated in 1974 to determine the presence and extent of early-life stages of local fish populations and assess possible detrimental effects from PNPS. Impingement and entrainment sampling has been conducted at least once weekly since the initiation of station operations.

Important Fish Species

A discussion of the ecology, life history, status, and trends of the important fish species in the area surrounding PNPS follows. These species include commercially or recreationally valuable species, species that are critical to the potentially affected ecosystem, and species for which essential fish habitat (EFH) has been designated in the vicinity of PNPS. These species are:

- Alewife (*Alosa pseudoharenqus*)
- American plaice (*Hippoglossoides platessoides*)
- Atlantic butterfish (*Peprilus triacanthus*)
- Atlantic cod (*Gadus morhua*)
- Atlantic halibut (*Hippoglossus hippoglossus*)
- Atlantic herring (*Clupea harengus*)
- Atlantic mackerel (*Scomber scombrus*)
- Atlantic menhaden (*Brevoortia tyrannus)*
- Atlantic sand lance (*Ammodytes americanus)*
- Atlantic silverside (*Menidia menidia)*
- Atlantic tomcod (*Microgadus tomcod)*
- Black sea bass (*Centropristus striata*)
- Bluefin tuna (*Thunnus thynnus*)
- Bluefish (*Pomatomus saltatrix*)
- Cunner (*Tautogolabrus adspersus)*
- Fourbeard rockling (*Enchelyopus cimbrius)*
- Fourspot flounder (*Paralichthyus oblongus)*
- Haddock (*Melanogrammus aeglefinus*)
- Little skate (*Leurcoraja erinacea*)
- Monkfish (*Lophius americanus*)
- Ocean pout (*Macrozoarces americanus*)
- Offshore hake (*Mercluccius albidius*)
- Pollock (*Pollachius virens*)
- Rainbow smelt (*Osmerus mordax)*
- Redfish (*Sebastes* fasciatus)
- Red hake (*Urophycis chuss*)
- Rock gunnel (*Pholis gunnellus)*
- Scup (*Stenotomus chrysops*)
- Silver hake / whiting (*Merluccius bilinearis*)
- Smooth skate (*Malacoraja senta*)
- Spiny dogfish (*Squalus acanthias*)
- Summer flounder (*Paralicthys dentatus*)
- Tautog (*Tautoga onitis)*
- Thorny skate (*Amblyraja radiata*)
- Tilefish (*Lopholatilus chamaeleonticeps*)
- White hake (*Urophycis tenuis*)
- Windowpane flounder (*Scopthalmus aquosus*)
- Winter flounder (*Pseudopleuronectes americanus*)

- Winter skate (*Leurcoraja ocellata*)
- Witch flounder (*Glyptocephalus cynoglossus*)
- Yellowtail flounder (*Pleuronectes ferruginea*)

An EFH assessment is provided in Appendix E to meet the consultation requirements according to the Magnuson-Stevens Fishery Conservation and Management Act. By letter dated January 23, 2007, NMFS concluded the EFH consultation with NRC regarding PNPS license renewal (see Appendix E).

An important component of the analysis in this SEIS is a determination of stock status. The status of a stock relates to two primary factors: the rate of removal of fish from the population (also known as the exploitation rate) and the current stock size or biomass. The exploitation rate is the proportion of the stock that is caught and removed from the population. If that proportion exceeds a sustainability threshold determined by fishery scientists, then overfishing of that stock is occurring (NEFSC 2004). The current stock size is typically defined by either the spawning stock biomass (SSB) or the total stock biomass. If the stock's total biomass falls below the biomass sustainability threshold for that species, then the stock is considered to be in an overfished condition (NEFSC 2004). If a stock is considered to be in an overfished condition (i.e., a biomass level that is less than a biomass threshold level), then NMFS develops plans for rebuilding and sustaining the stock (NEFSC 2004).

Pelagic Species

Alewife (*Alosa pseudoharengus*)

The alewife is an anadromous species common in New England (Mullen et al. 1986, in ENSR 2000), and in the area of PNPS. The species is historically one of the most commercially important fish species in Massachusetts (Belding 1921, in ENSR 2000). Spawning occurs in freshwater rivers and streams in the area of PNPS from the middle of April to early June (Belding 1921, in ENSR 2000). Spawning occurs at water temperatures between 16 and 19 °C (60.8°F and 66.2°F) (Kocik 1998, in ENSR 2000). The eggs adhere to the river bottoms until they harden and then become pelagic. The adults become sexually mature and begin migrating to rivers and streams to spawn when they are four or five years old (Marcy 1969, in ENSR 2000). Alewives are important forage fish in the ocean, as well as in freshwater during their migration and spawning activities (ENSR 2000). The species is planktivorous, feeding mainly on diatoms, algae, and small crustaceans (ENSR 2000). The alewife is common in Cape Cod Bay, and is one of the most commonly impinged species at PNPS (ENSR 2000). Alewife larvae and juveniles have been collected in the PNPS entrainment sampling. Juveniles and/or adults have been consistently collected in the PNPS impingement sampling program. Over the last 25 years (1980 to 2005), alewives have had the third highest number of individuals impinged at PNPS, based on annual extrapolated totals (Normandeau 2006b).

Atlantic butterfish (*Peprilus triacanthus*)

The Atlantic butterfish is a small bony pelagic fish that forms loose schools, living near the water surface (Schrieber 1973; Dery 1988b; Brodziak 1995, in Cross et al. 1999). The butterfish has been commercially fished since the late 1800s (Murawski and Waring 1979, in Cross et al. 1999). All life stages, including eggs, larvae, juveniles, and adults are pelagic (Cross et al. 1999). Adult butterfish become sexually mature at the age of one year (Overholtz 2000c). Spawning season varies depending on location and water temperature. In the Gulf of Maine, spawning begins in May to June, peaks in July, and ends in August (Bigelow and Schroeder 1953, in Cross et al. 1999). Spawning occurs offshore, at temperatures above 15°C (59°F) (Colton 1972, in Cross et al. 1999). Adult butterfish prey on small fish, squid, and crustaceans, and in turn are preyed upon by many species, including silver hake (*Merluccius bilinearis*), bluefish (*Pomatomus saltatrix*), swordfish (*Loligo pealei*), and longfin squid (*Xiphias gladius*) (ENSR 2000). The butterfish is short-lived, rarely living to more than three years of age (ENSR 2000).

The butterfish is found throughout the eastern coast of the U.S. and Canada, from Florida to Newfoundland. It is most commonly found from Cape Hatteras to the Gulf of Maine (Bigelow and Schroeder 1953, in ENSR 2000). In summer, the butterfish can be found over the entire continental shelf from sheltered bays and estuaries, over substrates of sand, rock, or mud, to a depth of 200 meters (m) (656 ft) (Cross et al. 1999). The butterfish migrates annually in response to seasonal changes in water temperature. During the summer, they migrate inshore into southern New England and Gulf of Maine waters, and in winter they migrate to the edge of the continental shelf in the Mid-Atlantic Bight (Cross et al. 1999).

The butterfish is managed as a single stock unit (Brodziak 1995, in Cross et al. 1999). The species is managed under the Mid-Atlantic Fishery Management Council's (MAFMC) Atlantic Mackerel, Squid, and Butterfish Plan (Overholtz 2000c). An assessment in 2004 determined that overfishing was not occurring (NMFS 2004a). However, fishing mortality was near the overfishing definition, with the discards estimated at twice the amount of landings. Because of this, the stock assessment report recommended that measures be implemented to reduce mortality due to discards (NMFS 2004a). Eggs and larvae of the Atlantic butterfish have been collected in the PNPS entrainment sampling. Juveniles and/or adults have been observed in the PNPS impingement sampling program.

Atlantic herring (*Clupea harengus*)

The Atlantic herring is a coastal pelagic, schooling species found on both sides of the Atlantic Ocean (Stevenson and Scott 2005). Atlantic herring have been an important commercial species in New England for 400 years (Anthony and Waring 1980, in ENSR 2000). In recent years, large-scale fisheries for adult herring have developed in the western Gulf of Maine, on Georges Bank, and on the Scotian Shelf (ENSR 2000).

The Atlantic herring lays eggs on the bottom, in gravel, rock, or shell substrates. The eggs adhere to the bottom in layers and form beds (Bigelow and Schroeder 1953; Mansueti and Hardy 1967, in ENSR 2000). As juveniles, Atlantic herring form large aggregations in coastal areas. Herring in the Gulf of Maine reach sexual maturity at an age of about three years (Stevenson and Scott 2005). Spawning occurs in high energy environments with strong tidal action (Iles and Sinclair 1982, in Stevenson and Scott 2005). Spawning occurs in water below 15°C, at water depths between 20 and 80 m (66 to 262 ft) (NEFMC 1998a, in ENSR 2000). In the Gulf of Maine and Georges Bank, spawning occurs from July to December (Stevenson and Scott 2005). Both the larvae and juveniles feed on zooplankton, including copepods (ENSR 2000). The Atlantic herring of all life stages are preyed upon by other fishes, including cod (*Gadus morhua*), pollock (*Pollachius virens*), haddock (*Melanogrammus aeglefinus*), silver hake, mackerel (*Scomber scombrus*), dogfish (*Squalus acanthias*), and squid (Hildenbrand 1963; Bigelow and Schroeder 1953, in ENSR 2000), as well as marine mammals and birds. Adult Atlantic herring feed on zooplankton, and capture prey by direct, predatory snapping action (Blaxter and Holliday 1963, in ENSR 2000). Atlantic herring become sexually mature between the ages of three and four years (Reid et al. 1999b).

In the western Atlantic, herring inhabit the continental shelf from Labrador to Cape Hatteras. In the U.S., herring are managed as a single stock, and a separate stock located further north is managed by Canada (Stevenson and Scott 2005). There is an annual migration of adult Atlantic herring from summer feeding areas along the Maine coast to southern New England (Stevenson and Scott 2005). The adults live in water at depths of 20 to 130 m (66 to 427 ft), and at temperatures less than 10°C (50°F) (NEFMC 1998a, in ENSR 2000). Trawl surveys in Massachusetts identified large catches of adult herring in Cape Cod Bay in the fall (Stevenson and Scott 2005).

Although the herring is managed as a single stock unit in the U.S., there may actually be separate Georges Bank and Gulf of Maine stocks (Stevenson and Scott 2005). The fishery is managed under an interstate fishery management plan (FMP) adopted by the Atlantic States Marine Fisheries Commission (ASMFC) in coordination with the New England Fishery Management Council (NEFMC) (Overholtz 2000a). Trawl survey data collected in 2003 determined that the herring biomass was stable and increasing over time (NEFMC 2004).

While the stock as a whole is considered to be under-utilized, the population within the Gulf of Maine is heavily exploited and being over-harvested (Stevenson and Scott 2005), but the overall stock was considered to be at sustainable levels at the time of 2006 ASMFC report (i.e., the SSB and/or total stock biomass are considered to be at levels greater than sustainable biomass thresholds, while the exploitation or fishing pressure is less than the threshold of sustainable fishing pressure) (ASMFC 2006). Atlantic herring eggs, larvae, and juveniles have been collected in the PNPS entrainment sampling. Juveniles and/or adults have been consistently collected in the PNPS impingement sampling program. Over the last 25 years they have been one of the numerically dominant impinged species.

Atlantic mackerel *(Scomber scombrus)*

The Atlantic mackerel is a pelagic, schooling species found in the northwest Atlantic between Labrador and North Carolina (Overholtz 2000b). Both the eggs and larvae of the species are pelagic, and transition from drifting to free swimming when they reach a size of 30 to 50 millimeters (mm) (1 to 2 in.) (Sette 1943, in Studholme et al. 1999). The Atlantic mackerel becomes sexually mature by the age of three years (O'Brien et al. 1993, in Studholme et al. 1999). Spawning occurs at two distinct times of the year; a southern population spawns in April and May, and a northern population spawns in June and July (ENSR 2000). Spawning takes place in the upper portion of the water column, in shoreward areas, at temperatures above 10°C (50°F) (ENSR 2000). Cape Cod Bay is reported to be an important spawning area in the months from May to August (Studholme et al. 1999). The adult mackerel can feed both by filter feeding and by preying on individuals. The prey consists of plankton such as amphipods, euphausiids, shrimp, crab larvae, small squid, and fish eggs (Scott and Scott 1988, in ENSR 2000).

Mackerel are found in both cold and temperate continental shelf areas, and form large schools near the surface (Collette and Nauen 1983, in ENSR 2000). The mackerel perform annual migrations, with movement generally northeast and inshore in the spring, and offshore to deeper water in the winter (ENSR 2000). Migration is closely related to seasonal temperature changes, as the mackerel prefers to live in waters with temperatures of 6 to 15°C (42.8 to 59°F) (Overholtz and Anderson 1976, in Studholme et al. 1999). Both juveniles and adults have been caught in trawl surveys in Cape Cod Bay. Juveniles were primarily found in the fall, while adults were identified in the spring (Studholme et al. 1999).

There are two separate spawning populations in the northwestern Atlantic, but all mackerel are considered to be a single stock and are managed as a single stock (Sette 1943; Anderson 1982; MAFMC 1994, in Studholme et al. 1999). The mackerel stock reached low biomass levels in the 1970s due to heavy exploitation by distant water fleets (NMFS 2006a). Since 1983, the species has been managed under the MAFMC Atlantic Mackerel, Squid, and

Butterfish Plan (Overholtz 2000b), and biomass levels had improved as of the mid 1990s (Anderson 1995, in Studholme et al. 1999). The current ASMFC report states the stock is considered to be at sustainable levels (i.e., the SSB and/or total stock biomass are considered to be at levels greater than sustainable biomass thresholds, while the exploitation or fishing pressure is less than the threshold of sustainable fishing pressure) (NMFS 2006a). Eggs and larvae of the Atlantic mackerel have been consistently collected in the PNPS entrainment sampling and are one of the numerically dominant species in the entrainment collections. Juveniles and/or adults have also been observed in the PNPS impingement sampling program.

Atlantic menhaden (*Brevoortia tyrannus*)

The Atlantic menhaden is a migratory fish species found in coastal and estuarine waters from Nova Scotia to Florida. Menhaden is a schooling fish species and serves as an important forage fish to larger predators (Rogers and Van den Avyle 1989). The menhaden is one of the most commercially important fish species along the Atlantic Coast, and is used for fish meal, fish oil, and bait for other species (VIMS 2006). The species becomes sexually mature at the age of three years, and spawns from March to May and September to October (VIMS 2006). The larvae live in brackish or freshwater areas, and when they become juveniles, they migrate south in schools (VIMS 2006). The status of the population is healthy, with stable stock size and high biomass (VIMS 2006). The current ASMFC report indicates the Atlantic menhaden population is considered to not be in an overfished condition, and overfishing is not occurring (ASMFC 2006).

Atlantic menhaden eggs, larvae, and juveniles have been consistently collected in the PNPS entrainment sampling and are one of the numerically dominant species in the entrainment collections. Juveniles and/or adults have been consistently collected in the PNPS impingement sampling program. Over the last 25 years they have had the second highest impingement rate.

Atlantic silverside (*Menidia menidia*)

The Atlantic silverside is found through the western Atlantic Ocean, and generally associates in large schools. The habitat includes shallow water with sand or gravel substrate. The species typically preys on small crustaceans, including copepods, shrimp, amphipods, and cladocerans (ENSR 2000). Silversides are an important forage fish in the diet of several other fish species, including bluefish, striped bass, cunner, and Atlantic cod (Bayliff 1950, in ENSR 2000). Spawning occurs in the late spring and early summer, mostly in shallow water where eggs and milt are deposited in strands that cling to vegetation (ENSR 2000). The silverside only live for about one year (ENSR 2000). The Atlantic silverside is the most commonly impinged fish at PNPS, and had the highest catch rate in Massachusetts Division of Marine Fisheries (MDMF) beach haul seines conducted in western Cape Cod Bay (ENSR 2000, Kelly et al. 1992).

Atlantic silverside eggs, larvae, and juveniles have been collected in the PNPS entrainment sampling. Juveniles and/or adults have been consistently collected in the PNPS impingement sampling program. Over the last 25 years they have had the highest impingement rate.

Black sea bass (*Centropristis striata*)

The black sea bass is a temperate species found in structured habitats of the continental shelf, such as reefs and shipwrecks (Steimle et al. 1999d). Eggs and larvae of the black sea bass are pelagic and are found in spawning areas on the continental shelf (Steimle et al. 1999d). As juveniles, the species moves inshore, where they form nurseries in estuaries (Able and Fahay 1998, in Steimle et al. 1999d). Juveniles mature as females, and then change to males as they grow larger (Lavenda 1949, in Steimle et al. 1999d). Juveniles begin to mature at one year of age, with most of the adults of this age being females (Mercer 1978, in Steimle et al. 1999d). Spawning occurs on the inner continental shelf, in water depths of 20 to 50 m (66 to 164 ft), between the Chesapeake Bay and Long Island (Steimle et al. 1999d). Larvae have been reported in Cape Cod Bay, but these are interpreted to have been spawned in Buzzards Bay and moved through the Cape Cod Canal (MAFMC 1996b, in Steimle et al. 1999d). Spawning in Massachusetts coastal waters occurs on sandy bottoms broken by rocky ledges (Kolek 1990; MAFMC 1996b, in Steimle et al. 1999d). Larval black sea bass probably prey on zooplankton (Steimle et al. 1999d). The juveniles are visual predators that feed on benthic crustaceans and small fish (Richards 1963; Allen et al. 1978; Werme 1981, in Steimle et al. 1999d).

The black sea bass in the western Atlantic occurs from southern Nova Scotia and Bay of Fundy south to Florida, and into the Gulf of Mexico (Steimle et al. 1999d). The population in the U.S. is managed as three separate stocks, including the Gulf of Mexico, the southern stock (south of Cape Hatteras), and the northern stock (north of Cape Hatteras) (Steimle et al. 1999d). The species is primarily a warm water fish, and begins to migrate offshore to depths of 30 to 240 m (98 to 787 ft) as bottom water temperatures reach 7°C (44.6°F) (Steimle et al. 1999d). The species lives in benthic areas where structures such as reefs provide shelter (Steimle et al. 1999d). Trawl surveys in Massachusetts in the spring found abundant juvenile populations south and west of Cape Cod, with a few juveniles collected in Cape Cod Bay (Steimle et al. 1999b).

The fishery for the black sea bass is managed under the MAFMC Summer Flounder, Scup, and Black Sea Bass FMP (Shepherd 2000a). As of 1997, the black sea bass population was considered to be over-exploited (NMFS 1997, in Steimle et al. 1999d). However, the 2004 Stock Assessment Summary (NMFS 2004b) concluded that the species is not overfished and that overfishing was not occurring. This was attributed to the fact that commercial landings were limited by quotas, while recreational landings were similar to long-term averages

(NMFS 2004b). In 2006, the NMFS determined that the overfishing status could not be determined (NMFS 2006b). The 2006 ASMFC report, indicates the black sea bass population is considered to be overfished, while the overfishing status is not known (ASMFC 2006). Black sea bass larvae have been collected in the PNPS entrainment sampling. Juveniles and/or adults have been observed in the PNPS impingement sampling program.

Bluefin tuna (*Thunnus thynnus*)

The bluefin tuna is found in two separate populations in the eastern and western Atlantic Ocean (Buck 1995). The species is among the largest bony fish in the Atlantic Ocean and can reach sizes of up to 1200 pounds (ENSR 2000). Bluefin tuna in the western Atlantic become sexually mature at the age of about eight years (NMFS 2005c). The prey of the bluefin tuna includes mackerel, herring, whiting (*Merluccius bilinearis*), and squid (Buck 1995).

The range of the bluefin tuna in the western Atlantic Ocean is from Newfoundland to Brazil (Buck 1995). The western Atlantic population is managed as a single stock unit (Buck 1995). Bluefin tuna primarily live in the upper 100 to 200 m (328 to 656 ft) of the water column in the open ocean (NMFS 1999). The bluefin tuna migrates extensively. Following spawning in the Gulf of Mexico area in spring and early summer, the species migrates north along the U.S. coast to waters off of Canada (Buck 1995).

The latest stock assessment for the bluefin tuna was conducted in 2001. This assessment determined that the SSB had declined about 80 percent between 1970 and the late 1980s, and had then leveled off (NMFS 2005c). In 2001, the stock of the bluefin tuna was determined to be overfished, and overfishing was continuing (NMFS 2001d). No life stages of the bluefin tuna have ever been observed in the PNPS entrainment or impingement sampling.

Bluefish (*Pomatomus saltatrix*)

Bluefish is a migratory, pelagic species found in temperate coastal zones throughout the world (Shepherd 2000b). Bluefish are very common along the east coast of the U.S., and are very popular among recreational fishermen, with recreational landings regularly exceeding commercial catches (NMFS 2005b). Bluefish reach sexual maturity at the age of two years (Deuel 1964, in Shepherd and Packer 2006, ENSR 2000). Spawning occurs in the area from New York south to Florida (Shepherd and Packer 2006). Spawning was previously thought to occur at two distinct times of year, with one population spawning in the spring and one in the summer (ENSR 2000). However, recent studies suggest that there is a single spawning season from spring to summer, but that there is high mortality among the young in the middle of the event, making it appear as two separate events in population studies (Shepherd and Packer 2006). Bluefish eggs and larvae are buoyant and live within surface waters, only within open oceanic waters (Able and Fahay 1998, in Shepherd and Packer 2006). The larvae feed on surface plankton until they reach juvenile stage, and then migrate to coastal nursery areas to feed on other fish species (Kendall and Walford 1979, in ENSR 2000; Shepherd and Packer 2006). Adult bluefish are voracious predators, and prey on squid, shrimp, crabs, alewives, menhaden, silver hake, butterfish and smaller bluefish (ENSR 2000).

Within the western Atlantic, bluefish are found from Maine to Florida, migrating northward in the spring and southward in the fall (ENSR 2000). Adults live in a variety of locations, including the open ocean, bays, and estuaries. In Massachusetts coastal areas, adults are found in water depths of between 6 and 25 m (20 to 82 ft), and temperatures from 10 to 20 °C (50 to 68°F) (Shepherd and Packer 2006). Bluefish migrate in response to temperature changes in order to remain in water with temperatures above 14 to 16°C (57.2 to 60.8 °F) (Bigelow and Schroeder 1953, in Shepherd and Packer 2006). They live in southern New England waters in spring and summer, and migrate to waters off of the southeastern U.S. in autumn (Shepherd and Packer 2006).

Bluefish are managed as a single stock unit (Fahay et al. 1999b; Shepherd and Packer 2006). The population of bluefish has varied widely through time, but appears to have declined significantly since the early 1980s (Fahay et al. 1999b). The Bluefish FMP was implemented in 2000 by the MAFMC and the ASMFC (Shepherd 2000b; NMFS 2005b). However, as of the 2006 stock assessment, the stock was considered to be at sustainable levels (i.e., the SSB and/or total stock biomass are considered to be at levels greater than sustainable biomass thresholds, while the exploitation or fishing pressure is less than the threshold of sustainable fishing pressure) (NMFS 2005b; ASMFC 2006). Bluefish juveniles and adults are reported to have been observed in the vicinity of PNPS (ENSR 2000). No life stages of the bluefish have ever been observed in the PNPS entrainment sampling. Juveniles and/or adults have been observed in the PNPS impingement sampling program.

Pollock (*Pollachius virens*)

The pollock is a bentho-pelagic fish found on both sides of the Atlantic Ocean (Mayo 2004). Pollock live throughout the water column (McGlade 1984, in ENSR 2000). Pollock are commercially important, but were primarily taken only as bycatch until the 1980s, at which time commercial fishing of the species began (Mayo 1998b, in ENSR 2000). Pollock eggs and larvae are pelagic until the larvae reach an age of about three to four months. At that time, the small juveniles migrate inshore and inhabit rocky subtidal and intertidal zones. At the end of their second year, the juveniles move offshore, where they remain through their adult life (Cargnelli et al. 1999e). Adults reach sexual maturity between the ages of three and six years (Mayo 1998b, in ENSR 2000), but the age and size at maturity has been decreasing, possibly due to size-selective overfishing (Cargnelli et al. 1999e).

The western Gulf of Maine, including Massachusetts Bay, is one of the principle spawning sites for pollock (Cargnelli, et al. 1999e). Spawning in the Gulf of Maine occurs from November to February (Steele 1963; Colton and Marak 1969, in Cargnelli, et al. 1999e), at water temperatures from 4.5 to 6°C (40.1 to 42.8°F) (Cargnelli et al. 1999e). Eggs are spawned on hard substrates in water depths between 10 and 365 m (33 to 1198 ft) (NEFMC 1998a, in ENSR 2000). Larvae living in near-surface waters feed on larval copepods, while juvenile pollock feed on crustaceans and fish, including young Atlantic herring (Steele 1963; Cargnelli et al. 1999e; Ojeda and Dearborn 1991). The primary food for adults is krill and Atlantic herring (Cargnelli et al. 1999e).

The most common locations for pollock in the northwestern Atlantic include the Scotian Shelf and the Gulf of Maine (Mayo 2004). Pollock migrate between these locations considerably, resulting in the three areas being managed as a single stock unit (Cargnelli et al. 1999e). Adults live in a wide range of temperatures and depths, but are most frequently found in water depths from 100 to 125 m (328 to 410 ft), and temperatures of 0 to 14°C (32 to 57.2°F) (Hardy 1978). There is no obvious preference for bottom type (Scott 1982a in Cargnelli et al. 1999e). Pollock is a schooling species, but does not have substantial migration, except for small movements related to temperature change (Hardy 1978).

The U.S. portion of the pollock fishery is managed under the NEFMC Northeast Multispecies FMP (Mayo 2004). Commercial landings and stock size of pollock in the Gulf of Maine and Georges Bank decreased substantially through the late 1980s, and reached historic lows in 1996 (Cargnelli et al 1999e). However, an assessment conducted in 2004 concluded that the stock is considered to be at sustainable levels (i.e., the SSB and/or total stock biomass are considered to be at levels greater than sustainable biomass thresholds, while the exploitation or fishing pressure is less than the threshold of sustainable fishing pressure) (Mayo et al. 2005b). Eggs and larvae of the pollock have been collected in the PNPS entrainment sampling. Juveniles and/or adults have also been observed in the PNPS impingement sampling program.

Rainbow smelt (*Osmerus mordax*)

The rainbow smelt is an anadromous fish, rarely found more than 1 mi from shore or deeper than 6 m (20 ft). Smelt are cold water fish (ENSR 2000). Information on the smelt's temperature preference is limited, but available data indicate they prefer water temperatures cooler than 15°C (59°F) in the freshwater habitat of Lake Michigan (ENSR 2000). In addition to marine populations found from Labrador to Virginia, there are landlocked populations in New England lakes, the Maritime Provinces, and the Great Lakes. The center of abundance for marine populations is the southern Maritime Provinces of Canada and Maine, and the southern limit of large populations is Massachusetts (Lee et al. 1980; Clayton et al. 1978, in ENSR 2000). The rainbow smelt is a schooling fish and serves a vital role in the ecological food web as a forage fish preyed upon by both marine and freshwater predators (Buckley 1989, in ENSR 2000). Although adult smelt are found in deeper waters outside of estuaries during the summer, the species gathers in harbors and brackish estuaries in the fall.

The principal spawning ground of smelt in the Plymouth area is the Jones River (Lawton et al. 1990). Jones River, located several miles north of PNPS, has its headwaters in Pembroke, Kingston, and Plympton before it empties into Plymouth Harbor (Lawton et al. 1990). Spawning of the demersal, adhesive eggs begins when water temperatures increase to around 4.4°C (40°F), usually in March. Peak egg production occurs at water temperatures of 10 to 13.9°C (50 to 57°F), and spawning is completed by May (Buckley 1989, in ENSR 2000). Lawton et al. (1990) also observed in the Jones River population that spawning was concluded in early May and that the smelt emigrated from the spawning ground when water temperature reached 16°C (60.8°F). A qualitative comparison of data collected in 2004 by the MDMF indicated that the smelt population, when compared to population data from previous seasons, had a relatively poor run in the four rivers sampled, including the Jones River (Chase 2006a). Sexual maturity typically occurs during the second winter (McKenzie 1964, in ENSR 2000). In the Jones River population, two-year-old fish made up approximately 88 percent of the spawning run (Lawton et al. 1990).

Sea-run smelt populations declined throughout the western North Atlantic during the 1990s (Lawton and Boardman 1999). In the late 1980s and early 1990s a decline of rainbow smelt was observed in the spawning runs of the Jones River. The depressed spawning numbers made the rainbow smelt a species of special concern to MDMF (Lawton et al. 1990). In 2004, the NMFS designated the rainbow smelt as a species of concern due to habitat degradation, structural impediments to spawning habitat, and recreational and commercial fishing pressures (NOAA Fisheries 2004). NOAA Fisheries (2004) reports that there has been a region-wide decline in smelt populations over the last two decades. According to the MDMF, populations are still at depressed levels (Chase 2006b). Eggs and larvae of the rainbow smelt have been collected in the PNPS entrainment sampling. Juveniles and/or adults have been consistently collected in the PNPS impingement sampling program. Over the last 25 years they have had the fourth highest impingement rate.

Redfish (*Sebastes* spp.)

Redfish is a common name used to describe several species of fish such as the Acadian redfish (*Sebastes fasciatus*) and the golden redfish (*S. norvegicus*). Redfish have been commercially fished in the U.S. since the 1930s (Pikanowski et al 1999). The two species are difficult to distinguish, and are managed as a single fishery (Templeman 1959; Mayo 1980, in Pikanowski et al. 1999). Eggs are fertilized internally, and the females give birth to larvae (Pikanowski et al. 1999). The new larvae live in the upper 10 m (33 ft) of the water column, and then live within the thermocline [10 to 30 m (33 to 98 ft)] when they become larger (Kelly and Barker 1961a, in Pikanowski et al. 1999). Juveniles are also pelagic until the fall of their first year, at which time they migrate to the bottom (Kelly and Barker 1961b, in Pikanowski et al 1999). Adults become sexually mature at an age of about five to six years (Mayo 2000). The demersal adults typically live within 3 to 7 m (10 to 23 ft) from the bottom (Atkinson 1989, in Pikanowski et al 1999). Very little is known about redfish spawning. Fertilization probably occurs in February to April (Ni and Templeman 1985, in Pikanowski et al 1999), and larvae are released throughout the range where the adults are found, in spring and summer (Steele 1957; Kelly and Wolf 1959; Kelly et al 1972; Kenchington 1984, in Pikanowski et al 1999). The larvae feed on copepods, euphausiids, and fish and invertebrate eggs (Marak 1973, in Pikanowski et al 1999). Juvenile and adult redfish prey on euphausiids, mysids, and bathypelagic fish (Pikanowski et al 1999).

Acadian redfish range from New Jersey to Iceland in the western Atlantic (Pikanowski et al. 1999). Acadian redfish can be found within shallow waters in the Gulf of Maine, but redfish are most common at depths of 128 to 366 m (420 to 1200 ft), and have been found as deep as 592 m (1950 ft) (Kelly and Barker 1961a, in Pikanowski et al. 1999). The redfish does not migrate latitudinally (Murawski 1973, in Pikanowski et al. 1999). The preferred temperature range is from 3 to 7°C (37.4 to 44.6°F) (Kelly et al. 1972, in Pikanowski et al. 1999). Redfish are found in areas of silt, mud, or sandy bottom substrates (Pikanowski et al. 1999). Larvae were identified in the Gulf of Maine from April to September, while juveniles and adults were found in the Gulf of Maine in all seasons (Pikanowski et al. 1999). Substantial numbers were reported to have been observed in Massachusetts Bay (NMFS 2001b).

The U.S. fishery for redfish is managed under the NEFMC Northeast Multispecies FMP (Mayo 2000). Redfish were not classified as overfished or approaching an overfished condition in 1997 (NMFS 1997, in Pikanowski 1999). In 2001, a stock assessment concluded that the stock was overfished at that time, but that overfishing was not occurring (NMFS 2001b). The most recent assessment, in 2004, concluded that the stock is considered to be at sustainable levels (i.e., the SSB and/or total stock biomass are considered to be at levels greater than sustainable biomass thresholds, while the exploitation or fishing pressure is less than the threshold of sustainable fishing pressure) (Mayo et al. 2005c). Larvae of one of the redfish species (*Sebastes norvegicus*) have been collected in the PNPS entrainment sampling. No life stages have been observed in the PNPS impingement sampling program.

Spiny dogfish (*Squalus acanthias*)

The spiny dogfish is the most abundant shark in the western North Atlantic (McMillan and Morse 1999). The spiny dogfish bears live young in litters numbering from 2 to 15 pups (NOAA 1998, in ENSR 2000). The adult spiny dogfish is a voracious and opportunistic predator, and is reported to prey on a variety of fish, mollusks, and crustaceans. The species travels in large packs, and attacks schools of fish, including cod, haddock, capelin (*Osmerus villosus*), mackerel, herring, and sand lance (*Ammodytes americanus*) (McMillan and Morse 1999). Spiny dogfish are known to live up to 35 to 40 years of age (Nammack et al. 1985, in McMillan and Morse 1999).

The range of spiny dogfish in the western North Atlantic is from Labrador to Florida. In the spring and autumn, the species is common in coastal waters, including estuaries and closed bays, between North Carolina and southern New England (Rago et al. 1994, in McMillan and Morse 1999). Spiny dogfish migrate annually, in schools, from winter habitat on the edge of the continental shelf to summer grounds in the Gulf of Maine and Georges Bank. Trawl surveys conducted in Massachusetts identified an abundance of adult spiny dogfish within Cape Cod Bay in the spring. Both juveniles and adults were abundant within Cape Cod Bay in the fall (McMillan and Morse 1999).

The spiny dogfish is the target of a commercial fishery within U.S. waters, with a large increase in activity beginning in 1996 (McMillan and Morse 1999). The population in U.S. waters is managed as a single unit (McMillan and Morse 1999) and is managed under a FMP developed by MAFMC and NEFMC (Sosebee 2000b). The stock was classified as overfished in 1998, due to an increase in commercial landings by a factor of six from 1991 to 1998 (MAFMC 1998, in McMillan and Morse 1999). It was also classified as overfished in 2003, although overfishing was not occurring (NMFS 2003b). The stock assessment summary for 2006 concluded that the species is not overfished, and that overfishing is not occurring (NMFS 2006b). However, most recently, the 2006 ASMFC Stock Status Overview (ASMFC 2006) indicated that the stock is overfished, although overfishing is not occurring. Juveniles and/or adult spiny dogfish have been observed in the PNPS impingement sampling program. They have not been detected in the PNPS entrainment sampling program.

Demersal Species

American plaice (*Hippoglossoides platessoides*)

The American plaice is a benthic, right-eyed flounder that exists in deeper waters of the continental shelf on both sides of the North Atlantic (Cooper and Chapleau 1998, in ENSR 2000). The American plaice is the most abundant flatfish species in the western North Atlantic, and became important as a commercial species in the Gulf of Maine after 1975 (Johnson 2004). Both the eggs and larvae of the American plaice are pelagic, and are found in shallow surface waters, including in southern New England and Cape Cod Bay (ENSR 2000). Adults are primarily benthic, but are known to migrate off of the bottom at night to prey on non-benthic species (DFO 1989, in Johnson 2004). The American plaice reaches sexual maturity at an age of two to four years (O'Brien 2000, in Johnson 2004). Spawning occurs between the months of March and May, in water temperatures between 3 to 6°C (37.4 to 42.8°F) (Johnson 2004). The Gulf of Maine and Georges Bank are considered to be areas of maximum spawning for the species (Johnson 2004). Larvae prey on plankton, diatoms, and copepods found in surface water layers. As larvae turn into juveniles, they feed on small crustaceans, polycheates, and cumaceans (Bigelow and Schroeder 1953, in Johnson 2004). Benthic crustaceans, mollusks, and small forage fish species make up the diet of the adults.

The range of the American plaice in the western North Atlantic includes the area from southern Labrador to Rhode Island. The species inhabits mostly deep waters, in depths ranging from 90 to 250 m (295 to 820 ft) (O'Brien 1998, in ENSR 2000), and they do not normally occur in water shallower than 25 to 35 m (82 to 115 ft) (O'Brien 2000, in Johnson 2004). Both juveniles and adults live and spawn on a variety of substrates, including fine sand, sand, and gravel, in water temperatures below 17°C (62.6°F) (NEFMC 1998a, in ENSR 2000). The American plaice does not migrate substantially. Results from tagging studies have found that most recaptured individuals were found within 30 mi from the tagging site, even as long as seven years later (DFO 1989, in Johnson 2004).

The American plaice is managed as a single stock unit (Johnson et al. 1999b). The American plaice fishery is managed under the NEFMC Northeast Multispecies FMP (O'Brien 2000). American plaice populations in the western Atlantic have declined dramatically since the early 1980s (Johnson 2004). The reasons for this are unknown, but may be attributed to temperature changes (Morgan 1992, in Johnson 2004), pollution (Nagler and Cyr 1997, in Johnson 2004), or overfishing (Nagler et al. 1999, in Johnson 2004). Northeast stock assessment reports through 2001 determined that the species is overfished, and that overfishing is occurring in the Gulf of Maine/Georges Bank stock (O'Brien et al. 2002, in Johnson 2004; NMFS 2001a). However, an updated assessment in 2005 concluded that the species was overfished, but overfishing was no longer occurring (O'Brien et al. 2005). In 2005, an analysis of juvenile populations resulted in a proposal for the potential designation of Habitat Area of Particular Concern (HAPC) for the American plaice, including areas within Cape Cod Bay, adjacent to PNPS (Crawford et al. 2005). Eggs and larvae of the American plaice have been collected in the PNPS entrainment sampling. Juveniles and/or adults have also been observed in the PNPS impingement sampling program.

Atlantic cod (*Gadus morhua*)

The Atlantic cod is a demersal fish found on both sides of the Atlantic Ocean (Mayo and O'Brien 2000, in Fahay et al. 1999a). As the cod become juveniles and adults, they are able to withstand deeper, colder, and more saline water, and become more widely distributed (Fahay et al. 1999a). Some studies have shown that juveniles tend to prefer shallow areas with cobble substrates, in order to avoid predation (Gotceitas and Brown 1993, in Fahay et al. 1999a). The average age and size of cod at maturity has changed through time, with adults reaching maturity at smaller size and younger age. In 1959, median age at maturity was reported to be 5.4 years (males) and 6.2 years (females), and by 1994 the ages were reported to be between 1.7 years (males) and 2.3 years (females) (Lough 2004). This trend is attributed to harvesting of the adult cod (Fahay et al. 1999a). Peak spawning within Massachusetts Bay occurs in January and February (Lough 2004). Juveniles and younger adults tend to consume pelagic and benthic invertebrates, while adult cod also feed on both crustaceans and other fish, including sand lance, cancer crabs (*Cancer* spp.), and herring (Lough 2004). Eggs and larvae are subject to being preyed upon by planktivorous fish, including Atlantic herring and Atlantic mackerel, and juveniles can be preyed upon by piscivorous fish such as dogfish, silver hake, sculpin, and larger cod (Edwards and Bowman 1979, in Fahay et al. 1999a).

The Atlantic cod is distributed throughout the western North Atlantic Ocean from Greenland to Cape Hatteras, with the highest densities in the U.S. being highest on Georges Bank and the western Gulf of Maine (Lough 2004). There are two separate stocks of cod within U.S. waters: a stock within the Gulf of Maine and a second stock at Georges Bank and southward (Mayo and O'Brien 2000). Within the temperate part of their range, including offshore New England, cod are non-migratory, and only make minor seasonal movements in response to temperature changes. At the extremes of their range, including Labrador and south of the Chesapeake, the cod migrate annually (Fahay et al. 1999a). Cod are generally found in areas over rough bottoms with water depths from 10 to 150 m (33 to 492 ft), and at temperatures between 0 and 10°C (32 and 50°F) (ENSR 2000). All stages of cod are reported to be common in Cape Cod Bay (Fahay et al. 1999a). Adult cod are reported to be abundant in the western portion of Cape Cod Bay in the spring (Fahay et al. 1999a), and occur in large numbers throughout Cape Cod Bay in the fall (Lough 2004).

Commercial and recreational fisheries for cod in the U.S. are managed under the NEFMC Northeast Multispecies FMP (Mayo and O'Brien 2000). The status of the Gulf of Maine stock indicates that the cod is possibly in an overfished condition. Annual landings have declined since 1991, and the stock is considered depressed and overexploited (Fahay et al. 1999a). In 2001, NMFS reported that the Gulf of Maine stock was not overfished, but that overfishing was occurring, and recommended further management actions to enhance spawning potential and the rate of recovery of the stock (NMFS 2001b, in Fahay et al. 1999a). Additional assessments were conducted in 2002 and 2005, and concluded that the stock was in an overfished condition, and that overfishing was still occurring (Mayo and Col 2005a). In 2005, an analysis of juvenile populations resulted in a proposal for the potential designation of HAPCs for the Atlantic cod, including areas within Cape Cod Bay, adjacent to PNPS (Crawford et al. 2005). Eggs and larvae of the Atlantic cod have been collected in the PNPS entrainment sampling. Juveniles and/or adults have also been observed in the PNPS impingement sampling program.

Atlantic halibut (*Hippoglossus hippoglossus*)

The Atlantic halibut, the largest flatfish species, is found on both sides of the North Atlantic Ocean, as well as in the Arctic Ocean (Cargnelli et al. 1999c). The halibut supported a U.S. commercial fishery beginning in the early 1800s, but the fishery had collapsed by the 1940s (Cargenelli et al. 1999c). The eggs of the halibut are bathypelagic, suspended within the water column at a depth of 54 to 200 m (175 to 656 ft) (Scott and Scott 1988; Blaxter et al. 1983, in Cargenelli et al. 1999c). Larvae are pelagic and live within this zone until they reach juvenile stage, at which time they transform into flatfish and migrate to the bottom (BMLSS 1997/8, in ENSR 2000). The age of maturity for halibut is approximately 10 years (Cargnelli et al. 1999c).

The Atlantic halibut in the Gulf of Maine and Georges Bank spawns over rough or rocky bottom substrates on the slopes of the continental shelf, or on offshore banks, at depths greater than 183 m (600 ft) (Scott and Scott 1988, in Cargnelli et al. 1999c). Spawning is reported to occur in late fall or spring, with peak spawning between November and December (NEFMC 1998a, in ENSR 2000). However, spawning is thought to no longer occur in the Gulf of Maine (Cargnelli et al. 1999c). The diet of the Atlantic halibut changes through its lifespan. Juveniles and smaller adults prey mostly on invertebrates, including annelids and crustaceans. As they grow larger, the adults prey primarily on other fish (Kohler 1967, in Cargnelli et al. 1999c). In the Gulf of Maine, the primary prey is squid, crabs, silver hake, northern sand lance, ocean pout (*Macrozoarces americanus*), and alewife (Cargnelli et al. 1999c).

The range of the western North Atlantic halibut is from Labrador to Long Island (Cargnelli et al. 1999c). In U.S. waters, their abundance is greatest in the Georges Bank, Nantucket Shoals, Stellwagen Bank, and off the coast of Maine and Massachusetts (Cargnelli et al. 1999c). However, only 18 halibut, all juveniles, were captured in trawl surveys in Massachusetts between 1978 and 1997 (Cargenelli et al. 1999c). Juveniles live within their nursery areas until the age of three to four years, and after that time perform annual migrations (Stobo et al. 1988, in Cargnelli et al. 1999c). The species lives at depths of 100 to 700 m (328 to 2297 ft), with most commercial catches made at 200 to 300 m (656 to 984 ft) (Scott and Scott 1988, in Cargnelli et al. 1999c). The species is found in areas with substrates of sand, gravel, and clay (NEFMC 1998a, in ENSR 2000), and at temperatures from -0.5 to 13.6°C (31.1 to 56.5°F) (Mahon 1997, in Cargnelli et al. 1999c).

The Atlantic halibut population was considered to be in an overfished condition in the late 1990s (NMFS 1997, in Cargnelli et al. 1999c). It was designated as a species of concern in 2004, and no directed fishing mortality is permitted until the stock is rebuilt (Cargnelli et al. 1999c). In a 2004 stock assessment, it was determined that the stock was overfished, but that there were not enough data upon which to determine whether overfishing was occurring

(Brodziak and Col 2005). No life stages of the Atlantic halibut have ever been observed in the PNPS entrainment or impingement sampling.

Atlantic sand lance (*Ammodytes americanus)*

The Atlantic sand lance is found in the western North Atlantic from Cape Hatteras north to Labrador, Hudson Bay, and western Greenland (Fisheries and Oceans Canada 2006). The species is small (rarely over 6 in. long) and forms schools consisting of thousands of individuals. The species is not directly fished for commercial purposes, but it is an important bait fish in fisheries such as those in the Stellwagen Bank area. Spawning occurs in the winter, with females releasing over 20,000 eggs that settle and attach to the sandy substrate. Larval sand lance are pelagic and drift with tides and currents for approximately two months. The species becomes sexually mature at an age of two years and may live to about five years of age (Provincetown Center for Coastal Studies 2006).

Sand lance is an important prey species for many demersal fish species and the endangered fin whale (*Balaenoptera physalus*) and humpback whale (*Megaptera novaengliae*) (Winters 1983). Sand lance typically live in shallow water less than 90 m (295 ft) deep, along the coast or above offshore banks, and in areas with sand or gravel substrates. The species burrows into the sand in the intertidal zone, allowing it to be harvested by persons on foot, with shovels, to be used as bait (Fisheries and Oceans Canada 2006). Larvae of the Atlantic sand lance are frequently observed in the PNPS entrainment sampling and are periodically observed in the impingement sampling (Normandeau 2006a, Normandeau 2006b). Eggs and larvae of the Atlantic sand lance have been collected in the PNPS entrainment sampling. Juveniles and/or adults have been observed in the PNPS impingement sampling program.

Atlantic tomcod (*Microgadus tomcod*)

The Atlantic tomcod is a demersal, anadromous species found from southern Labrador to Virginia. Eggs of the species form globules that sink to the bottom, and only develop in fresh or brackish water. Spawning occurs from November to February, in estuaries north of the Hudson River (Stewart and Auster 1987). After hatching, the larvae float to the surface and are swept out to estuaries, where they develop into juveniles. The species generally lives in brackish or fresh water at depths shallower than 10 m (33 ft) in coastal areas, and has been found in landlocked lakes in Canada (Fishbase 2006). Atlantic tomcod feed principally on small crustaceans and to a lesser extent on polychaete worms, mollusks, and fish (Bigelow and Schroeder 1953 in Stewart and Auster 1987).

The species was an important commercial species in the 1800s in Massachusetts, but was not targeted in the 20th century (Stewart and Auster 1987). Currently, the species is the target of a minor commercial fishery and is also fished recreationally (Fishbase 2006). Atlantic tomcod larvae have been observed in the PNPS entrainment sampling (Normandeau 2006a). Juveniles and/or adults are one of the numerically dominant species collected as part of the PNPS impingement sampling (Normandeau 2006b).

Cunner (*Tautogolabrus adspersus*)

The cunner is a marine species that is common along the western North Atlantic coast from Labrador to the Chesapeake Bay. Cunner become sexually mature at the age of two years (Serchuk and Cole 1974, in ENSR 2000). Cunner spawn from late spring to summer in water temperatures between 12 to 22°C (53.6 to 71.6°F). In Cape Cod Bay, cunner spawning occurs primarily from late March through mid July (MRI 1992, in ENSR 2000). Cunner commonly spawn in pairs or groups, depending on the conditions (Wicklund 1970, Pottle and Green 1979; in ENSR 2000). The species forages on a variety of benthic invertebrates, predominantly blue mussels (*Mytilus edulis*), barnacles, soft shell clams, amphipods, shrimp, and small lobsters.

Cunner are associated with rocky subtidal environments such as that found in the vicinity of PNPS. The cunner typically lives in rocky areas that are covered with algae, and among pilings and shipwrecks that can provide shelter (ENSR 2000). Because of this association with shelter in shallow water, the intake breakwaters and discharge jetties at PNPS provide a high-relief, structurally complex habitat for the cunner (ENSR 2000). Additionally, two nearby areas, Rocky Point and White Horse Beach, provide habitat important for settlement of cunner larvae, although these areas do not appear to be as important to recruitment success as the discharge area (Lawton et al. 2000). Cunner are found primarily between 3 and 10 m (9.8 and 32.8 ft) deep, but have been caught as deep as 150 m (492 ft) on Georges Bank (ENSR 2000). Cunner are year-round residents, and do not migrate except for movements to deeper water during deep freezes (Green and Farwell 1971, in ENSR 2000). Because the species does not migrate long distances, population trends may be an indicator of local stressors (ENSR 2000). The PNPS area provides cunner spawning and nursery grounds due to the breakwater walls creating an ideal habitat; therefore, cunner have a high incidence of entrainment and impingement at PNPS relative to other species (Lawton et al. 2000).

Cunner eggs and larvae are commonly found in the entrainment samples, and adult cunner are frequently found in the impingement collections. The species was the focus of investigative programs at PNPS from 1990 to 1997, because of the relatively high incidence of eggs and larvae entrained. Based on the results of these studies, it appears that PNPS has a minor effect on recruitment success to the local cunner population (Lawton et al. 2000). Eggs and larvae of the cunner have been consistently collected in the PNPS entrainment sampling and are one of the numerically dominant species in the entrainment collections. Juveniles and/or adults have also been observed in the PNPS impingement sampling program.

Fourbeard rockling (*Enchelyopus cimbrius*)

The fourbeard rockling is a demersal fish found from the northern Gulf of Mexico to Newfoundland, Greenland, and throughout the northeast Atlantic coast of Europe. The species typically spawns in waters less than 140 m (459 ft) deep. Adults feed on flatfish, amphipods, decapods, copepods, and small crustaceans (Census of Marine Life 2006). The species reaches a maximum age of about nine years (Deree 1999).

The species is a sedentary bottom dweller, living on mud or muddy sand substrates on the continental slope (Census of Marine Life 2006; Bigelow and Schroeder 1953, in Deree 1999). The typical depth range for the species is from 20 to 650 m (66 to 2132 ft) (Census of Marine Life 2006). Fourbeard rockling eggs and larvae are frequently observed in the PNPS entrainment sampling (Normandeau 2006a). Fourbeard rockling have also been collected as part of the PNPS impingement sampling; however, this only occurred during 1998 (Normandeau 2006b).

Fourspot flounder (*Paralichthyus oblongus*)

The fourspot flounder is a benthic species found along the western Atlantic coast from Georges Bank to South Carolina (Gulf of Maine Research Institute 2006). The eggs are buoyant, but the larvae complete transformation and move to the bottom within 3 months of hatching (Gulf of Maine Research Institute 2006). Spawning occurs from May to mid-July (Census of Marine Life 2006). The species’ habitat includes bays and sounds, at water depths up to 275 m (902 ft) (Robins et al. 1986).

Fourspot flounder eggs and larvae have been observed in the PNPS entrainment sampling (Normandeau 2006a). Fourspot flounder have also been periodically collected as part of the PNPS impingement sampling (Normandeau 2006b). Eggs and larvae of the fourspot flounder have been collected in the PNPS entrainment sampling. Juveniles and/or adults have been observed in the PNPS impingement sampling program.

Haddock (*Melanogrammus aeglefinus*)

The haddock is a demersal gadoid species found on both sides of the North Atlantic (Brown 2000). Eggs, larvae, and juveniles all live within the upper part of the water column until the juveniles reach a size of 3 to 10 cm (1 to 4 in.) (Brodziak 2005). At that time, juveniles travel to the bottom, locate suitable habitat, and become demersal (Klein-MacPhee 2002, in Brodziak 2005). Spawning varies by location and time of year, with spawning generally occurring from February to May in the Gulf of Maine. The largest spawning area in U.S. waters is Georges Bank, and for the Gulf of Maine stock, spawning occurs at the Jeffrey's Ledge and

Stellwagen Bank areas (Brodziak 2005). Spawning can occur over substrates of various types, including rock, gravel, sand, or mud (Klein-MacPhee 2002, in Brodziak 2005). The size and age at maturity vary by location and population density, and have also been decreasing through time (Cargnelli et al. 1999a). Spawning in the Gulf of Maine peaks from February to April (Bigelow and Schroeder 1953, in Cargnelli et al. 1999a). The diet of haddock changes through their life cycle. Larvae and small juveniles feed on phytoplankton, copepods, and invertebrate eggs suspended in the water column. Once juveniles move to the bottom, they primarily eat small crustaceans, polychaetes, and small fish. As adults, the haddock feed primarily on benthic organisms such as echinoderms, crustaceans, polychaetes, and mollusks (Brodziak 2005).

The haddock is distributed throughout the western North Atlantic Ocean from Cape May, New Jersey to Newfoundland (Brodziak 2005). Haddock are generally found at depths of between 45 and 135 m (147 to 443 ft), and at temperatures between 2 and 10°C (35.6 to 50°F) (Brown 2000). The preferred bottom types include gravel, pebbles, and smooth hard sand, and this preference appears to result in the location of primary spawning areas on Georges Bank, and in isolated locations within the Gulf of Maine (Lough and Bolz 1989; Colton 1972, in Cargenelli et al. 1999a). Data suggest that larvae drift with currents from Canadian waters as far south as Cape Cod, and then live a portion of their life in this area (Colton and Temple 1961, in Cargnelli et al. 1999a). Haddock are not migratory, with only minor movements shoreward in summer, and to deeper water in winter (Brodziak 2005). In inshore trawl surveys, juveniles were found in Cape Cod Bay in low numbers in autumn, but were not found in the bay in spring. Adults were not found in the bay (Cargnelli et al. 1999a; GOMCML 2006).

Six separate haddock stocks have been identified in the western North Atlantic, with two stocks recognized in U.S. waters in the Gulf of Maine and Georges Bank (Brodziak 2005). The U.S. fishery for haddock is managed under the NEFMC Northeast Multispecies FMP (Brown 2000). The Gulf of Maine stock was overfished as of 2004 (NMFS 2001a; Brodziak 2005). However, numbers of haddock in the Gulf of Maine have increased since they reached their lowest levels in the early 1990s, and the age structure has broadened as well. In a 2004 assessment, the determination was made that the stock was overfished, but overfishing was not occurring (Brodziak and Traver 2005). Similarly, the Georges Bank stock, although still in an overfished condition, had rebounded substantially due to fishery management measures (Brodziak 2005). However, in 2005, an analysis of juvenile populations resulted in a proposal for the potential designation of HAPCs for the haddock, including areas within Cape Cod Bay, adjacent to PNPS (Crawford et al. 2005). Eggs and larvae of the haddock have been collected in the PNPS entrainment sampling. Juveniles and/or adults have not been observed in the PNPS impingement sampling program.

Little skate (*Leucoraja erinacea*)

The little skate is a dominant species among the demersal fish community in the western North Atlantic (Bigelow and Schoeder 1953, in Packer et al. 2003b). The little skate is often confused with the larger winter skate due to similarity in appearance, but the little skate is far more common (McEachran and Musick 1975, in Packer et al. 2003b). Skates are fished commercially, but with no distinction among the seven species (Packer et al. 2003b). Most commercial use of skates, including the little skate, is for lobster bait (Sosebee 2000c). Eggs of all skates are encapsulated in a leathery capsule that rests on the bottom (Sosebee 2000c; Packer et al. 2003b). The eggs hatch fully developed, so there is no larval stage (Sosebee 2000c; McEachran 2002, in Packer et al. 2003b). Adults are estimated to reach sexual maturity at the age of four years (NMFS 2000, in Packer et al. 2003b). Spawning may occur at any time during the year, with a peak in southern New England from July to September (Bigelow and Schroeder 1953, in Packer et al. 2003b). The major prey reported for the little skate in the Gulf of Maine area includes decapod crustaceans, amphipods, and polycheates. (McEachran 1973; McEachran et al. 1976, in Packer et al. 2003b).

The little skate is most commonly found on the Georges Bank, and in the northern section of the Mid-Atlantic Bight (McEachran and Musick 1975, in Packer et al. 2003b). The little skate is found through the year in these areas, including the entire range of temperatures that occur in those areas (McEachran and Musick 1975, in Packer et al. 2003b). Skates have been landed as bycatch in New England since the late 1960s, but were not directly targeted as a fishery until the 1980s. There is no stock differentiation among the skate species. Little skate have a reported depth range of 0 to 137 m (0 to 450 ft), with most being found less than about 100 m (328 ft) deep (Bigelow and Schroeder 1953; McEachran and Musick 1975, in Packer et al. 2003b). The corresponding water temperature ranges from 1 to 21°C (33.8 to 69.8°F) (Bigelow and Schroeder 1953; Tyler 1971; McEachran and Musick 1975, in Packer et al. 2003b). Little skates typically prefer sandy or gravelly substrates (Bigelow and Schroeder 1953, in Packer et al. 2003b), and are known to bury themselves in depressions during the day (Michalopouloos 1990, in Packer et al. 2003b). Skates do not migrate substantially, but generally move offshore in summer and early autumn and onshore during winter and spring (Sosebee 2000c). Bottom trawl surveys found juvenile little skates in heavy concentrations nearshore in Cape Cod Bay in the spring (Packer et al. 20003b). Adults were also found in Cape Cod Bay during the spring, summer, and fall (Packer et al. 2003b). Little skate abundance has increased since the early 1980s, and as of 2000 was at its highest numbers since 1975 (Sosebee 2000c). According to a 2000 stock assessment, the little skate was not overfished, and overfishing was not occurring (NMFS 2000, in Packer et al. 2003b). No life stages of the little skate have ever been observed in the PNPS entrainment sampling. Juveniles and/or adults have been observed in the PNPS impingement sampling program.

Monkfish (*Lophius americanus*)

The common name used for this species in commercial fishing is monkfish, but the name recognized by the American Fisheries Society is goosefish (Steimle et al. 1999c). The monkfish is a solitary, bottom-dwelling angler fish occurring all along the eastern coast of the U.S. (primarily north of Cape Hatteras) and Canada up to Newfoundland (Steimle et al. 1999c). Eggs are buoyant, and are laid in rafts that may be up to 6 to 12 m (20 to 39 ft) long (Steimle et al. 1999c). Larvae and juveniles are also pelagic, and eventually descend to the bottom to live their adult lifespan as benthic fish (NOAA 1998, in ENSR 2000). Once they have settled to the bottom, juveniles prefer a substrate of sand-shell mix, algae-covered rocks, hard sand, pebbly gravel, or mud, with water temperatures below 15°C (59°F) (NEFMC 1998a, in ENSR 2000). Adults spend most of their lives resting on the bottom in depressions within sandy sediment (Steimle et al. 1999c). The monkfish becomes sexually mature between the ages of four and five years (Wood 1982, in Steimle et al. 1999c). Spawning occurs in locations including inshore shoals and offshore surface water, in temperatures below 18°C (64.4°F), in the months of May and June within the Gulf of Maine (Scott and Scott 1988; Hartley 1995, in Steimle et al. 1999c). The larvae feed on zooplankton, including copepods and crustacean larvae, while juveniles eat smaller fish (including sand lance), shrimp, and squid (Bigelow and Schroeder 1953, in Steimle et al. 1999c). Adults eat a variety of benthic and pelagic species, sea birds, and even younger monkfish, and capture prey with an ambush or sudden rush (Steimle et al. 1999c). The age span of the monkfish ranges from 9 years for males to 12 years for females.

Monkfish are found throughout the continental shelf in waters shallower than 668 m (2192 ft). They are most commonly found in shallow waters of the Gulf of Maine during the summer (Steimle et al. 1999c). Although the monkfish population appears to exist as only one distinct stock, it is managed as two separate stocks, one north and one south of the Georges Bank (Steimle et al. 1999c; NEFMC 2006a). Adult monkfish generally inhabit waters from 70 to 100 m (230 to 328 ft) deep, and may also be found in inshore areas or at depths greater than 800 m (2625 ft) (Richards 2000). The monkfish are found in temperatures ranging from 0 to 24°C (32 to 75.2°F), most abundantly between 4 to 14°C (39.2 to 57.2°F) (Steimle et al. 1999c). The monkfish has annual migrations in search of spawning habitat and food. Monkfish were not extensively fished commercially until the 1970s. Since that time, harvests have increased and stock numbers have declined dramatically (Idoine 1995, in Steimle et al. 1999c). In 2000, the Monkfish FMP was developed by the NEFMC and MAFMC (NEFMC 2006b). Neither stock was considered to be overfished based on a stock assessment performed in 2004 (NMFS 2005a), but a 2006 assessment has concluded that both stocks are overfished (NEFMC 2006b). Eggs and larvae of the monkfish have been collected in the PNPS entrainment sampling. Juveniles and/or adults have also been observed in the PNPS impingement sampling program.

Ocean pout (*Macrozoarces americanus*)

The ocean pout is also known as eel pout or muttonfish. It is a bottom-dwelling, cool-temperate species that lives on the western North Atlantic continental shelf from Labrador to Virginia (Steimle et al. 1999b). The species lays eggs in nests, which it then guards until they hatch (Steimle et al. 1999b). Both the larvae and adults are demersal, and are not known to form schools (Steimle et al. 1999b). The ocean pout spawns in areas with hard bottom substrates, including artificial reefs or in rock crevices, in late summer through the early winter (Steimle et al. 1999b). Spawning peaks in the months of September and October (NEFMC 1998a, in ENSR 2000). Spawning occurs at depths of less than 50 m (164 ft), and temperatures of 10°C (50°F) or less (Clark and Livingstone 1982, in Steimle et al. 1999b). There are differing reports on how the ocean pout feeds. According to a report by MacDonald (1983, in Steimle et al. 1999b), ocean pout feed by sorting through mouthfuls of sediment for fauna contained within the sediment, and do not appear to visually follow prey or leave the bottom to feed. However, Auster (1985, in Steimle et al. 1999b) reported that ocean pout hide within sediment depressions to wait for prey to swim or drift by. The prey is reported to consist of echinoderms, crustaceans, and other benthic invertebrates (Anderson 1994, in ENSR 2000).

The range of the ocean pout on the continental shelf extends from Labrador to Delaware. It is managed as two separate stocks, a northern stock in the Gulf of Maine and a southern stock in Cape Cod Bay, Georges Bank, and south to Delaware (Wigley 2000a). However, studies suggest that there are up to five separate stocks, including one confined to the Gulf of Maine and Cape Cod Bay (Orach-Meza 1975, in Steimle et al. 1999b). The ocean pout does not migrate, although it moves seasonally within a limited region (Bigelow and Schroeder 1953, in Steimle et al. 1999b). The ocean pout lives at depths from 15 to 80 m (50 to 262 ft) (Wigley 2000a) and in water temperatures below 10°C (50°F) (NEFMC 1998a, in ENSR 2000). The ocean pout typically live and feed in areas with soft or sandy substrates, and move to rocky areas to spawn (Wigley 2000a). Juvenile ocean pout were reported to be commonly found in saline water (greater than 25 parts per thousand [ppt]) in many estuaries and coastal areas, including Cape Cod Bay, throughout the year (Jury et al. 1994, in Steimle et al. 1999b).

Of the two managed stocks, only the southern stock, which includes Cape Cod Bay, is commercially fished (Wigley 1998, in Steimle et al. 1999b). The population of ocean pout has varied considerably, with high levels in the 1960s, low levels in the 1970s, and record high levels again in the 1980s (Steimle et al. 1999b). The ocean pout are managed under the NEFMC's Northeast Multispecies FMP (Wigley 2000a). Although there is no clear trend, the population is considered to be fully exploited (Wigley 1998, in Steimle et al. 1999b). In a 2004 assessment, the stock was found to be overfished, but overfishing was not occurring at that time (Wigley and Col 2005b). In 2005, an analysis of juvenile populations resulted in a proposal for the potential designation of HAPCs for the ocean pout, including areas within Cape Cod

Bay, adjacent to PNPS (Crawford et al. 2005). The ocean pout has not been observed in the PNPS entrainment sampling. Juveniles and/or adults have been observed in the PNPS impingement sampling program.

Offshore hake (*Merluccius albidus*)

Offshore hake are found throughout the continental shelf and slope of the northwestern Atlantic from the Scotian Shelf to the Gulf of Mexico. The species has often been confused with the silver hake, which it resembles, resulting in a lack of research and fishery data specific to the species (Chang et al. 1999c). The offshore hake has mostly been fished as bycatch of the silver hake fishery (Chang et al. 1999c). Very little information exists on the early life stages, growth, or ages of the species (Chang et al. 1999c). Eggs and larvae are pelagic, and have been found off of Massachusetts from the months of April to July (Marak 1967, in Chang et al. 1999c). Juvenile offshore hake feed on small fish, shrimp, and other crustaceans, while adults eat other fish, including lantern fishes, sardines, and anchovies (Chang et al. 1999c).

In the northwestern Atlantic, the offshore hake is most commonly found along the outer edge of the Scotian Shelf (Chang et al. 1999c). Offshore hake in the Georges Bank-New England-Mid-Atlantic area are considered to be a single stock (Chang et al. 1999c). No information is available on migration of the offshore hake. The species appears to live at depths ranging from 70 to 640 m (230 to 2100 ft), with a concentration found at about 200 m (656 ft), throughout the year (Chang et al. 1999c). Larvae are reported to be abundant in continental shelf waters of the Gulf of Maine during the months of August and September. However, juveniles and adults were reported to be only rarely found within the Gulf of Maine (Chang et al. 1999c).

There is no directed fishery for offshore hake, so there has been no evaluation of the status of the stock (Chang et al. 1999c). No life stages of the offshore hake have ever been observed in the PNPS entrainment or impingement sampling.

Red hake (*Urophycis chuss*)

Red hake is a demersal species inhabiting bottom waters, ranging from Nova Scotia to North Carolina in the western North Atlantic continental slope (Cohen et al. 1990, in ENSR 2000). Both the eggs and larvae of the red hake are pelagic, occurring in surface waters less than 10°C (50°F) (eggs) and 19°C (66.2°F) (larvae) (NEFMC 1998a, in ENSR 2000). Shelter is an important habitat requirement for red hake (Steiner et al. 1982, in Steimle et al. 1999a). When the fish become juveniles, they migrate to shallower waters along the coast, and live among shell litter or live scallop beds (Cohen et al. 1990; NEFMC 1998a, in ENSR 2000). Adult red hake typically live in areas with soft sediment bottoms and less commonly near gravel or rock bottoms (Steimle et al. 1999a). Adults become mature at an age of about 1.5 years (Steimle et al. 1999a). The adults migrate in the spring to shallow waters for spawning, which can take place between May and November, with peaks in June and July (Sosebee 1998; NEFMC 1998a, in ENSR 2000). Spawning occurs in temperatures of 5 to 10°C (41 to 50°F) (Steimle et al. 1999a), within depressions in muddy or sandy substrates (NEFMC 1998a, in ENSR 2000). The primary spawning grounds include the southern edge of Georges Bank, and shallow areas off of the southern New England coast (Sosebee 1998, in ENSR 2000). Larvae feed mainly on copepods and other micro-crustaceans (Steimle et al. 1999a). Juvenile red hake feed primarily on crustaceans such as amphipods and shrimp, and the adults feed on amphipods and shrimp, as well as squid, herring, flatfish, and mackerel (Cohen et al. 1990, in ENSR 2000).

Red hake are most commonly found between Georges Bank and New Jersey (Sosebee 1998, in Steimle et al. 1999a). Red hake migrate extensively due to seasonal and temperature variations. During winter, they live offshore in water greater than 100 m (328 ft) deep, but in summer, red hake migrate into shallow coastal water and estuaries of the Gulf of Maine, and live in water less than 10 m (33 ft) deep (Steimle et al. 1999a). Red hake generally live in bottom waters over a substrate of mud or sand (Cohen et al. 1990; NEFMC 1998a, in ENSR 2000). In the spring and summer, red hake undergo seasonal migration from offshore deeper water to nearshore shallow waters (Sosebee 1998, in ENSR 2000).

Two stocks are recognized for management of the red hake, a northern stock from the Gulf of Maine to northern Georges Bank and a southern stock from Georges Bank to the Mid-Atlantic Bight (Sosebee 1998, in Steimle et al. 1999a; Brodziak 2001b). The red hake fishery is managed under the Northeast Multispecies FMP under the "nonregulated multispecies" category (Brodziak 2001b). Both the northern and southern stocks were considered underexploited as recently as 1998. In 2001, the stock appeared to be healthy, and yields could be increased (Brodziak 2001b). Eggs and larvae of the red hake have been collected in the PNPS entrainment sampling. Juveniles and/or adults have also been observed in the PNPS impingement sampling program.

Rock gunnel (*Pholis gunnellus)*

The rock gunnel is a demersal species found on both sides of the Atlantic, with the population in the western Atlantic ranging from Labrador to Delaware Bay (Robins et. al 1986). In warm months, the species lives in shallow coastal waters, and is often stranded in tide pools (Biomes Marine Biology Center 2006). In winter, the species migrates to offshore waters up to 100 m (328 ft) deep (Census of Marine Life 2006). The habitat consists of areas with rocky or shell fragment substrates where the species finds shelter, and feeds on worms and small crustaceans (Biomes Marine Biology Center 2006). The spawning season occurs from November to January (Census of Marine Life 2006). The species is not the target of commercial fisheries. Rock gunnel larvae have been observed in the PNPS entrainment sampling (Normandeau 2006a). Rock gunnel have also been periodically collected as part of the PNPS impingement sampling (Normandeau 2006b).

Scup (*Stenotomus chrysops*)

The scup is a demersal, temperate fish found in the western Atlantic (Steimle et al. 1999f). Scup are fished both commercially and recreationally, although both types of landings have declined (MAFMC 1996a, in Steimle et al. 1999f). Both eggs and larvae are pelagic, and the larvae become demersal in shoal areas in early July (Able and Fahay 1998, in Steimle et al. 1999f). The adults can occupy a variety of benthic habitats, from open water to structured areas (Steimle et al. 1999f). Adult scup become sexually mature by the age of three years (Gabriel 1998, in Steimle et al. 1999f). Southern New England, including Massachusetts Bay, is considered to be a primary spawning area for scup (Steimle et al. 1999f). Scup spawn in shallow shoal waters less than 10 m (33 ft) deep until late June, and then move to deeper water (MAFMC 1996a, in Steimle et al. 1999f). Both juvenile and adult scup are benthic feeders. Adults eat small crustaceans, polychaetes, mollusks, small squid, detritus, insect larvae, sand dollars, and small fish (Bigelow and Schroeder 1953; Morse 1978; Sedberry 1983, in Steimle et al. 1999f).

The scup is known to occur in the western Atlantic from the Bay of Fundy to Florida, but is most commonly found from Massachusetts to South Carolina (Steimle et al. 1999f). Adults are abundant in schools in the Mid-Atlantic Bight from spring to fall, and live in areas with bottom substrates ranging from open sandy bottoms to mussel beds, reefs, or rocks (Steimle et al. 1999f). The temperature range for scup is from 6 to 27°C (42.8 to 80.6°F) (Neville and Talbot 1964, in Steimle et al. 1999f). Smaller scup are frequently found in bays and estuaries, but larger adult scup usually live in deeper water ranging from 70 to 180 m (230 to 590 ft) (Steimle et al. 1999f). Larval scup were reported in Cape Cod Bay in May through September, in water temperatures of 14 to 22°C (52.7 to 71.6°F) (MAFMC 1996a, in Steimle et al. 1999f).

Some researchers have considered the population in the Mid-Atlantic Bight area to be two separate stocks, but it is now considered to be a single stock (Pierce 1981; Mayo 1982, in Steimle et al. 1999f; Terceiro 2001a). The fishery is managed under the Summer Flounder, Scup, and Black Sea Bass FMP (Terceiro 2001a). In the late 1990s, the Mid-Atlantic Bight stock was considered overfished because the biomass was at near record low levels (Gabriel 1998; NMFS 1997, in Steimle et al. 1999f). However, a 2002 stock assessment concluded that the stock is not overfished and that the status with respect to overfishing could not be evaluated (NMFS 2002a). This report noted that this conclusion was based on anomalously high abundance estimates in 2002, compared to 2001, and that the sudden increase created uncertainty in the data (NMFS 2002a). The 2006 ASMFC report considers the scup population to be overfished, while the overfishing status is not known (ASMFC 2006). Eggs and larvae of the scup have been collected in the PNPS entrainment sampling. Juveniles and/or adults have also been observed in the PNPS impingement sampling program.

Silver hake / Whiting (*Merluccius bilinearis*)

Silver hake, also known as whiting, is a demersal fish that lives in a range from Nova Scotia to South Carolina (Bigelow and Schroeder 1953; NEFMC 1998a, in ENSR 2000), and is most abundant from Nova Scotia to New Jersey (Lock and Packer 2004). Silver hake eggs and larvae are pelagic, existing in the water column at depths between 50 and 150 m (164 to 492 ft) (NEFMC 1998a, in ENSR 2000). As larvae mature into juveniles, they settle to the bottom (Lock and Packer 2004). As adults, silver hake are found in water ranging from shallow to depths greater than 400 m (1312 ft) (Dery 1988a; Bolles and Begg 2000, in Lock and Packer 2004). Silver hake become sexually mature between the ages of two and three years (Mayo 1998a, in ENSR 2000). The adults spawn over a variety of substrates in the Gulf of Maine, Georges Bank, and the southern New England area south of Martha's Vineyard (Lock and Packer 2004). Spawning within the Gulf of Maine generally begins in June, with a peak in July to August (Lock and Packer 2004). Juvenile silver hake feed mainly on crustaceans (Cohen et al. 1990, in ENSR 2000), and the adults feed on both fish and pelagic invertebrates, such as shrimp and squid (Mayo 1998a, in ENSR 2000). Silver hake is a dominant predator species on the continental shelf in the northwestern Atlantic, and its large biomass and high consumption affect help to regulate the ecosystem (Bowman 1984; Garrison and Link 2000, in Lock and Packer 2004).

Silver hake spend the winter in deep waters of the Gulf of Maine and outer continental shelf, and then migrate annually to shallow offshore waters in the spring (Mayo 1998a, in ENSR 2000). Adults tend to live in cool bottom water at temperatures lower than 13°C (55.4°F), and with a variety of substrates (NEFMC 1998a, in ENSR 2000). The migration of silver hake is seasonal. The northern stock moves to the deep basins of the Gulf of Maine during the winter, and migrates into nearshore waters in the Gulf of Maine in the spring and summer (Lock and Packer 2004). Trawl surveys conducted for silver hake in 1999 identified concentrations of silver hake in Cape Cod Bay in spring and autumn (Reid et al. 1999a, in Lock and Packer 2004). A summary of annual NMFS Bottom Trawl Survey data identified substantial numbers of silver hake in Cape Cod Bay during the fall every year between 1979 and 2003, but found a more limited number in the bay during the spring in those years (GOMCML 2006).

Silver hake in the U.S. are divided into northern (Gulf of Maine to northern Georges Bank) and southern (Georges Bank to Cape Hatteras) stocks for management purposes (NEFMC 2003).

The silver hake fishery is managed under the NEFMC Northeast Multispecies FMP under the "nonregulated multispecies" category (Brodziak 2001a). Based on data presented in the 2006 Assessment Summary Report, neither the northern nor southern stock of the silver hake is in an overfished condition, and overfishing is not occurring (NMFS 2006a). The northern stock is at a high biomass level (Lock and Packer 2004). The southern stock was reported to be overfished in 2001 (NMFS 2001a), and although not currently overfished, the southern stock still has a low biomass level resulting from this overfishing in 1998-2000 (NEFMC 2003). Eggs and larvae of the silver hake have been collected in the PNPS entrainment sampling. Juveniles and/or adults have also been observed in the PNPS impingement sampling program.

Smooth skate (*Malacoraja senta*)

The smooth skate occurs along the Atlantic coast of North America from the Gulf of St. Lawrence and the Labrador Shelf to South Carolina (Bigelow and Schroeder 1953; McEachran 1973; McEachran and Musick 1975, in Packer et al. 2003d). It is one of seven species of skates found throughout the northwestern Atlantic (Sosebee 2000c). Skates are fished commercially, but with no distinction among the seven species (Packer et al. 2003d). Most commercial use of skates, including the smooth skate, is for lobster bait (Sosebee 2000c). Little information is known of the life history of the smooth skate (Packer et al. 2003d). Eggs of all skates are known to be encapsulated in a leathery capsule that rests on the bottom (Sosebee 2000c; Packer et al. 2003d). The eggs hatch fully developed, so there is no larval stage (Sosebee 2000c; also McEachran 2002, in Packer et al. 2003d). Females with fully formed egg capsules are found in both summer and winter (McEachran 2002, in Packer et al. 2003d), but no other information on spawning times or locations is available. The primary food source for the smooth skate is epifaunal crustaceans, with decapod shrimps and mysids also being important (McEachran 1973; McEachran et al. 1976; Bowman et al. 2000; McEachran 2002, in Packer et al. 2003d).

The Gulf of Maine is reported to be the center of abundance for the smooth skate (Bigelow and Schroeder 1953; McEachran and Musick 1975; McEachran 2002, in Packer et al. 2003d), including Massachusetts Bay (Collette and Hartel 1988, in Packer et al. 2003d). Skates have been landed as bycatch in New England since the late 1960s, but were not directly targeted until the 1980s. There is no stock differentiation among the skate species.

The water depth range for the smooth skate is from 31 to 874 m (102 to 2867 ft), with most being found from 110 to 457 m (361 to 1499 ft) (McEachran and Musick 1975; McEachran 2002, in Packer et al. 2003d). The temperature range of the species is from 2 to 13°C (35.6 to 55.4°F) for juveniles and adults, with most found between temperatures of 4 to 8°C (39.2 to 46.4 °F) (Packer et al. 2003d). The smooth skate is found mostly on bottom substrates of soft mud and fine sediments (Bigelow and Schroeder 1953; McEachran and

Musick 1975; Scott 1982a, in Packer et al. 2003d). Skates do not migrate substantially, but do generally move offshore in summer and early autumn, and onshore during winter and spring (Sosebee 2000c). No seasonal trends in abundance were identified by McEachran and Musick (1975, in Packer et al. 2003d). Inshore trawl surveys in Massachusetts identified juveniles in both the spring and fall near Cape Cod Bay (Packer et al. 2003d).

In the 2000 stock assessment, the smooth skate was considered to be overfished (NMFS 2000, in Packer et al. 2003d). However, the 2002 assessment determined that the species was not in an overfished condition at that time (NMFS 2002b, in Packer et al. 2003d). No life stages of the smooth skate have ever been observed in the PNPS entrainment or impingement sampling.

Summer flounder (*Paralicthys dentatus*)

The summer flounder, also known as fluke, inhabits shallow estuarine waters and the outer continental shelf from Nova Scotia to Florida (Packer et al. 1999). The species is important along the east coast both as a commercial and recreational fishing resource, with recreational landings exceeding commercial landings in some years (Packer et al. 1999). Both eggs and larvae of the species are buoyant and pelagic. Eggs are most abundant in the western North Atlantic in October and November, and larvae are most abundant from October to December (Able et al. 1990, in Packer et al. 1999). The larvae are transported toward coastal areas by the prevailing water currents, and development of post-larvae and juveniles occurs primarily within bays and estuarine areas (ENSR 2000). Sexual maturity is reached by the age of two years (Morse 1981, in Packer et al. 1999). The timing of spawning varies by location. In southern New England and the Mid-Atlantic, spawning occurs primarily in September (Berrien and Sibunka 1999, in Packer et al. 1999). Spawning occurs in open ocean areas of the shelf (Packer et al. 1999), in waters ranging from 30 to 200 m (98 to 656 ft) deep (ENSR 2000). The timing of spawning appears to coincide with the maximum production of autumn plankton, which is the primary food source for larvae (Morse 1981, in Packer et al. 1999). Juvenile summer flounder feed upon crustaceans and polychaetes, and as they grow larger they begin to feed more on fish (Packer et al. 1999). Adults are opportunistic feeders, preying mostly on fish and crustaceans (Packer et al. 1999). Species preyed upon include windowpane flounder, winter flounder, Atlantic menhaden, red hake, silver hake, scup, Atlantic silverside, and bluefish, among others (Packer et al. 1999).

Although found all along the east cost, the primary center of abundance for the summer flounder is the area from Cape Cod to Cape Hatteras (Packer et al. 1999). Adult summer flounder in Massachusetts migrate inshore in May, and migrate to offshore waters in late fall (Packer et al. 1999). Inshore trawl surveys in Massachusetts found seasonal variation in the depths and temperatures at which adults were caught. In the spring, adults were found at depths from 0 to 360 m (0 to 1181 ft), at temperatures between 8 to 16°C (46.4 to 60.8°F). In the summer and autumn, the species was found almost entirely at depths shallower than 100 m (328 ft), in water between 15 to 28°C (59 to 82.4°F). In the winter, the species is found in deeper locations, greater than 70 m (230 ft), in temperatures between 5 to 11°C (41 to 51.8°F) (Sissenwine et al. 1979, in Packer et al. 1999). The shoal waters of Cape Cod Bay, including estuaries and harbors, are considered to be critically important habitat for the species (Packer et al. 1999).

The species is managed as a single stock, although it is possible that different stocks exist, with some information suggesting different stocks north and south of Cape Hatteras (Packer et al. 1999). The fishery is managed under the summer flounder, scup, and black sea bass FMP (Terceiro 2001b). As of 1999, the stock was considered to be at a medium level of its historical abundance and was over-exploited (Terciero 1995; NMFS 1997, in Packer et al. 1999). More recently, total stock biomass is reported to have increased substantially since 1989 (NMFS 2005b). The 2006 ASMFC report indicates the stock is not currently considered to be overfished, but overfishing is occurring (NMFS 2005b, ASMFC 2006). Eggs and larvae of the summer flounder have been collected in the PNPS entrainment sampling. Juveniles and/or adults have also been observed in the PNPS impingement sampling program.

Tautog (*Tautoga onitis*)

The tautog is an inshore species ranging from Nova Scotia to South Carolina, and is popular for recreational fishing from Cape Cod south to Delaware (MDMF 2006). The eggs of the tautog are buoyant, and hatch within two days. Within four days after hatching, the pelagic larvae begin feeding on plankton. Juvenile and adult tautog feed on shallow water invertebrates, and have flat, grinding teeth that allow them to open the shells of mussels. Spawning in Massachusetts occurs in June, in inshore waters containing eelgrass beds, at water temperatures of 62 to 70°F (17 to 21°C). The species becomes sexually mature at an age of about three to four years, and can live to be 35 years of age (MDMF 2006).

The species lives in inshore areas at water depths of less than 60 ft deep, including rocky areas around breakwaters and pilings along the coast (Robins et al. 1986). Adults do not undertake long migrations, but feed inshore in spring and move offshore to waters 50 to 150 ft deep in winter (MDMF 2006).

Until recently, population levels were considered to have remained relatively stable since colonial times, as the species was not commercially fished. In the early 1980s, a commercial fishery developed, and recreational landings increased substantially as well. By the early 1990s, the average size of landed tautog was much smaller, which led to State fishery restrictions (MDMF 2006). In a 2004 assessment, tautog were considered to be overfished and believed to be at low population levels (NEFSC 1998, in Normandeau 2006a). Tautog eggs and larvae have been observed in the PNPS entrainment sampling (Normandeau 2006a). Tautog have been periodically collected as part of the PNPS impingement sampling (Normandeau 2006b).

Thorny skate (*Amblyraja radiata*)

The thorny skate occurs on both sides of the Atlantic Ocean (Packer et al. 2003c), and is one of seven species of skates found throughout the western North Atlantic (Sosebee 2000c). Skates are fished commercially, but with no distinction among the seven species (Packer et al. 2003c). Most commercial use of skates is for lobster bait, but two skates (including the thorny skate) are used for human consumption (Packer et al. 2003c). Eggs of all skates are known to be encapsulated in a leathery capsule that rests on the bottom (Sosebee 2000c; Packer et al. 2003c). The eggs hatch fully developed, so there is no larval stage (Sosebee 2000c; also McEachran 2002, in Packer et al. 2003c). Based on the capture of females with fully formed egg capsules, spawning is thought to occur throughout the year, but with a peak during the summer (Templeman 1982a; McEachran 2002, in Packer et al. 2003c). The primary prey for the thorny skate is fish, including haddock, sand lance, and redfish (Templeman 1982b, in Packer et al. 2003c). Thorny skates may live up to 20 years (Templeman 1984, in Packer et al. 2003c).

In the western Atlantic, the thorny skate ranges from Greenland to South Carolina, and it is one of the most common skates found within the Gulf of Maine (McEachran and Musick 1975, in Packer et al. 2003c). Skates have been landed as bycatch in New England since the late 1960s, but were not directly targeted as a fishery until the 1980s. There is no stock differentiation among the skate species. The water depth of the thorny skate habitat can range from 18 to 1200 m (59 to 3937 ft) (McEachran 2002, in Packer et al. 2003c). Trawl surveys in the Gulf of Maine found most adults in the range from 71 to 300 m (233 to 984 ft), and at temperatures between 4 and 9°C (39.2 and 48.2°F) (Packer et al. 2003c). The species can be found over a variety of substrates, including sand, gravel, broken shell, pebbles, and soft mud (Bigelow and Schroeder 1953, in Packer et al. 2003c). Skates do not migrate substantially, but do generally move offshore in summer and early autumn, and onshore during winter and spring (Sosebee 2000c).

The abundance of thorny skate is reported to be near historic lows, with a population of about 10 to 15 percent of the peak population in the early 1970s (Sosebee 2000c). The thorny skate was first designated as a species of concern in 2004 (NMFS 2004c). In a 2000 stock assessment, the thorny skate was considered to be overfished (NMFS 2000, in Packer et al. 2003c). No life stages of the thorny skate have ever been observed in the PNPS entrainment or impingement sampling.

Tilefish (*Lopholatilus chamaeleonticeps*)

Tilefish, also known as golden tilefish, is a burrowing fish that inhabits the outer continental shelf from Nova Scotia to South America (Nitschke 2000). The tilefish began supporting a fishery in the U.S. in 1879 (Steimle et al. 1999e). Tilefish eggs and larvae are buoyant and pelagic, and are found over the outer continental shelf in the Mid-Atlantic Bight (Steimle et al. 1999e). As they grow into juveniles, the tilefish descend to the bottom and occupy existing shelters or burrows (Able et al. 1982; Freeman and Turner 1977, in Steimle et al. 1999e). As adults, the tilefish either occupy existing shelter such as rocks or boulders, or dig their own burrows. The burrowing habits of the tilefish are reported to modify significantly the topography of the outer continental shelf (Able et al. 1982, in Steimle et al. 1999e). The adults become sexually mature at an age of five to seven years (Grimes et al. 1988, in Steimle et al. 1999e). Information on spawning is sparse and is pair-specific, as male and female pairs are observed to share burrows (Grimes et al. 1988, in Steimle et al. 1999e). Tilefish are reported to eat a large variety of benthic and pelagic prey, including crabs, conger eels, bivalve mollusks, polycheates, and many types of fish (Dooley 1978, in Steimle et al. 1999e).

They occupy submarine canyons, and are restricted to depths of 80 to 540 m (262 to 1772 ft) deep, in waters between 8 and 17°C (46.4 and 62.6°F) (Bigelow and Schroeder 1953; Freeman and Turner 1977; Dooley 1978, in Steimle et al. 1999e). The tilefish does not appear to undergo any major migration (Freeman and Turner 1977; Grimes et al. 1986, in Steimle et al. 1999e). In 1999, Steimle et al. (1999e) summarized a variety of surveys to identify tilefish. In these reports, tilefish were only identified in offshore areas, including submarine canyons. No tilefish in any life stage were reported in Massachusetts Bay or the Gulf of Maine (Steimle et al. 1999e).

Tilefish are most commonly found from southern New England to the Mid-Atlantic region (Nitschke 2000). The species is managed as two separate stocks, with one occurring in the Mid-Atlantic Bight and the other south of Cape Hatteras and into the Gulf of Mexico (Steimle et al. 1999e). The tilefish fishery established in 1879 was eliminated by a mass mortality of tilefish between Nantucket and Maryland in 1882. This event killed an estimated 1.5 billion tilefish (Bigelow and Schroeder 1953, Dooley 1978, in Steimle et al. 1999e). The fishery recovered by 1915, and has remained active ever since. In 1986, it was estimated that the effects of fishing had been drastic, reducing stock size by a half to two-thirds (Turner 1986, in Steimle et al. 1999e). However, a 2005 stock assessment determined the stock is considered to be at sustainable levels (i.e., the SSB and/or total stock biomass are considered to be at levels greater than sustainable biomass thresholds, while the exploitation or fishing pressure is less than the threshold of sustainable fishing pressure) (NMFS 2005b). No life stages of the tilefish have ever been observed in the PNPS entrainment or impingement sampling.

White hake (*Urophycis tenuis*)

The white hake occurs from the Gulf of St. Lawrence to the Mid-Atlantic Bight, and at depths from shallow estuaries to deep submarine canyons (Chang et al. 1999a). The species generally inhabits bottom waters, with either muddy or fine-grained sand substrates (Sosebee 2000a). The eggs, larvae, and early juvenile stages of the white hake are pelagic (Chang et al. 1999a), and are found in surface waters of the Gulf of Maine, Georges Bank, and southern New England (NEFMC 1998a, in ENSR 2000). White hake reach sexual maturity at an age of about 1.5 years (Chang et al. 1999a). The white hake spawning grounds are centered on the Gulf of St. Lawrence, the southern Georges Bank, and Mid-Atlantic Bight. However, the use of the Gulf of Maine as a spawning ground is reported to be negligible (Fahay and Able 1989, in Chang et al. 1999a). Spawning occurs in shallow water over mud or fine-grained sand substrates. Juvenile white hake feed mainly on polychaetes, shrimp, and other crustaceans, while the adults feed primarily on crustaceans and other fish, including juvenile white hake (Langston et al. 1994, in Chang et al. 1999a).

White hake are distributed from the Gulf of St. Lawrence to Cape Hatteras, with the highest concentrations in the Gulf of St. Lawrence, southern edge of the Grand Bank, Scotian Shelf, Gulf of Maine, and Georges Bank (Chang et al. 1999a). White hake live at depths of 5 to 325 m (16 to 1066 ft), usually at temperatures below 14°C (57.2°F) (NEFMC 1998a, Sosebee 1998, in ENSR 2000). Migration of adults occurs annually, with adults moving to shallower waters in the spring to spawn, and then moving offshore in the autumn. A summary of annual NMFS Bottom Trawl Survey data identified no white hake in Cape Cod Bay during the fall between 1979 and 2003, and only a few limited occurrences in the bay during the spring in those years (GOMCML 2006).

The white hake fishery is managed under the NEFMC Northeast Multispecies FMP (Sosebee 2000a). Within U.S. waters, the Gulf of Maine and Georges Bank populations are managed as separate stocks (Chang et al. 1999a). The populations of white hake in both areas has fluctuated without a consistent trend, but neither stock was considered to be overfished in 1999 (Chang et al. 1999a). In 2005, the stock was considered to be overfished, and overfishing was occurring (Sosebee 2005). In 2005, an analysis of juvenile populations resulted in a proposal for the potential designation of HAPCs for the white hake, including areas within Cape Cod Bay, adjacent to PNPS (Crawford et al. 2005). Eggs and larvae of the white hake have been collected in the PNPS entrainment sampling. Juveniles and/or adults have also been observed in the PNPS impingement sampling program.

Windowpane flounder (*Scopthalmus aquosus*)

Windowpane flounder is a left-eyed, benthic flatfish species that inhabits estuaries, nearshore waters, and the continental shelf in the western North Atlantic (Chang et al. 1999b). The windowpane is not itself a target of commercial fishing, but it is caught as a bycatch in other groundfish fisheries (Chang et al. 1999b). Both the eggs and larvae are pelagic, and exist in surface waters cooler than 20°C (68°F) (NEFMC 1998a, in ENSR 2000). Sexual maturity is reached at ages of three to four years (O'Brien et al. 1993). The windowpane flounder prefers a soft substrate for spawning, and generally spawns between April and December, with peak spawning activity in July and August on Georges Bank and in May in the Mid-Atlantic (NEFMC 1998a; Hendrickson 1998, in ENSR 2000). Spawning occurs in water temperatures from 6 to 21°C (42.8 to 69.8°F) (Bigelow and Schroeder 1953, in Chang et al. 1999b). The prey for the windowpane flounder is small benthic invertebrates, including polychaete worms and amphipods. The species may also prey on small forage bony fish species (Langton and Bowman 1981, in ENSR 2000).

The distribution of windowpane flounder includes the northwestern continental shelf in the Gulf of Maine, Georges Bank, southern New England and the Mid-Atlantic south to Florida (NEFMC 1998a; Robins and Ray 1986; Hendrickson 1998, in ENSR 2000). South of Cape Cod, the windowpane lives in bays and estuaries, including the Chesapeake Bay and Delaware Bay, but north of Cape Cod, it lives in nearshore waters and is not documented within estuaries (Chang et al. 1999b). The species lives at shallow depths from 1 to 75 m (3 to 246 ft), and lives within soft muddy and fine sand substrates (NEFMC 1998a, in ENSR 2000). Juveniles living in shallow waters tend to move to deeper waters as they mature (Chang et al. 1999b). In studies in Massachusetts, juveniles were most abundant in inshore waters at depths of less than 20 m (66 ft), at water temperatures between 5 to 12°C (41 to 53.6°F) in the spring, and between 12 to 19°C (53.6 to 66.2°F) in the fall (Chang et al. 1999b).

The windowpane flounder is managed as two separate stocks, a Gulf of Maine/Georges Bank stock and a southern New England/Mid-Atlantic Bight stock (Chang et al. 1999b). The windowpane flounder fishery is managed under the Northeast Multispecies FMP (Hendrickson 2000b). In the late 1990s, the stock in the Gulf of Maine/Georges Bank stock was considered to be fully exploited (Hendrickson 1998, in Chang et al. 1999b). In the 2004 assessment, it was concluded that the stock was at sustainable levels (i.e., the SSB and/or total stock biomass are considered to be at levels greater than sustainable biomass thresholds, while the exploitation or fishing pressure is less than the threshold of sustainable fishing pressure) (Hendrickson 2005). However, in 2005, an analysis of juvenile populations resulted in a proposal for the potential designation of HAPCs for the windowpane flounder, though none were within Cape Cod Bay, (Crawford et al. 2005). Eggs and larvae of the windowpane flounder have been collected in the

PNPS entrainment sampling. Juveniles and/or adults have also been observed in the PNPS impingement sampling program.

Winter flounder (*Pseudopleuronectes americanus*)

The winter flounder is a right-eyed flatfish species commonly found along the Atlantic coast from Labrador to Georgia. The winter flounder commonly inhabits estuarine and coastal waters, but may be found as deep as 128 m (420 ft) (Bulloch 1986). The various life stages of winter flounder can generally be found in areas where the bottom habitat has a substrate of mud, sand, or gravel (NEFMC 1998b). Winter flounder eggs are demersal, adhesive, and stick together in clusters. Hatching may occur in 2 to 3 weeks, depending upon the water temperature (Bulloch 1986, Pereira et al. 1999). Larvae are initially planktonic but as metamorphosis continues, they settle to the bottom. Winter flounder have multiple larval stages, which are defined differently by different authors. For the purposes of this SEIS, there are four larval stages as defined in ENSR and MRI (2005). Newly metamorphosed young-of-the-year fish take up residence in shallow water. Winter flounder typically mature at three to four years. Spawning takes place at night over sandy bottoms in shallow estuaries starting in mid December and ending in May, with a peak in the February to March time frame. Spawning occurs at water temperatures between 34 and 50°F, with the optimum temperature around 40°F (Bulloch 1986).

Pereira et al. (1999) describes winter flounder as omnivorous or opportunistic feeders, consuming a wide variety of prey, with polychaetes and amphipods making up the majority of their diet. Typically adult winter flounder migrate inshore in the fall and early winter and spawn in late winter and early spring; they then may leave inshore areas if the water temperature exceeds 15°C (59°F), although there may be exceptions to this due to water temperature and food availability (Pereira et al. 1999). Winter flounder may move significant distances (Pereira et al. 1999). However, they also can exhibit a high degree of fidelity and, in general, their movement patterns are localized (Nitschke et al. 2000). Studies done by PNPS have shown that winter flounder in the area immediately surrounding PNPS (i.e., in Plymouth Outer Harbor) have relatively localized movements and are basically confined to inshore waters (Lawton et al. 1999), resulting in highly localized populations (Lawton et al. 2000).

Winter flounder are managed as three distinct stocks: Gulf of Maine, Southern New England/ Mid-Atlantic, and Georges Bank (Pereira et al. 1999). Winter flounder in the local area surrounding PNPS would be considered part of the Gulf of Maine stock. According to Nitschke et al. (2000), the commercial landings of the winter flounder Gulf of Maine stock has continued to trend downward, and the stock is at a low biomass level and is considered to be overexploited. However, more recent data (through 2001) from the 36th Northeast Regional Stock Assessment Workshop (NMFS 2003a) indicate that the stock is not overfished and that overfishing is not occurring. The Northeast Fisheries Science Center (NEFSC) (NMFS 2003a) also states that recruitment to the stock has been near or above average since 1995. The 2005 Groundfish Assessment Review Meeting (GARM) also concluded, that based on 2004 data, the Gulf of Maine winter flounder stock is not overfished and overfishing is not occurring. The SSB has also been steadily increasing (Figure 2-7); however, there is a high degree of uncertainty associated with these estimates (NEFSC 2005).

These estimates of the status of the Gulf of Marine Stock contrast with data from the local population (MRI 2006). Annual abundance estimates of winter flounder in western Cape Cod Bay have declined in recent years (Figure 2-8). The authors hypothesize that the low numbers, particularly those associated with the 2005 data, may be partially due to natural and fishing-induced mortalities that precipitated a decline in the strong 1997 and 1998 year classes. Based on a review of other resource assessments (NEFSC and MDMF abundance indices) (Figures 2-9 and 2-10), the decline in eastern Cape Cod Bay may not just be local to the PNPS area (MRI 2006). Eggs and larvae of the winter flounder have been consistently collected in the PNPS entrainment sampling and are one of the numerically dominant species in the entrainment collections. Juveniles and/or adults also have been consistently collected in the PNPS impingement sampling program. Over the last 25 years winter flounder has been one of the numerically dominant impinged species.

Winter skate (*Leucoraja ocellata*)

The winter skate is one of seven species of skates found throughout the western North Atlantic (Sosebee 2000c). The winter skate is often confused with the little skate due to similarity in appearance, but the winter skate is not as abundant (McEachran and Musick 1975, in Packer et al. 2003a). Skates are fished commercially, but with no distinction among the seven species (Packer et al. 2003a). Most commercial use of skates is for lobster bait, but two skates (including the winter skate) are used for human consumption (Packer et al. 2003a). Little information on the life history of the winter skate exists. Eggs of all skates are known to be encapsulated in a leathery capsule that rests on the bottom (Sosebee 2000c; Packer et al. 2003a). The eggs hatch fully developed, so there is no larval stage (Sosebee 2000c; McEachran 2002, in Packer et al. 2003a). Off of Nova Scotia and in the Gulf of Maine, spawning occurs during summer and fall (Bigelow and Schroeder 1953, in Packer et al. 2003a). The predominant food source for winter skates is polychaetes and amphipods, with additional feeding upon decapods, isopods, bivalves, and fish (McEachran 1973, in Packer et al. 2003a). Fish species that are prey for the winter skate include smaller skates, eels, alewives, blueback herring, menhaden, smelt, sand lance, chub mackerel (*Scomber japonicus*), butterfish, cunners, and silver hake (Bigelow and Schroeder 1953, in Packer et al. 2003a).

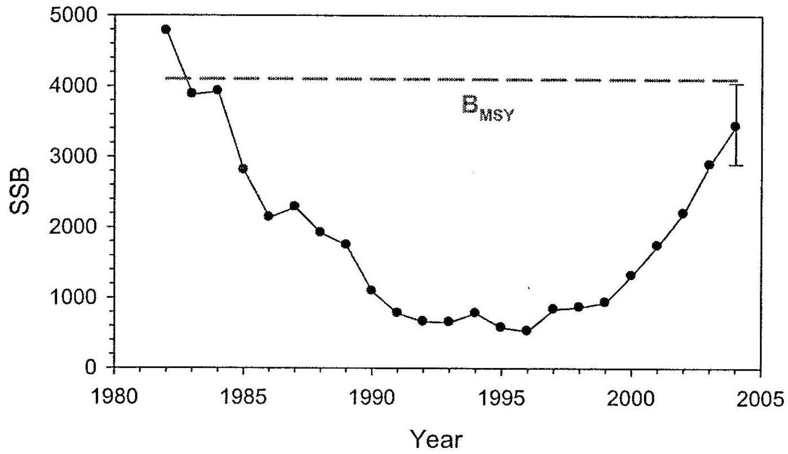

Figure 2-7. Gulf of Maine Winter Flounder
Spawning stock biomass (SSB) estimates during 1982 to 2004 reported in GARM (2005) and the total biomass that produces the maximum sustainable yield for the fishery (B_{MSY})
(As provided in: NEFMC 2006b)

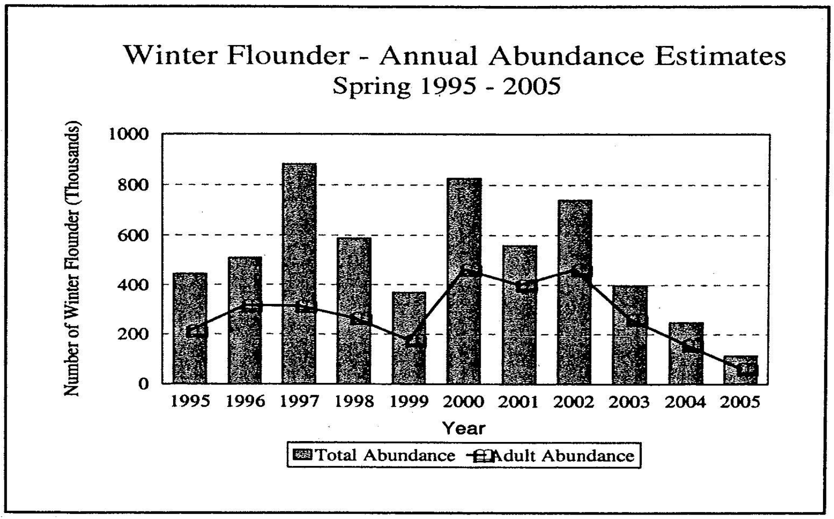

Figure 2-8. Winter Flounder Abundance Estimates in Northwestern Cape Cod Bay
(As provided in: MRI 2006)

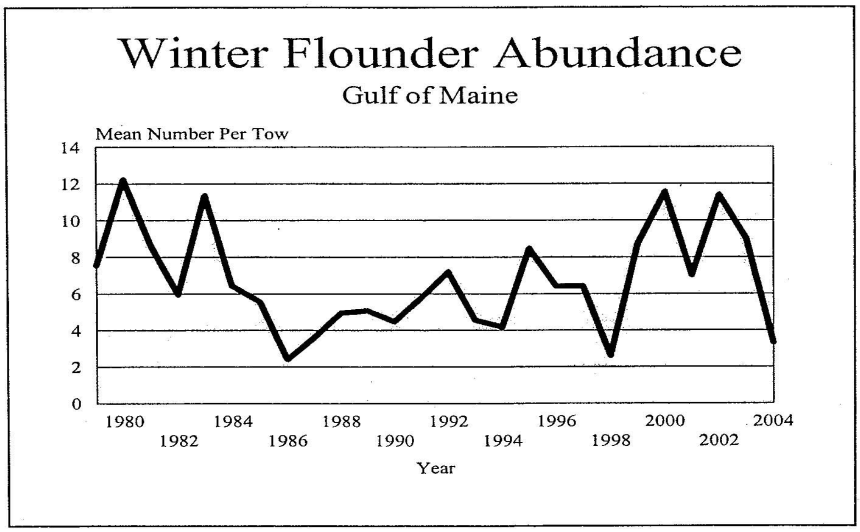

Figure 2-9. NMFS Winter Flounder Abundance in the Gulf of Maine (As provided in: Normandeau 2006a)

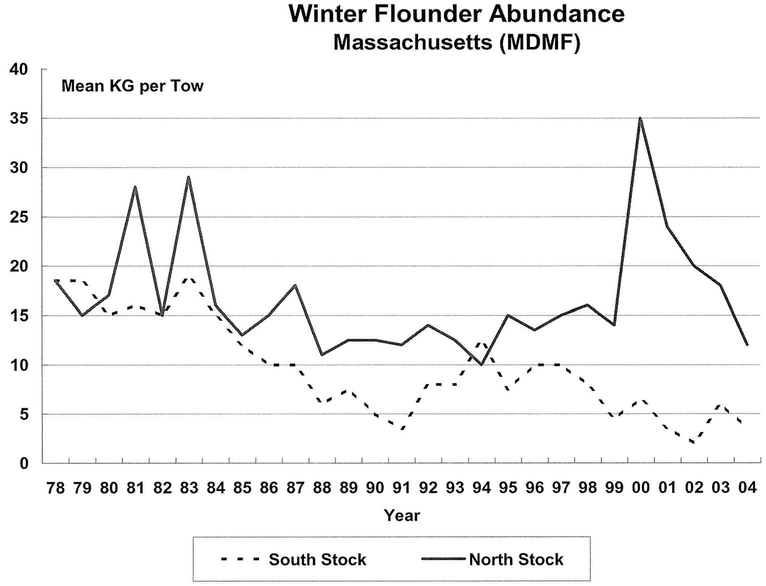

Figure 2-10. MDMF Winter Flounder Abundance in the Gulf of Maine (Recreated from: Normandeau 2006a)

The winter skate is most commonly found on the Georges Bank and in the northern section of the Mid-Atlantic Bight (McEachran and Musick 1975; in Packer et al. 2003a). Skates have been landed as bycatch in New England since the late 1960s, but were not directly targeted as a fishery until the 1980s. There is no stock differentiation among the skate species. Winter skates in the Gulf of Maine primarily live at depths of 46 to 64 m (151 to 210 ft) (Bigelow and Schroeder 1953; McEachran 2002, in Packer et al. 2003a). The species can live in a variety of water temperatures, and are reported near the Massachusetts coast in water from 1 to 20°C (33.8 to 68°F) (Bigelow and Schroeder 1953; in Packer et al. 2003a). The species prefers sandy and gravel bottom substrates (Scott 1982a, in Packer et al. 2003a). Skates do not migrate substantially, but do generally move offshore in summer and early autumn and onshore during winter and spring (Sosebee 2000c).

In 2001, NMFS determined that the winter skate was in an overfished condition, and that overfishing was occurring (NMFS 2001c). In 2002, a new assessment resulted in a change of the status to not overfished (NMFS 2002b, in Packer et al. 2003a). No life stages of the winter skate have ever been observed in the PNPS entrainment sampling. Juveniles and/or adults have been observed in the PNPS impingement sampling program.

Witch flounder (*Glyptocephalus cynoglossus*)

The witch flounder is a deep-water, right-eyed flatfish that occurs on both sides of the Atlantic Ocean (Wigley et al. 2003). Prior to the 1980s, witch flounder was not targeted and was landed mostly as bycatch (Wigley 2000b). Eggs are released on the bottom, but are pelagic and rise to the surface. Larvae are also pelagic, and the species descend to the bottom as juveniles at the age of 4 to 12 months (Bigelow and Schroeder 1953; Evseenko and Nevinsky 1975, in Cargnelli et al. 1999d). Sexual maturity is reached at various ages, with a range of from five to nine years (Beacham 1983, in Cargnelli et al. 1999d). Spawning occurs from March to November, with peak spawning during the summer, at temperatures from 0 to 10°C (32 to 50°F) (Bigelow and Schroeder 1953, in Cargnelli et al. 1999d). The western and northern areas of the Gulf of Maine are reported to be the most active spawning areas for the species (Burnett et al. 1992, in Cargnelli et al. 1999d). The primary prey for the witch flounder are polychaetes and crustaceans, with additional contribution from mollusks and echinoderms (Cargnelli et al. 1999d).

In U.S. waters, the witch flounder is common in the Gulf of Maine and lives in deeper areas of the Georges Bank and along the continental shelf as far south as Cape Hatteras (Cargnelli et al. 1999d). The witch flounder lives in deep water, down to depths of 1500 m (4921 ft), in water about 2 to 9 °C (35.6 to 48.2°F) (Lange and Lux 1978; Scott 1982b, in Cargnelli et al. 1999d). The witch flounder is associated with mud, silt, and clay substrates, and is rarely found on any other bottom types (Powles and Kohler 1970; Martin and Drewry 1978; Scott

1982a, in Cargnelli et al. 1999d). All life stages of witch flounder are common in Massachusetts Bay. Eggs were found to be abundant in Massachusetts Bay in the months of May and June (Cargnelli et al. 1999d). Bottom trawl surveys and inshore surveys found the greatest concentrations of juveniles on Stellwagen Bank in Massachusetts Bay. Adults were found in the highest concentrations in Massachusetts Bay in the autumn, including some catches in Cape Cod Bay (Cargnelli et al. 1999d).

The species is managed as a single stock under the NEFMC Northeast Multispecies FMP (NEFMC 1993, in Cargnelli et al. 1999d; Wigley and Col 2005a). The stock extends from the northern Gulf of Maine to southwestern Georges Bank (NMFS 2003b). As of 1997, the witch flounder stock was reported to be in an overfished condition (NMFS 1997). In 2003, the stock was reported to not be overfished, but overfishing was occurring (NMFS 2003b, Wigley et al. 2003). Eggs and larvae of the witch flounder have been collected in the PNPS entrainment sampling. No life stages have been observed in the PNPS impingement sampling program.

Yellowtail flounder (*Pleuronectes ferruginea*)

The yellowtail flounder is a right-eyed, benthic flatfish that is an important commercial species (Cadrin 2000b). Both the eggs and larvae of the yellowtail flounder reside in the water column, and are found between mid March and July, peaking between April and June. Larvae may drift in surface waters before developing into juveniles, and dropping to the bottom (Overholtz and Cadrin 1998, in ENSR 2000). The median age for sexual maturity is about 2.6 years for females off of Cape Cod (O'Brien et al. 1993, in Johnson et al. 1999a). Spawning occurs in the Gulf of Maine, Georges Bank, and southern New England shelf during the spring and summer months (Overholtz and Cadrin 1998; NEFMC 1998a, in ENSR 2000). Adult yellowtail flounder feed on small benthic invertebrates such as polychaete worms, isopods, shrimp, and amphipods, and also can feed on small forage fish species (Cooper and Chapleau 1998, in ENSR 2000).

The yellowtail flounder ranges from Labrador to the Chesapeake Bay, and is most abundant in the western Georges Bank, western Gulf of Maine, east of Cape Cod, and southern New England (Johnson et al. 1999a). Mark-and-recapture studies have shown that yellowtail flounder do not migrate, other than minor movements between shallow and deeper water in response to seasonal temperature variation (Royce et al. 1959; Lux 1964, in Johnson et al. 1999a). Yellowtail flounder typically live at depths of between 37 to 87 m (121 to 285 ft), with substrates of mud or sand (Cooper and Chapleau 1998; Overholtz and Cadrin 1998, in ENSR 2000). Adults live in waters ranging from 2 to 12°C (35.6 to 53.6°F) (Johnson et al. 1999a). In a MDMF bottom-trawl survey, both adults and juveniles were found to concentrate seasonally in coastal waters from northwestern Cape Cod Bay to Ipswich Bay. Juveniles were found to migrate inshore in Cape Cod Bay in the fall (Johnson et al. 1999a).

In the U.S., the populations are managed as four separate stocks, including southern New England, Georges Bank, Cape Cod, and Mid-Atlantic Bight (Johnson et al. 1999a). The yellowtail flounder fishery is managed under the NEFMC Northeast Multispecies FMP (Cadrin 2000b). Yellowtail flounder has been a major constituent of the commercial fishery since the early 1930s. Population data evaluated by Johnson et al. (1999a) for all four stocks showed significant variation through time, with increases and decreases occurring throughout the 1960s through the 1990s. The Cape Cod/Gulf of Maine stock was considered to be at low biomass and overexploited in 2001 (Cadrin et al. 2005). In 2005, an analysis of juvenile populations resulted in a proposal for the potential designation of HAPCs for the yellowtail flounder, though none were within Cape Cod Bay, (Crawford et al. 2005). Eggs and larvae of the yellowtail flounder have been collected in the PNPS entrainment sampling. Juveniles and/or adults have also been observed in the PNPS impingement sampling program.

2.2.5.3.2 Pelagic Invertebrates

Longfin squid (*Loligo pealei*)

The longfin squid is a schooling species, which is distributed in the waters of the continental shelf and slope from Newfoundland to the Gulf of Venezuela (Cadrin 2000a, in ENSR 2000). During late autumn to winter, longfin squid migrate to warmer waters along the edge of the continental shelf (Cadrin 2000a, in ENSR 2000). During the spring and early summer, the species moves inshore to spawn (Cadrin 2000a, in ENSR 2000). The species is known to spawn year round, which varies seasonally and geographically (Brodziak and Macy 1996; Hatfield and Cadrin 2002, in Jacobson 2005). Males can grow to reach more than 40 cm (16 in.) in dorsal-mantle length, even though the majority of squid collected in the commercial fishery are smaller than 30 cm (12 in.) long (Cadrin 2000a). Food habits of longfin squid depend on size; small individuals consume planktonic organisms (Vovk 1972; Tibbetts 1977, in Cargnelli et al. 1999g) whereas larger individuals consume crustaceans and small fish (Vinogradov and Noskov 1979, in Cargnelli et al. 1999g). Seasonal and inshore/offshore variances in the diets of longfin squid were demonstrated by Maurer and Bowman (1985, in Cargnelli et al. 1999g). Longfin squid are typically observed in waters with temperatures of at least 9°C (48.2°F) (Lange and Sissenwine 1980, in Cargnelli et al. 1999g).

Overfishing of longfin squid is an important issue due to the fact that the species recruits to the population and to the spawning stock in the same year (Cadrin 2000a). During 1998, the stock was reported to be approaching an overfished condition and overfishing was also occurring (Cadrin 2000a). Based on data presented in the 2002 Assessment Status Summary, the stock is not in an overfished condition, and overfishing is not occurring (NMFS 2002c). The longfin squid has not been observed in the PNPS entrainment sampling program. It has been collected within the impingement sampling program.

Shortfin squid (*Illex illecebrosus*)

The shortfin squid is highly migratory and is found primarily in the offshore waters of the continental shelf and slope from Florida to Labrador (Hendrickson and Holmes 2004). Individuals experience an extensive spawning migration to warmer waters south of Cape Hatteras during the autumn (Hendrickson and Holmes 2004). Peak spawning occurs during the winter, and larvae and juveniles drift northward in the warm waters of the Gulf Stream (Hendrickson 2000a in ENSR 2000). The squid that spawned throughout the winter migrate during late spring onto the continental shelf (Hendrickson 2000a in ENSR 2000). Shortfin squid live for approximately one year and grow rapidly during the first few months of existence (NOAA 1998). Shortfin squid can reach dorsal-mantle lengths up to 35 cm (14 in.), even though the majority of squid collected in the commercial fishery are smaller than 25 cm (10 in.) (Hendrickson and Holmes 2004). The diet of shortfin squid typically consists of fish and crustaceans (Squires 1957; Froerman 1984; Mauer and Bowman 1985; Dawe 1988, in Cargnelli et al. 1999h).

Data collected during 1994 to 1998 demonstrated that the stock was probably not in an overfished condition (Hendrickson 2000a). Based on data presented in the 2003 Advisory Report, the stock did not experience overfishing during 1999 to 2002 (NMFS 2003b). However, according to the 2005 Assessment Summary, the current stock was not able to be evaluated due to the lack of reliable data for determining stock biomass and fishing mortality rate (NMFS 2006a). The shortfin squid has not been observed in the PNPS entrainment or impingement sampling program.

2.2.5.3.3 Plankton

Phytoplankton

The western Cape Cod Bay phytoplankton community, including the surrounding area of PNPS, seems to be more similar to the Gulf of Maine (to the north of Cape Cod) than to the communities located south of the Cape (ENSR 2000). In the 1970s, two studies were performed to identify the phytoplankton communities in the PNPS surrounding area (ENSR 2000). Various samples were taken from the intake and discharge areas of PNPS and from a station positioned 1000 ft (305 meters) offshore during 1971 (ENSR 2000). A widespread study was also conducted to identify phytoplankton entrained at the plant between 1973 and 1975 (Toner 1984, in ENSR 2000). The samples gathered at the discharge were examined to determine the onshore species composition and then compared to populations collected monthly at various distances offshore (i.e., 0.25, 0.5, and 1 mi) between December 1974 and February 1975 (ENSR 2000). The 1971 onshore samples consisted of 46 species of phytoplankton and three unidentifiable taxa (ENSR 2000). The offshore samples collected in 1974/1975 included 73 taxa, with 50 identified to the species level (ENSR 2000). No significant difference in species composition was detected between the onshore and offshore samples.

Based on these two studies, diatoms appear to be the most abundant taxa throughout the year (Marshall 1978 in ENSR 2000). These studies have also demonstrated a seasonal pattern in the phytoplankton communities adjacent to PNPS (ENSR 2000).

Phytoplankton density peaks were observed, which included two annual peaks, one in February to March (11 million cells/L) referred to as the spring bloom, and a second peak was noted in July (1 to 2 million cells/L) (ENSR 2000). The December/January densities were the lowest noted, followed by April (ENSR 2000). These results are somewhat confirmed by Thomas et al. (2003) who used satellite-based imaging of the Gulf of Maine to evaluate chlorophyll levels, detected both a spring and fall bloom. Thomas et al. (2003) also determined that seasonal cycles in chlorophyll are dependent upon the relationship of tidal mixing, bathymetry, and residual circulation with the most dominant seasonal cycles occurring in deeper basins.

Zooplankton

New England zooplankton studies have focused on the Gulf of Maine and the Georges Bank area southeast of Cape Cod (ENSR 2000). The effects of the Cape Cod Canal on the copepods of Buzzards Bay and Cape Cod Bay were examined (Ankaru 1964, in ENSR 2000). During 1970 and 1971, the samples collected from Cape Cod Bay in the surrounding area of PNPS demonstrated a zooplankton community that was minimal during the winter months, followed by increasing densities in the summer (ENSR 2000). Copepods, which included *Pseudocalanus elongates*, *Temora longicornus*, and *Acartia clause*, dominated the zooplankton community throughout this study (Stone and Webster 1975 in ENSR 2000). This study demonstrated seasonal cycles for zooplankton abundances, attaining maximum densities in August and minimum densities in January and February (ENSR 2000) (Figure 2-2).

2.2.5.3.4 Benthic Invertebrates

Habitats found within the area of PNPS include both rocky and sandy intertidal and rocky and sandy subtidal areas (ENSR 2000). Surveys of all four habitat types were included in the long-term benthic monitoring program at PNPS (1974 to 1991), with sampling transects located at Rocky Point, in the vicinity of the discharge canal, near White Horse Beach, and near Manomet Point (Davis and McGrath 1984; SAIC 1992 in ENSR 2000).

The sandy intertidal areas close to PNPS, while limited, are typically composed of coarse gravel overlying finer sands in a fairly high-energy environment (ENSR 2000). Interstitial organisms or larger, mobile organisms, such as hermit crabs, participate in the limited faunal colonization

(ENSR 2000). A discussion follows of monitoring studies for the other three habitat types: rocky intertidal, rocky subtidal, and sandy subtidal (ENSR 2000).

The rocky intertidal habitat is composed of large boulders interspersed with smaller rocks and patches of cobble, gravel, and coarse sand (ENSR 2000). The fauna in this zone are adjusted to the extreme conditions associated with the tidal cycles, including the physical stresses of temperature fluctuations, desiccation, and ice scouring (ENSR 2000). Populations also are controlled by predation and competition for space (Menge 1976 in ENSR 2000). Rocky intertidal samples were taken from late 1971 through mid 1979 (ENSR 2000). The barnacle *Balanus balanus* is common throughout the area and is the primary macrofaunal organism in the upper rocky intertidal zone (ENSR 2000). The gastropods *Littorina littorea* and *L. obtusata* are also frequent in this habitat. In the middle and lower intertidal zones, the blue mussel and macroalgae replaced barnacles (ENSR 2000). *Asterias* spp. and the carnivorous gastropod *Nucella lapillus* are regular predators of sessile species in this zone (ENSR 2000). The holdfasts of the macroalgae supply a habitat for small polychaetes, mollusks, and amphipods, including the sabellid polychaete *Fabricia sabella* and the amphipods *Hyale nilsoni* and *Caprella penantis (*Davis and McGrath 1984 in ENSR 2000). Faunal densities typically ranged from 10^4 to 10^5 individuals/m^2 (929 to 9290 individuals/ft^2) (ENSR 2000).

The most heavily studied benthic habitat in the PNPS area is the rocky subtidal habitat (ENSR 2000). Sampling started in 1971 and continued through 1991 at Rocky Point, near the discharge and Manomet Point. Crustaceans were the biggest taxonomic group collected in the samples (ENSR 2000). The main crustaceans included 34 species of amphipods and also 30 species each of polychaetes and mollusks (ENSR 2000). Twelve percent of the total fauna was represented by nemerteans, echinoderms, and anemones (ENSR 2000). The dominant 15 species represented 90 to 98 percent of the observed fauna at each of the three stations and between 40 and 80 species represented the remaining 2 to 10 percent (ENSR 2000). Total faunal densities in the rocky subtidal habitat fluctuated widely from 1983 through 1991, mainly because of periodic mass settlements of blue mussel (*Mytilus edulis*) (ENSR 2000). Densities still demonstrated a seasonal pattern and a long-term cyclic pattern even without blue mussel data (ENSR 2000). The data reveal a seasonal pattern of low diversity in the spring followed by higher values in the fall (ENSR 2000). Rocky Point typically had the highest diversity, even though Manomet Point samples had very similar results (ENSR 2000).

Sandy subtidal habitat is extensive all through western Cape Cod Bay (ENSR 2000). The area immediately surrounding PNPS is predominantly sand, although just to the north in the Rocky Point area, rock ledges and boulders are found (ENSR 2000).

At White Horse Beach and close to the discharge area at PNPS, transects of sandy subtidal locations were established (ENSR 2000). Two sites were established at each of the sampling locations, one located at the 3 m (10 ft) depth and the other at the 9 m (30 ft) depth (ENSR 2000). Quantitative sampling was performed at these locations from 1971 through 1979 (ENSR 2000). Amphipods *Acanthohaustorius millsi* and *Protohaustorius deichmannae* were the most prevalent species reported, regularly resulting in 75 percent of the total individuals in a sample (ENSR 2000). The sevenspine bay shrimp (*Crangon septemspinosus)*, the northern moon snail (*Lunatia heros*), and the sand dollar *Echinarachnius parma* were other species reported in this environment (ENSR 2000). These species, while prevalent and dispersed throughout the area, were not present in significant quantities (ENSR 2000). Davis and McGrath (1984 in ENSR 2000) demonstrated that faunal densities ranged from 10^3 to 10^4 individuals/m^2 (93 to 929 individuals / ft^2) at both the 3 m (10 ft) and 9.1 m (30 ft) depths; these densities are approximately an order of magnitude lower than those found at the rocky subtidal stations.

In addition to the benthic species described above, there are several species of benthic macroinvertebrates, which are found in the area and are considered to be important to the benthic community of western Cape Cod Bay. These include the American lobster (*Homarus americanus*), Atlantic sea scallop (*Placopecten magellanicus*), surf clam (*Spisula solidissima*), and ocean quahog (*Arctica islandica*). Discussions of the ecology, life history, and status of these species follow.

American lobster (*Homarus americanus*)

The American lobster is a large, mobile, benthic macroinvertebrate of the sublittoral zone (ENSR 2000). It is a marine crustacean that occurs in a wide range of habitats along the continental shelf and upper slope of the western North Atlantic from Labrador to Cape Hatteras (ENSR 2000). The primary depth range is from the sublittoral fringe to 50 m (164 ft), but lobster may be fished out to depths of 700 m (2297 ft) (ENSR 2000). Off the coast of Newfoundland to Maine, the largest numbers of this species occur near the middle of this range, where ambient bottom water temperatures typically range from -2.2 to 23.9°C (28 to 75°F) (McLeese and Wilder 1958 in ENSR 2000). Changes in temperature initiate seasonal migrations to offshore waters in the fall and inshore waters in the spring (McLeese and Wilder 1958 in ENSR 2000) to reach temperatures for proper synchrony of molting and reproductive cycles (Harding 1992 in ENSR 2000).

The majority of lobster populations hatch from mid June through September (Perkins 1972, in ENSR 2000). The typical hatching process of lobsters was documented by Sherman and Lewis (1967) as occurring from June through August as water temperatures range from 54 to 59°F (12.2 to 15°C) (ENSR 2000). The early larval stages I, II, and III are planktonic, lasting from 6 to 8 weeks, and stage IV postlarvae, also planktonic, metamorphose into adult shape and start to demonstrate actions that result in the lobster settling to the bottom (ENSR 2000). The newly settled juveniles reside in burrows, steadily adjusting to life on the surface of the substrate (ENSR 2000).

Various special studies relating to the lobster have been performed within the PNPS area due to the commercial importance of this species (ENSR 2000). Results of studies performed from 1974 to 1977 on the seasonal occurrence, abundance, and distribution of larval lobsters proposed that a major percentage of the larval lobsters discovered in Cape Cod Bay in June may have traveled through the Cape Cod Canal due to the warmer temperatures favorable to hatching (ENSR 2000). Matthiessen (1984) proposes that the Cape Cod Canal may be a major source of recruitment to the Cape Cod Bay lobster stocks due to the intricate dispersal patterns (ENSR 2000). From 1970 to 1977, in the PNPS area, a tag and retrieval study was performed to examine the movement and growth of sublegal, sexually immature lobsters that were captured and released (Lawton et al. 1984, in ENSR 2000). Examination of the data implied that movement of this population was very restricted, since 71 percent of the returns were recaptured on the ledges where they had initially been released (ENSR 2000). The remaining 29 percent had moved from 4.8 to 45 km (3.0 to 28 mi), in various directions such as northwest towards Boston and east southeast through the Cape Cod Bay (ENSR 2000). Comparable research implied that there was a moderate seasonal movement to inshore waters in the spring and offshore waters in the fall, but not as great as the migrations of larger, sexually mature individuals (Lawton et al.1984 in ENSR 2000).

The second largest U.S. lobster fishery is the Massachusetts lobster fishery, accounting for about 28 percent of the U.S. landings (Estrella and Morissey 1997, in ENSR 2000). Predominantly during the months of March and November, the lobster is prevalent in western Cape Cod Bay and enhances an important commercial fishery in the PNPS area (Lawton et al. 1984, in ENSR 2000). The most economically valuable fishery in Massachusetts territorial waters is the commercial lobster fishery in the PNPS area (ENSR 2000). American lobster larvae have been collected in the PNPS entrainment sampling. Juveniles and/or adults have been observed in the PNPS impingement sampling program.

Atlantic sea scallop *(Placopecten magellanicus)*

The Atlantic sea scallop is a bivalve distributed along the northwestern North Atlantic shelf between the Gulf of St. Lawrence and Cape Hatteras (Hart and Chute 2004). North of Cape Cod, the sea scallop is generally found at depths of less than 20 m (65 ft) on hard substrates of cobble, shell litter, or coarse gravel/sand (NEFMC 1998a; Lai and Rago 1998, in ENSR 2000). Some sea scallops begin reaching sexual maturity at age 2; however, most do not reach sexual maturity until age 3 (Hart and Chute 2004). Spawning season begins in May and extends through October. Peak spawning activity depends on location. Spawning peaks between May and June in the mid Atlantic and in September and October in Georges Bank, usually in water temperatures below 16°C (60.8°F) (NEFMC 1998a). Scallops spawn as many as one million eggs per year, depending on the size of the female (MacKenzie 1979, in Hart and Chute 2004). Eggs are not buoyant and remain on the substrate until hatching into free swimming larvae (NEFMC 1998a). Larvae occupy pelagic waters and bottom habitats of gravel, shell litter, algae, or sedentary benthic infauna (NEFMC 1998a). Sea scallops are suspension filter feeders, and their diet typically consists of phytoplankton and microzooplankton (Hart and Chute 2004).

The Atlantic sea scallop supports one of the most valued shellfish fisheries in the U.S. (Hart and Chute 2004). Based on the 2004 stock assessment, the stock in the area appears to be healthy with recent landings data being the highest on record and recruitment to the stock being above average (NEFSC 2004). No life stages of the Atlantic sea scallop have ever been observed in the PNPS entrainment or impingement sampling.

Cancer crabs (*Cancer* spp.)

Two species of cancer crabs found in Massachusetts are the rock crab (*Cancer irroratus*) and the Jonah crab (*C. borealis*). Both species are distributed from Nova Scotia to the southeastern U.S. (Estrella undated). All species of cancer crabs share similar life history characteristics. Eggs undergo a development period of several weeks, and after hatching, the larvae are planktonic. The larvae advance through six stages of successive increases in size by molting, a process which take several weeks. Once the larvae reach the first crab stage (first instar), they sink to the bottom and begin their benthic phase. Both species become sexually mature within one to two years. Mating occurs while they are in the soft-shell molt condition, usually in winter (CRWQCB 2004).

Rock crabs exist in rocky habitats, but can be displaced onto sandy habitat by shelter-space competition with Jonah crabs and the American lobster (Estrella undated). Rock crabs are found in intertidal habitats north of Cape Cod, and in progressively deeper water farther south along the Atlantic coast (Gosner 1978). Jonah crabs live in exposed locations on rocky coasts, but can also be found on muddy bottom substrates in deeper waters. Both species are commercially fished within Massachusetts, and the Commonwealth places restrictions on landings from December 1 to March 31, which includes the rock crab's molting period. The population of rock crabs within Massachusetts is at or below its median population for the past 24 years, while the Jonah crab population is considered to be stable (Estrella undated). Cancer crabs are frequently observed in the PNPS impingement monitoring program (Normandeau 2006b). Cancer crabs have been collected as part of the PNPS impingement monitoring program; however, they have not been observed in the PNPS entrainment monitoring program.

Sevenspine bay shrimp (Sand shrimp) (C*rangon septemspinous*)

The sevenspine bay shrimp, also known as the sand shrimp, is an ecologically important species of coastal and estuarine waters of the western Atlantic. The range of the species extends from the northern Gulf of St. Lawrence to Florida (Squires 1996 in Locke et. al 2005). The species lives in shallow subtidal areas up to 90 m (295 ft) deep, and up to the low tide line (Gosner 1978). The species prefers sandy bottoms and eelgrass beds, but mostly lives at the sediment-water interface, as opposed to burrowing (Gosner 1978).

Sevenspine bay shrimp are the numerically dominant invertebrate species collected as part of the PNPS impingement sampling (Normandeau 2006b). They have not been collected as part of the entrainment sampling at PNPS (Normandeau 2006b).

Ocean quahog (*Arctica islandica*)

The ocean quahog is a bivalve mollusk distributed from Newfoundland to Cape Hatteras at depths of up to 256 m (840 ft). In the Gulf of Maine region, they are found in relatively nearshore waters (Weinberg 2001). They are among the longest lived and slowest growing of marine bivalves and may reach an age of 225 years (Cargnelli et al.1999f). Similar to surf clams, they are planktivorous, siphon feeders and are preyed upon by moon snails, boring snails, and predatory fish such as haddock and cod. (Cargnelli et al.1999f). Estimates for attaining sexual maturity have ranged from 9 to 13 years (Cargnelli et al.1999f). No life stages of the ocean quahog have ever been observed in the PNPS entrainment or impingement sampling.

Surf clam (*Spisula solidissima*)

The surf clam is a bivalve mollusk that is distributed in waters of the western North Atlantic from the Gulf of St. Lawrence to Cape Hatteras (Cargnelli et al.1999b). Surf clams inhabit sandy bottom habitats and are most common at depths of 8 to 66 m (26 to 217 ft) in the turbulent areas beyond the breaker zone (Cargnelli et al. 1999b). Surf clams are planktivorous, siphon feeders including diatoms and ciliates (Cargnelli et al.1999b). They are preyed upon by moon snails, boring snails, and predatory fish such as haddock and cod. Surf clams are capable of reproduction in their first year of life, although they may not reach full maturity until the second year (Weinberg 2000). Water currents in areas where planktonic surf clam larvae live are important in determining eventual patterns of distribution and settlement for developing juveniles (ENSR 2000). Based on the 2003 stock assessment, the stock throughout the entire Exclusive Economic Zone (EEZ) is not overfished and overfishing is not occurring (NMFS 2003b). No life stages of the surf clam have ever been observed in the PNPS entrainment or impingement sampling.

2.2.5.3.5 Marine Aquatic Plants

The marine environment in the vicinity of PNPS is typical of shallow, exposed areas in western Cape Cod Bay and is characterized by sand and gravel interspersed with large rocks and boulders. Several surveys of macroalgae have been conducted at PNPS and have included intertidal (through 1978) and subtidal (through 1991) qualitative and quantitative sampling.

In the intertidal zone, qualitative sampling was performed for four years, beginning in October 1974, at four locations: Rocky Point, northwest of the PNPS discharge canal, White Horse Beach, and Manomet Point. At each station, a 6-in.-wide transect extending from the mean high to the mean low water levels was established. A total of 137 species was recorded, including two cyanophyta, 40 chlorophyta, 48 phaeophyta, and 47 rhodophyta. The number of species per station over the sampling period ranged from a low of 97 at Manomet Point to a high of 111 at the station discharge. Species richness generally ranged between 60 and 70 representative taxa each year, with a greater number of species recorded after the first year of sampling. The dominant algae at all elevations were the brown fucoids *Ascophyllum nodosum* and *Fucus vesiculosus*. The greatest cover by *Ascophyllum* was at the Manomet Point and Rocky Point station, whereas *Fucus* was more common at the discharge location. Five species were recorded only at the discharge location: *Enteromorpha aragonensis*, *Bryopsis plumosa*, *Codium fragile*, *Gracilaria follifera*, and *Soliera tenera*. These species are known to prefer the warmer waters south of Cape Cod, and their presence at this location was probably a consequence of the thermal discharge (ENSR 2000).

In the subtidal zone, the long-term benthic monitoring program at PNPS (1974 to 1991) included surveys of subtidal macroalgae at three sampling sites: Rocky Point, near the PNPS discharge canal, and Manomet Point (Grocki 1984; SAIC 1992). Over 112 species of algae were identified from the samples taken over the course of the monitoring program. The subtidal macrophytes are dominated by the rhodophyta or red algae. There are no reports of eelgrass (*Zostera marina*) in the immediate vicinity of PNPS. Irish moss (*Chondrus crispus*) is the dominant subtidal macrophyte in Cape Cod Bay and is the chief component of the subtidal flora near PNPS. Depending on depth, Irish moss covers up to 90 percent of the available substrate, attaining a maximum density between MLW and 4.3 m (14 ft) below MLW.

Irish moss is a benthic, marine red alga found from New Jersey to Labrador, with highest abundances near the center of this range. It inhabits rocky substrates from below MLW to a depth of 38 m (125 ft), with maximum densities in the PNPS area occurring between MLW and a depth of 6 m (19.7 ft). The lower limits of its distribution are controlled by light, water transparency, availability of substrate, and competition for space. It is euryhaline, occurring in salinities between 8 and 40 ppt, and it is a dominant component of the subtidal flora in the vicinity of PNPS (ENSR 2000).

The PNPS thermal discharge is located in the middle of an Irish moss commercial bed. The immediate area of the discharge is denuded; just beyond the denuded area is an area of stunted or sparse growth of Irish moss. Through 1998, the largest affected area ever observed was in 1997. This included denuded areas as well as areas of stunted or sparse growth, covered about 1.1 ac (ENSR 2000).

Irish moss is an important commercial species that has been harvested along the western shore of Cape Cod Bay since the 1800s (ENSR 2000). The seaweed is harvested as a source of carrageenan, a hydrocolloid unique for its jellying, suspension, and viscosity properties.

Carrageenan is widely used as a suspending and thickening agent in the brewing, baking, pharmaceutical, and dairy industries. The harvesting season extends from early June through August, with peak harvest usually occurring in July. However, since the 1990s, harvesting of Irish moss has been virtually nonexistent in the Plymouth area (Lawton et al.1992).

At greater depths, Irish moss density decreases and phyllophora *(Phyllophora brodiaei* and *P. membranifolia*) become the dominant macrophytes. *Lamineria* sp., *Corrallina officinalis*, *Polydesrotundus* sp., and *Lithothamnion* sp. are the remaining conspicuous representatives of the subtidal algal flora. Epiphytic species include the rhodophytes *Ceramium rubrum*, *Cystoclonium purpureum*, and *Spermothamnion repens*. The warm-water species *Gracilaria tikvahiae* has been recorded on several occasions, primarily in the area of the discharge canal. No life stages of the Irish moss have been observed in the impingement monitoring; however, spores have been observed in the entrainment sampling (ENSR 2000).

2.2.5.3.6 Marine Mammals

A variety of marine mammals may occur within Cape Cod Bay for at least a part of their life cycle. All marine mammals are protected under the Marine Mammal Protection Act (MMPA) of 1972, as amended. The MMPA prohibits, with certain exceptions, the direct or indirect taking of marine mammals. Several of these marine mammals species are Federally listed whales, which are additionally protected under the Endangered Species Act of 1976, as amended (ESA). Such species are discussed further in Section 2.2.5.3.7 as well as in the biological assessment provided in Appendix E. The Section 7 consultation with NMFS is ongoing.

The two major groups of marine mammals that may occur within Cape Cod Bay include the cetaceans (whales, dolphins, and porpoises) and pinnipeds (seals, sea lions, and walruses).

Among the non-Federally listed whale species that may occur in this area are beluga whale (*Delphinapterus leucas*), killer whale (*Orcinus orca*), minke whale (*Balaenoptera acutorostrata*), and long-finned pilot whale (*Globicephala melaena*) (Provincetown Center for Coastal Studies

2006, Short and Michelin 2006). Of these four species only the long-finned pilot whale and the minke whale are seen with any regularity in the Gulf of Maine, which includes Cape Cod Bay (Provincetown Center for Coastal Studies 2006, Short and Michelin 2006).

Non-Federally listed dolphin and porpoise species that may occur in this area include the white-beaked 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 2006). 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 2006). Both of these species are also commonly observed in Cape Cod Bay (Short and Michelin 2006).

Sea lions and walruses are not found in Gulf of Maine; thus, the only pinnipeds potentially found in Cape Cod Bay would be the true seals. Five species of seals have been observed in the Gulf of Maine. These include harbor seals (*Phoca vitulina*), gray seals (*Halichoerus grypus*), harp seals (*P. groenlandica*), hooded seals (*Cystophora cristata*), and ringed seals (*P. hispida*) (Provincetown Center for Coastal Studies 2006). Both the gray seal and the harbor seal are commonly observed in Cape Cod Bay (Short and Michelin 2006).

There are no known occurrences of PNPS operations affecting any marine mammals.

2.2.5.3.7 Federally Listed Anadromous and Marine Species

This section provides information on marine aquatic species that are protected by Federal and State laws. Protected aquatic species that occur in freshwater habitats on the mainland, as well as birds that forage in the marine environment, are discussed as terrestrial resources in Section 2.2.6.2. Protected marine species include those that are Federally protected under the ESA, and managed by the U.S. Fish and Wildlife Service (FWS) and/or the NMFS. Also included are marine species listed as endangered, threatened, or special concern species by the Commonwealth of Massachusetts. Eleven Federally and/or State-listed marine species could occur in Cape Cod Bay in the vicinity of PNPS, including five whales, four sea turtles, and two fishes (NMFS 2006c; NHESP 2006a). These listed marine aquatic species that have the potential to occur in the vicinity of the PNPS site are presented in Table 2-4.

Four listed species of sea turtle may occur in Cape Cod Bay: loggerhead (*Caretta caretta*), Kemp's ridley (*Lepidochelys kempii*), leatherback (*Dermochelys coriacea*), and green (*Chelonia mydas*) turtles. The leatherback and Kemp's ridley turtles are listed as endangered. The green turtle is listed as endangered in its breeding populations in Florida and threatened in other areas of the U.S. The loggerhead turtle is listed as threatened.

Table 2-4. Anadromous and Marine Threatened or Endangered Species

Scientific Name	**Common Name**	**Federal Status**	**Massachusetts Status**
		TURTLES	
Caretta caretta	loggerhead turtle	Threatened	Threatened
Chelonia mydas	green turtle	Threatened (endangered in FL)	Threatened
Dermochelys coriacea	leatherback turtle	Endangered	Endangered
Lepidochelys kempii	Kemp's ridley turtle	Endangered	Endangered
		WHALES	
Balaenoptera borealis	sei whale	Endangered	Endangered
Balaenoptera physalus	fin whale	Endangered	Endangered
Eubalaena glacialis	North Atlantic right whale	Endangered	Endangered
Megaptera novaengliae	humpback whale	Endangered	Endangered
Physeter catadon (a)	sperm whale	Endangered	Endangered
		FISH	
Acipenser brevirostrum	shortnose sturgeon	Endangered	Endangered
Acipenser oxyrinchus	Atlantic sturgeon	not listed	Endangered

(a) The sperm whale has two accepted scientific names: *Physeter catadon* and *P. macrocephalus*.
Source: FWS 2006b

Sea turtles are only rarely found along the Massachusetts coast, and are primarily limited to individual juvenile "wanderers" (Prescott 2000 in Entergy 2006a). Many sea turtle species migrate north in summer months, and may be found in Cape Cod Bay. Loggerhead turtles inhabit neritic habitats in nearshore coastal areas, including bays, sounds, and estuaries in Massachusetts (NMFS 2006d). Kemp's ridley turtles can live in water temperatures as low as 11°C (51.8°F) and may be present in New England waters from June 1 to November 30, when water temperatures exceed 16°C (60.8°F) (NMFS 2006c). Leatherback turtles are expected to be present in New England waters in the summer months (NMFS 2006c). Green sea turtles are expected to be present in New England waters only sporadically (NMFS 2006c).

In late fall and winter, sea turtles still present in the bay may become cold-stunned and wash ashore (Entergy 2006a). This typically includes fewer than 20 sea turtles in any given year. The largest incident recorded was in the winter of 1999 to 2000, when a total of 277 sea turtles were found on Cape Cod beaches (Entergy 2006a). In 2003, the total number of turtles found stranded was 89 (Mass Audubon 2003 in Entergy 2006a). Records have been maintained on turtle strandings in Massachusetts for 25 years, and in that time, only one sea turtle was stranded in the Plymouth area (Entergy 2006a). This incident occurred in November 2003, when a small (approximately 50 pounds) loggerhead turtle was stranded on Priscilla Beach approximately 0.63 mi south of PNPS (Prescott 2005 in Entergy 2006a).

Six different species of great whales migrate along the Massachusetts coast, with the largest number sighted in the spring on Stellwagen Bank off of the tip of Cape Cod (Entergy 2006a). The most common species seen in this area are minke, fin, and humpback whales (Entergy 2006a). Of the six species, three endangered great whale species are found seasonally in New England waters and have been documented in Cape Cod Bay: the North Atlantic right whale (*Eubalaena glacialis*), humpback whale, and fin whale. In addition, two other endangered species, the sei whale (*B. borealis*) and sperm whale (*Physter catodon*), are known to migrate in New England waters off of the coast of Massachusetts.

Right whales may be found in Massachusetts and Cape Cod Bays throughout the year (Brown et al. 2002, in Short and Michelin 2006), and Cape Cod Bay has been designated as critical habitat for the species (Entergy 2006a). Right whales have been documented in the nearshore waters of Massachusetts from December through June, and are likely to be present in Cape Cod Bay from December 15 to April 15 (NMFS 2006c). North Atlantic right whales are the most critically endangered whale species in the Atlantic with population estimates of approximately 300 individuals. Humpback whales may be found off of the coast of Massachusetts during the period from March 15 to November 30 (NMFS 2006c). Humpback whales are documented in the Stellwagen Bank area from mid April to November, with a peak abundance in May and June (CETAP 1982, in Short and Michelin 2006). Fin whales are the most frequently sighted endangered whale species found in Massachusetts and Cape Cod Bays (EPA 1993 in, Short and Michelin 2006). Sei whales are only rarely sighted in Massachusetts and Cape Cod Bays (EPA 1993, in Short and Michelin 2006). Sperm whales may be seasonally present in New England waters, but are typically found in deeper offshore waters (NMFS 2006c).

Although these species have been documented in Cape Cod Bay and/or coastal Massachusetts waters, no whales have been observed in the shallow waters off PNPS or in the intake and discharge areas by Boston Edison or Entergy biologists since biological monitoring began in the late 1960s (Entergy 2006a).

Two species of fish are State-listed as endangered in Massachusetts: the shortnose sturgeon (*Acipenser brevirostrum*) and the Atlantic sturgeon (*A. oxyrinchus*). The shortnose sturgeon is also Federally listed as endangered by the FWS.

The shortnose sturgeon is much smaller than the Atlantic sturgeon, rarely exceeding 3 ft in length. It is often confused with the Atlantic sturgeon, but the two species can be distinguished by comparing the widths of the mouth. The shortnose sturgeon has a much wider mouth than the Atlantic sturgeon. The shortnose sturgeon is amphidromous, which indicates that the fish spawns in freshwater, but regularly enters marine and freshwater habitats during its lifespan. The shortnose sturgeon spawns in fast-flowing, rocky rivers in April and May. There are three known shortnose sturgeon populations in Massachusetts: one in the Merrimack River in northeastern Massachusetts and two in the Connecticut River in the western portion of the state. There are no known occurrences of the shortnose sturgeon in Plymouth or the surrounding area (NHESP 2006b).

The Atlantic sturgeon is a very large anadromous fish that averages 6 to 9 ft in length, but can exceed a length of 13 ft and a weight of 800 pounds. Spawning occurs generally in rocky, fast-flowing rivers in May and June, slightly later than the shortnose sturgeon. Populations of Atlantic sturgeon have been documented in the Merrimack and Taunton Rivers in eastern Massachusetts; however, none have been observed in the Plymouth area (NHESP 2006b).

2.2.6 Terrestrial and Freshwater Aquatic Resources

The PNPS site is located within and near the western border of the Atlantic Coastal Pine Barrens ecoregion, which extends in Massachusetts from Plymouth to the tip of Cape Cod and the islands of Martha’s Vineyard and Nantucket. The site is in an area of transition between this ecoregion and the Northeastern Coastal Zone ecoregion, which extends to the north and west and has a more irregular topography that includes hills and concentrations of glacial lakes. The coarse-grained, nutrient-poor soils of the area currently support temperate mixed broadleaf and coniferous forests dominated by oak and pine, similar to the forests that existed in the area historically (EPA 2006a). Thirteen sub-ecoregions have been delineated within Massachusetts. The PNPS site is within the Cape Cod/Long Island sub-ecoregion, which is characterized by terminal glacial moraines and outwash plains, coastal deposits, elevations less than 200 ft, a moderate maritime climate, and typical vegetation of stunted oak and pine forests (Swain and Kearsley 2001).

The vegetation communities that occur in the Massachusetts sub-ecoregions have been classified into 105 community types (Swain and Kearsley 2001). These natural communities have been mapped by the Massachusetts Office of Geographic and Environmental Information using interpretation of aerial photography flown in the spring of 1999 and 2000 in conjunction with field information from local ecologists and community information from the NHESP of the Massachusetts Division of Fisheries and Wildlife (MDFW). The community maps are available online from the Massachusetts Geographic Information System (MassGIS 2006). These natural community maps of the site and vicinity provide information on a local scale about the vegetation communities and, indirectly, the animals they support, which may include both common and rare species.

Among the natural communities monitored and mapped by the NHESP are vernal pools, which are small, shallow ponds that are seasonally to semi-permanently flooded basin depressions characterized by annual or semi-annual periods of dryness and a lack of fish. NHESP has a program to identify potential vernal pools and to certify, based on official guidelines, those shown by field data to function as vernal pools (MassGIS 2006). Review of the data layer for certified vernal pools indicated there are none present within the PNPS site or along the transmission line ROW.

2.2.6.1 Description of Site Terrestrial and Freshwater Aquatic Environments

An aerial photograph of the PNPS facility and its environs is shown in Figure 2-3. The approximately 140-ac PNPS site includes a central developed area that contains the generating facilities, switchyard, warehouses, office buildings, and parking lots. Prior to construction of PNPS, the developed area was occupied by a private estate. The surrounding areas to the north, west, and south are mainly undeveloped and wooded. The western shoreline of Cape Cod Bay forms the northern and eastern boundaries of the site. From the shoreline to the most inland boundary of the site along Rocky Hill Road (approximately in bands that parallel the shoreline), at least six natural community types occur: coastal beach, marine intertidal rocky shore, maritime erosional cliff, maritime shrubland, maritime oak-holly forest, and coastal forest. The maritime shrubland, maritime forest, and coastal forest communities grade into each other and into more upland forests (Swain and Kearsley 2001; MassGIS 2006).

A coastal beach community occurs in the intertidal zone along the shoreline north and south of the developed area of the site. The beach substrate is sand, gravel, and scattered rocks, which supports only sparse, non-vascular plants (algae) in this high-energy environment affected by waves and tides. An area of marine intertidal rocky shore community, which also supports algae and lacks vascular plants, occurs along a portion of the intake embayment shoreline (Swain and Kearsley 2001; MassGIS 2006). The riprap covering the man-made banks of the intake embayment, the breakwaters, and the discharge canal provides similar habitat. An area of sandy beach also occurs at the western end of the intake embayment.

Along the shoreline to the north and south of the developed areas, bluffs and cliffs rise 10 to 40 ft above the beach. In the northern segment of the shoreline, the cliffs immediately above the beach have been classified as a maritime erosional cliff community. The unconsolidated cliff face is eroding and is within the salt spray zone. Consequently, the vegetation of this community is very sparse but may include poison ivy (*Toxicodendron radicans*), Virginia creeper (*Parthenocissus quinquefolia*), bayberry (*Myrica pennsylvanica*), sweet fern (*Comptonia peregrina*), and greenbrier (*Smilax rotundifolia*) (Swain and Kearsley 2001; MassGIS 2006).

Located inland and above the beach, bluffs, and cliffs along the entire undeveloped shoreline of the site is a narrow zone of maritime shrubland community. This community receives storm salt spray and is dominated by dense patches of shrubs consisting of species such as black huckleberry (*Gaylussacia baccata*), bayberry, red cedar (*Juniperus virginiana*), black cherry (*Prunus serotina*), beach plum (*P. maritima*), chokeberry (*Aronia melanocarpa*), lowbush blueberry (*Vaccinium angustifolium*), and bearberry (*Arctostaphylos uva-ursi*). Also, greenbrier and poison ivy often grow in dense patches or cover other plants (Swain and Kearsley 2001; MassGIS 2006).

The maritime shrubland develops a tree canopy as it transitions inland into a maritime oak-holly forest community, which is a mixed deciduous/evergreen forest within the coastal salt spray zone behind the bluffs. The trees in this community tend to be short relative to interior forests (i.e., less than 10 m [30 ft] tall) with tops that are sculpted by winds and salt spray. Common overstory species include the scarlet oak (*Quercus coccinea*), black oak (*Q. velutina*), other oaks (*Q.* spp.), American holly (*Ilex opaca*), sassafras (*Sassafras albidum*), black gum (*Nyssa sylvatica*), black cherry, and red maple (*Acer rubrum*). The pitch pine (*Pinus rigida*) and red cedar also occur in this community. Vines such as greenbrier and poison ivy, Virginia creeper and/or grape (*Vitis aestivalis*) may be dense, especially near openings. Shrubs include bayberry, winged sumac (*Rhus copallinum*), and sweet pepperbush (*Clethra alnifolia*). The herbaceous layer is highly variable and may include grasses and sedges (Swain and Kearsley 2001; MassGIS 2006).

Moving inland, the trees increase in height, and the forest transitions to a coastal forest community that covers the majority of the wooded area of the site and is dominated by mixed oaks. The coastal forest is sheltered from direct daily maritime influences because it is not in the daily salt spray zone, but it receives wind and salt during storms. The climate in which this community occurs is moderated by being near the ocean, with warmer winters and cooler summers, as well as more fog and precipitation, than more inland areas. Historically, fire was often an important factor in coastal forests. The dominant oaks in this community are scarlet oak and black oak. Other trees in this community include white oak (*Q. alba*), chestnut oak (*Q. prinus*), shagbark hickory (*Carya ovata*), red maple, sassafras, gray birch (*Betula populifolia*), beech (*Fagus grandifolia*), black cherry, quaking aspen (*Populus tremuloides*), white pine (*P. strobus*), and pitch pine (MassGIS 2006; Swain and Kearsley 2001; AEC 1974). Although its natural range is well to the south, the black locust (*Robinia pseudoacacia*) also is present in site forests as a result of its historical planting as a source for fence posts and its subsequent escape from cultivation (AEC 1974). The dense understory includes a low shrub heath layer dominated by lowbush blueberries (*Vaccinium pallidum*) and black huckleberry. Other shrubs present include arrowwood (*Viburnum dentatum*), sweet pepperbush, staghorn sumac (*R. typhina*), and winged sumac. The herbaceous layer is typically sparse, with bracken fern (*Pteridium aquilinum*), wintergreen

(*Gaultheria procumbens*), and wild sarsaparilla (*Aralia nudicaulis*) often present, as well as little blue-stem grass (*Schizachyrium scoparius*) and bearberry beneath canopy openings. Common vines in this community include poison ivy, Virginia creeper, grape, and greenbriers (Entergy 2002c; MassGIS 2006; Swain and Kearsley 2001; AEC 1974).

Isolated forested wetlands are present at several locations on the site, principally south and southeast of the developed area. The dominant species in the canopy of these moist areas is the red maple, with greenbrier, cattail (*Typha latifolia*), rush (*Juncus* spp.), and bulrush (*Scirpus cyperinus*) in the understory. A small, seasonal wetland also is located in a depression within the mixed oak forest at the northern end of the site. Non-native invasive plants that occur on the site include Japanese honeysuckle (*Lonicera japonica*) and multiflora rose (*Rosa multiflora*) (AEC 1974).

Entergy also owns over 1530 ac of undeveloped land located predominantly across Rocky Hill Road south of the 140-ac PNPS site (Figure 2-3). The majority of this property (the Entergy Woodlands) has been placed in a forest land trust and is being managed under a Forest Management Plan (Entergy 2002c) approved by the Massachusetts Department of Environmental Management (MA DEM 2003). This Entergy Woodlands property encompasses the northern end of the Pine Hills, a north-south oriented ridge of low hills approximately 4 mi long (AEC 1972). The area is characterized by sandy to fairly rocky, well-drained soils and flat to steeply sloped, wooded terrain. Typical forest in the area is dominated by pitch pine and mixed oaks, with a component of white pine that is slowly recovering from repeated forest fires in the past. Typical plant species include those listed above for the on-site forest. Historically, much of the area was cleared for agriculture. Although the forest has regenerated, there are several remaining abandoned fields in varying stages of succession to forest. There also are several small, seasonal wetlands on the property (Entergy 2002c).

Wildlife species in the vicinity of PNPS are typical of those found in eastern Massachusetts. The predominant habitats at the site are those provided by the shoreline and the forested uplands and wetlands. Many wildlife species are highly mobile, moving between and utilizing habitats provided by multiple vegetation communities. In addition, many non-resident birds migrate along the coastline and, as a result, briefly utilize site habitats for food and shelter during migration.

Wildlife that utilize the shoreline habitat at the site primarily are birds, many of which are migratory and occur in the area in either summer or winter. Birds that may use the shoreline habitats at the site include shorebirds such as the willet (*Catoptrophorus semipalmatus*), dunlin (*Calidris alpina*), purple sandpiper (*C. maritima*), piping plover (*Charadrius melodus*), and sanderling (*Calidris alba*); waterfowl such as the great cormorant (*Phalacrocorax carbo*), brant (*Branta bernicla*), and sea ducks, including the common eider (*Somateria mollissima*), king eider

(*S. spectabilis*), oldsquaw (*Clangula hyemalis*), harlequin duck (*Histrionicus histrionicus*), white-winged scoter (*Melanitta deglandi*), black scoter (*M. nigra*), and surf scoter (*M. pespicillata*); wading birds such as the black-crowned night heron (*Nycticorax nycticorax*) and snowy egret (*Egretta thula*); and seabirds such as the herring gull (*Larus argentatus*), ring-billed gull (*L. delawarensis*), and greater black-backed gull (*L. marinus*) (Peterson 1980). A marine mammal that may occur here is the harbor seal, which potentially may utilize the rocky shoreline habitat of the site for basking.

Wildlife that utilize the shrub and forest habitats at the site include birds, mammals, reptiles, and amphibians. Birds that occur in site forests include both migratory species and permanent residents. Migratory species that forage and breed in forest habitats such as those at the site include the broad-winged hawk (*Buteo platypterus*), gray catbird (*Dumetella carolinensis*), wood thrush (*Hylocichla mustelina*), red-eyed vireo (*Vireo olivaceous*), black-and-white warbler (*Mniotilta varia*), yellow warbler (*Dendroica petechia*), American redstart (*Setophaga ruticilla*), common yellowthroat (*Geothlypis trichas*), ovenbird (*Seiurus aurocapillus*), and scarlet tanager (*Piranga olivacea*). Resident species that may breed in forest habitats on the site and forage there throughout the year include the red-tailed hawk (*B. jamaicensis*), sharp-shinned hawk (*Accipiter striatus*), screech owl (*Otus asio*), great-horned owl (*Bubo virginianus*), ruffed grouse (*Bonasa umbellus*), wild turkey (*Meleagris gallopavo*), cardinal (*Cardinalis cardinalis*), black-capped chickadee (*Parus atricapillus*), swamp sparrow (*Melospiza georgiana*), American robin (*Turdus migratorius*), cedar waxwing (*Bombycilla cedrorum*), downy woodpecker (*Picoides pubescens*), American crow (*Corvus brachyrhynchos*), blue jay (*Cyanocitta cristata*), and dark-eyed junco (*Junco hyemalis*) (Peterson 1980; Entergy 2006a).

Mammals likely to occur in the terrestrial forest, shrubland, and/or wetland habitats at the site include the white-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), opossum (*Didelphis virginiana*), striped skunk (*Mephitis mephitis*), New England cottontail (*Sylvilagus transitionalis*), gray squirrel (*Sciurus carolinensis*), woodchuck (*Marmota monax*), white-footed mouse (*Peromyscus leucopus*), and woodland vole (*Microtus pinetorum*) (AEC 1972;AEC 1974; Entergy 2006a; Whitaker 1980). Reptiles that commonly occur in these habitat types include the eastern hognose snake (*Heterodon platirhinos*), eastern garter snake (*Thamnophis sirtalis*), northern black racer (*Coluber constrictor*), northern ringneck snake (*Diadophis punctatus*), and eastern box turtle (*Terrapene carolina*). Amphibians likely to occur in these habitats at the site include the American toad (*Bufo americanus*), Fowler’s toad (*B. woodhousii*), spotted salamander (*Ambystoma maculatum*), and redback salamander (*Plethodon cinereus*) (AEC 1974; Conant and Collins 1998; Entergy 2006a).

2.2.6.2 Transmission Line ROW

Section 2.1.7 describes the two 345-kV transmission lines that connect PNPS to the electrical transmission system. The two lines share a single 300-ft-wide transmission line ROW that connects the PNPS switchyard with the power grid at the Snake Hill Road substation approximately 7 mi to the southwest (Entergy 2006a; AEC 1972). Within the PNPS site property, the transmission line ROW extends southeast from the switchyard, then turns south and crosses Rocky Hill Road before reaching the station access road. This on-site segment of the ROW passes through the coastal forest community and crosses the wooded deciduous wetland community located south of the main parking lot. After crossing Rocky Hill Road, the ROW enters the Entergy Woodlands property. It extends approximately 1 mi south within the woodland before turning south-southwest along the southeastern boundary of the property for another 2/3 mi. The ROW then turns farther west, leaves the Entergy Woodlands, and crosses the Pine Hills as it continues approximately southwest over 5 mi to the Snake Hill Road substation. Entergy does not own, operate, or maintain the PNPS-to-Snake Hill Road transmission lines or ROW. The lines and ROWs are owned and maintained by NSTAR Electric and Gas Corporation, which provides electricity and natural gas to businesses and residents in eastern Massachusetts (Entergy 2006a; NSTAR 2006).

The transmission line ROW does not cross any state or federal parks, wildlife refuges, or wildlife management areas (Entergy 2006a), nor does it cross any major lakes, ponds, or streams. Approximately 1.3 mi of the corridor at its southern end are within Myles Standish State Forest. The largest water feature traversed by the corridor is a medium-sized creek (approximately 8 ft wide and 1 ft deep) next to Old Sandwich Road. Dense riparian vegetation, including shrubs and small trees, is present beneath the transmission lines in the low-lying floodplain along the stream in this area. The predominant vegetation community through which the corridor passes is dry upland forest dominated by mixed oaks and pitch pine. This community supports the typical inland forest species of plants and animals discussed earlier.

NSTAR maintains the transmission line ROW in accordance with a Vegetation Management Plan (NSTAR 2006) approved by the Massachusetts Department of Agricultural Resources and the NHESP. Under this plan, NSTAR maintains the PNPS ROW from the station to the Snake Hill Road substation, as well as the rest of their system, using an integrated vegetation management program. This program integrates the selective use of herbicides approved in Massachusetts for use in sensitive areas with the use of cultural methods (i.e., selective mechanical removal of targeted vegetation by hand-cutting or mowing) and biological methods (i.e., encouraging development of stable communities of low-growing plants) to restore and maintain habitat and control invasive species in the ROW. Herbicides are used to manage vegetation by foliar treatment (spraying diluted herbicide on the foliage and stems of targeted vegetation), low-pressure basal treatment (applying herbicides, diluted in mineral oil to the lower

12 to 18 in. of the main stem of the target plants), and cut-stump treatments (applying herbicides to newly cut surfaces of mechanically cut stumps). Additionally, tree growth regulators are utilized to slow or regulate the growth of a tree, which minimizes clearance pruning and/or tree removal (NSTAR 2006). The program encourages the development of natural communities of low-growing woody shrubs and herbaceous plants while avoiding adverse environmental impacts and controlling tall-growing trees and undesirable shrub species that would interfere with operation of the transmission lines (NSTAR 2006). NSTAR's environmental personnel review work plans with maintenance crews and consult with local town conservation committees to ensure that wetland areas and sensitive plant communities are protected prior to conducting vegetation management (Entergy 2006a).

2.2.6.3 Rare Terrestrial and Freshwater Aquatic Species

Rare species include those Federally listed as endangered or threatened, as well as those listed as endangered, threatened, or special concern species by the Commonwealth of Massachusetts. Determination of listing status and protection of Federally listed terrestrial and freshwater aquatic species are within the jurisdiction of the FWS. The NHESP of the MDFW maintains a listing of rare species occurrences by town. PNPS and its transmission corridor are within the Town of Plymouth. Occurrences of 77 rare species listed by the FWS and/or the Commonwealth of Massachusetts have been recorded in the Town of Plymouth and are presented in Table 2-5. A subset of these species occurs or has a greater potential to occur on the PNPS site or in the transmission line ROW. The names of these species are indicated in bold in Table 2-5.

The Federally listed species identified by FWS (FWS 2006a) as potentially occurring in the PNPS vicinity were the piping plover (*Charadrius melodus*), roseate tern (*Sterna dougallii*), bald eagle (*Haliaeetus leucocephalus*), and northern red-bellied cooter (*Pseudemys rubriventris*), which was formerly known as the Plymouth redbelly turtle (*P. rubriventris bangsi*).

The piping plover is a small, stocky shorebird that is Federally listed as threatened in areas outside the Great Lakes watershed and is State-listed as threatened in Massachusetts. The Atlantic Coast population of the piping plover nests from Newfoundland south to North Carolina and winters from North Carolina to Florida, the Gulf of Mexico, and the West Indies. Other populations nest along rivers of the northern Great Plains and along the shores of the Great Lakes. The piping plover requires coastal beaches for nesting that are sandy, relatively flat, and free of vegetation. Their population has declined significantly over the past 50 years, due principally to habitat loss from development and beach disturbance (NHESP 1990). The piping plover is known to occur along Plymouth Beach just north of PNPS (FWS 2006a), and it may move through the PNPS site while foraging along the shoreline and during northward migration in spring or southward migration in late summer (NHESP 1990).

Table 2-5. Federally Listed Terrestrial and Freshwater Aquatic Species Potentially Occurring in the Vicinity of PNPS and the Associated Transmission Line ROW

Scientific Name[a]	Common Name[a]	Federal Status[b]	State Status[c]
Mammals			
Synaptomys cooperi	southern bog lemming		SC
Birds			
Ammodramus savannarum	grasshopper sparrow		T
Bartramia longicauda	upland sandpiper		E
Charadrius melodus	**piping plover**	(PS[1]: LT)	T
Gavia immer	**common loon**		SC
Haliaeetus leucocephalus	**bald eagle**		E
Ixobrychus exilis	least bittern		E
Parula americana	**northern parula**		T
Pooecetes gramineus	**vesper sparrow**		T
Sterna antillarum	**least tern**		SC
Sterna dougallii	**roseate tern**	(PS[3]: LE)	E
Sterna hirundo	**common tern**		SC
Sterna paradisaea	**Arctic tern**		SC
Tyto alba	**barn owl**		SC
Reptiles			
Pseudemys rubriventris	**northern red-bellied cooter**	LE[4]	E
Terrapene carolina	**eastern box turtle**		SC
Amphibians			
Hemidactylium scutatum	**four-toed salamander**		SC
Fish			
Lampetra appendix	American brook lamprey		T
Notropis bifrenatus	bridle shiner		SC
Insects			
Cicindela purpurea	purple tiger beetle		SC
Abagrotis nefascia	**coastal heathland cutworm**		SC
Acronicta albarufa	**barrens daggermoth**		T

Table 2-5. (contd)

Scientific Name	Common Name	Federal Status[b]	State Status[C]
Apamea inebriata	**drunk apamea moth**		SC
Callophrys irus	**frosted elfin**		SC
Catocala herodias gerhardi	Gerhard's underwing moth		SC
Catocala pretiosa pretiosa	**precious underwing moth**		E
Chaetaglaea cerata	**wax sallow moth**		SC
Cicinnus melsheimeri	Melsheimer's sack bearer		T
Cingilia catenaria	chain dot geometer		SC
Erynnis persius persius	**Persius duskywing**		E
Hemaris gracilis	slender clearwing sphinx moth		SC
Hemileuca maia	barrens buckmoth		SC
Hypomecis buchholzaria	Buchholz's gray		E
Itame sp.	pine barrens itame		SC
Lithophane viridipallens	**pale green pinion moth**		SC
Metarranthis pilosaria	coastal swamp metarranthis moth		SC
Papaipema sulphurata	water-willow stem borer		T
Psectraglaea carnosa	**pink sallow**		SC
Zale sp.	pine barrens zale		SC
Zanclognatha martha	pine barrens zanclognatha		T
Anax longipes	comet darner		SC
Enallagma daeckii	attenuated bluet		SC
Enallagma laterale	New England bluet		SC
Enallagma pictum	scarlet bluet		T
Enallagma recurvatum	pine barrens bluet		T
Mussels			
Alasmidonta heterodon	dwarf wedgemussel	LE	E
Alasmidonta undulata	triangle floater		SC
Leptodea ochracea	tidewater mucket		SC
Ligumia nasuta	eastern pondmussel		SC
Strophitus undulatus	creeper		SC

Table 2-5. (contd)

Scientific Name	**Common Name**	**Federal Status$^{(b)}$**	**State Status$^{(C)}$**
Vascular Plants			
Calamagrostis pickeringii	reed bentgrass		E
Carex striata	Walter's sedge		E
Conioselinum chinense	hemlock parsley		SC
Corema conradii	broom crowberry		SC
Dichanthelium wrightianum	Wright's panic-grass		SC
Eupatorium leucolepis var. novae-angliae	New England boneset		E
Helianthemum dumosum	bushy rockrose		SC
Isoetes acadiensis	Acadian quillwort		E
Lachnanthes caroliana	redroot		SC
Liatris scariosa var. novae-angliae	New England blazing star		SC
Linum intercursum	sandplain flax		SC
Lipocarpha micrantha	dwarf bulrush		T
Mertensia maritima	oysterleaf		E
Myriophyllum pinnatum	pinnate water-milfoil		SC
Ophioglossum pusillum	adder's-tongue fern		T
Polygonum puritanorum	pondshore knotweed		SC
Potamogeton confervoides	algae-like pondweed		T
Rhynchospora inundata	inundated horned-sedge		T
Rhynchospora nitens	short-beaked bald-sedge		T
Rhynchospora scirpoides	long-beaked bald-sedge		SC
Rhynchospora torreyana	Torrey's beak-sedge		E
Sabatia kennedyana	Plymouth gentian		SC
Sagittaria teres	terete arrowhead		SC
Spartina cynosuroides	salt reedgrass		T
Sphenopholis pensylvanica	swamp oats		T
Utricularia resupinata	resupinate bladderwort		T
Utricularia subulata	subulate bladderwort		SC

Table 2-5. (contd)

[a] Species names in **bold** indicate those with a greater potential to occur on the PNPS site or transmission line ROW based on the possible presence of suitable habitat.

[b] LE: Listed endangered; LT: Listed threatened
PDL: Proposed for delisting
(PS): Partial status: listing status in only a portion of the species's range, as specified:
[1] Piping plover status in Great Lakes region is endangered; populations elsewhere are threatened
[2] Bald eagle status is threatened in the conterminous (lower 48) U.S.
[3] Roseate tern status is endangered for the northeast U.S. nesting population; status is threatened elsewhere in the Western Hemisphere
[4] Status applies to population 1.

[c] E: Endangered
T: Threatened
SC: Special concern
Sources: NHESP (2006a) and FWS (2006b)

The roseate tern is a pale gray seabird with a black cap and underparts tinged with pink. Its northeastern U.S. nesting population is Federally listed as endangered, and it is State-listed as endangered in Massachusetts. The northeastern population breeds from Nova Scotia to Long Island and winters from the Caribbean to the coast of South America. The roseate tern nests in Massachusetts on coastal beaches, islands, and inshore beaches. It prefers dense herbaceous cover such as beach grass and seaside goldenrod, and it is a colonial nester that is always found with the common tern (*Sterna paradisaea*). The northeastern U.S. population has declined precipitously, approximately 70 percent since 1935, due to factors such as alteration of nesting habitats, displacement from nesting areas by gulls, erosion, flooding, and human predation on their wintering grounds (NHESP 1988). The roseate tern is known to occur along Plymouth Beach just north of PNPS (FWS 2006a), and it may pass through the PNPS site during northward migration in late spring or southward migration in early fall (NHESP 1988).

On June 28, 2007 the bald eagle was removed from the Federal list of threatened and endangered species (FWS 2007). It is State-listed as endangered in Massachusetts. The bald eagle occurs in Massachusetts primarily in winter, but nesting also occurs in certain areas near the coast or large inland water bodies. Bald eagle populations declined due to habitat loss, human predation, and the eggshell-thinning effects of organochlorine pesticides in the food web. With regulatory protection and the banning of organochlorine pesticide use, bald eagle populations have increased. Wintering bald eagles occasionally occur in the area of PNPS (FWS 2006a), and in 2005 juveniles and adults were observed at Plimoth Plantation, approximately 2 mi southwest of PNPS (Entergy 2006a).

The Massachusetts population of the northern red-bellied cooter is both Federally and State-listed as endangered. The Massachusetts population currently is considered a disjunct population of the species, which is a freshwater aquatic turtle whose primary range extends from New Jersey south to North Carolina and inland to West Virginia. The isolated Massachusetts population formerly was considered a distinct subspecies, which is why it is listed by the FWS as the Plymouth redbelly turtle. The endangered Massachusetts population of the northern red-bellied cooter inhabits freshwater ponds that have abundant aquatic vegetation. Sandy soil with an open canopy on land surrounding the ponds is required for successful nesting (NHESP 1995b). In accordance with the ESA, the FWS has identified and designated critical habitat for the red-bellied cooter (at 50 CFR 17.95) in the site vicinity. Critical habitat is habitat that is considered essential to the conservation of the species and that may require special management considerations or protection (FWS 1980). Approximately 1400 ft of the transmission line ROW, near its southern end and adjacent to the boundary of Myles Standish State Forest, crosses the southeastern tip of the area designated as critical habitat for the red-bellied cooter. The ponds encompassed in this critical habitat area are located west of the Jordan Road Tap-to-Snake Hill Road Substation segment of the ROW.

In addition to the four Federally listed species discussed above, a fifth species that is both Federally and State-listed as endangered and has the potential to occur in the Town of Plymouth is the dwarf wedgemussel (*Alasmidonta heterodon*). This mussel inhabits well-oxygenated rivers and streams with sand, muddy sand, and gravel bottoms, slow to moderate currents, and little silt deposition. Such habitats do not occur on the PNPS site or in the transmission line ROW. In addition, the dwarf wedgemussel may no longer exist in the state. The last known Massachusetts population was extirpated by 1988 (NHESP 1991). Therefore, this species is not considered to have the potential to occur in the study area.

There are approximately 73 additional species within the Town of Plymouth that are State-listed as endangered, threatened, or of special concern in Massachusetts (Table 2-5). Approximately 22 of the State-listed species (names bolded in the table) potentially could utilize habitats available on the PNPS site or the transmission line ROW based on their preferred habitat characteristics; however, their presence has not been confirmed. The Massachusetts NHESP has mapped Priority Habitats for State-Protected Rare Species based on occurrence and population records maintained in the NHESP database, and it also has mapped Estimated Habitats for Rare Wildlife for use with the Massachusetts Wetland Protection Act Regulations (310 CMR 10) (NHESP 2005).

No priority habitats have been mapped within the PNPS site for species currently listed as rare by the Commonwealth of Massachusetts. An area of priority habitat for a previously State-listed species of special concern, the spotted turtle (*Clemmys guttata*), was mapped in the northern end of the PNPS property. This area also was designated as an Estimated Habitat for Rare

Wildlife. However, the spotted turtle was deleted from the State list of rare species in May 2006 based on occurrence records that have demonstrated the turtle to be more common and widespread in Massachusetts than previously known and on the significant areas of habitat that have been protected since its listing in 1986 (NHESP 2006b). Consequently, there currently are no state-listed rare species with designated habitat on the PNPS site. The transmission line ROW does not cross any Priority Habitats for State-Protected Rare Species or Estimated Habitats for Rare Wildlife (NHESP 2005).

2.2.7 Radiological Impacts

A radiological environmental monitoring program (REMP) has been conducted around the PNPS site since August 1968 (AEC 1974). Licensed operations at PNPS began in 1972. The REMP is conducted to monitor the radiation and radioactivity released to the environment as a result of PNPS operation.

The results of measurements of radiological releases and environmental monitoring are summarized in two annual reports: the PNPS Radiological Environmental Monitoring Program Report (Entergy 2006b) and the PNPS Radioactive Effluent and Waste Disposal (REWD) Report (Entergy 2006c). The Offsite Dose Calculation Manual (ODCM) specifies the limits for all radiological releases (Entergy 2003c). These limits are designed to meet Federal standards and requirements for all radiological releases including ambient radiation.

The REMP consists of taking radiation measurements and collecting samples from the environment at a variety of locations surrounding the PNPS site, analyzing them for radioactivity content, and interpreting the results. Sampling locations are chosen based on meteorological factors, pre-operational planning, and results of land-use surveys. A number of locations in areas unlikely to be affected by plant operations are selected as controls. With emphasis on the critical radiation exposure pathways to humans, samples from the aquatic, atmospheric, and terrestrial environments are collected. These samples include, but are not limited to: air, soil, seawater, shellfish, lobster, fishes, cranberries, vegetables, and forage.

Thermoluminescent dosimeters are placed in the environment to measure gamma radiation levels. The thermoluminescent dosimeters are processed and the environmental samples are analyzed to measure the very low levels of radiation and radioactivity present in the environment as a result of the PNPS operation and other natural and man-made sources (Entergy 2006b). Results from the 5-year period 2001 through 2005 indicate that the radiation and radioactivity in the environmental media monitored around the plant are well within applicable regulatory limits and are not significantly higher than pre-operational levels
(Entergy 2002a, 2003a, 2004a, 2005a, 2006b).

In addition to monitoring radioactivity in environmental media, Entergy annually assesses doses to the maximally-exposed individuals from gaseous and liquid effluents based on actual liquid and gaseous effluent release data (Entergy 2006c). Calculations are performed at several locations using the plant effluent release data, on-site meteorological data, and appropriate pathways identified in the ODCM (Entergy 2003c). A summary of the calculated maximum doses to individuals in the vicinity of PNPS from liquid and gaseous effluents for 2005 follows:

- No liquid effluents containing radioactivity were discharged during the calendar year 2005, so there is no associated contribution to radiation dose (Entergy 2006c).

- The maximum total body dose from noble gases in gaseous effluents was 0.075 mrem from gamma radiation, which is 0.75 percent of the 10 mrem gamma dose design objective specified in 10 CFR Part 50, Appendix I, and 1.6 mrem from beta radiation, which is 8.0 percent of the 20 mrem beta dose design objective (Entergy 2006c).

- The critical organ dose from gaseous effluents because of iodines, tritium, and particulates with half-lives greater than 8 days was 3.2 mrem, which is 21 percent of the 15 mrem dose design objective (Entergy 2006c).

- As a result of current water management practices that emphasize reprocessing and reuse rather than release, PNPS had liquid radioactive effluent releases in some years and some years it had none. For example, while liquid radioactive waste releases were reported for each year from 2001 through 2003, there were no liquid effluent releases made during 2004 or 2005. During this 5-year period, the maximum annual total body dose from liquid effluents occurred in 2003. It was 0.003 mrem, which is 0.1 percent of the 3 mrem design objective specified in 10 CFR Part 50, Appendix I. The maximum critical organ dose during this period also occurred in 2003. It was 0.008 mrem, which is 0.08 percent of the 10 mrem design objective specified in 10 CFR Part 50, Appendix I.

In all cases, doses were well below the limits as defined in the ODCM and confirm that PNPS is operating in compliance with 10 CFR Part 50, Appendix I, 10 CFR Part 20, and 40 CFR Part 190.

No significant changes to the radioactive effluent releases or exposures from PNPS operations during the license renewal term are expected, and therefore, the impacts to the environment are not expected to change.

2.2.8 Socioeconomic Factors

2.2.8.1 Housing

Approximately 80 percent of the permanent PNPS work force resides in Plymouth (63 percent) and Barnstable (19.5 percent) counties in southeastern Massachusetts, which is the fastest growing region in the state (Entergy 2006a). PNPS employs approximately 700 personnel, including Entergy employees normally on-site (or at off-site training facilities) and contractor employees. During refueling and maintenance outages, typically lasting 30 days, there are an additional 900 workers on-site. Maintenance outages usually occur every 24 months. There are no plans to add additional employees at the site. The residences of the PNPS employees are shown in Table 2-6 by State and county and, for Plymouth and Barnstable counties, by city or town in Table 2-6.

Data on total housing units in the region are shown by county for 1990 and 2000 in Table 2-7 together with the numbers of occupied units, and vacant units available for sale or rent. The Massachusetts counties shown had a total of 1,377,360 housing units in 2000, an increase of 7.1 percent since 1990. Occupied units in the region totaled 1,278,641 units in 2000, an increase of 10 percent since 1990. The number of vacant units for sale or rent in 2000 was 22,421, a decline of 44 percent over the number of vacant units for sale or rent in 1990. In the context of the scale of southeastern Massachusetts' housing market, however, accommodating the plant's approximately 700 employees has not been a problem; they would represent only 0.05 percent of the occupied units in 2000. Accommodating the additional plant workers during the periods of biennial maintenance outages, when an additional 900 workers are on site, is facilitated by the region's extensive seasonal accommodations, as well as the 22,421 units in year 2000 that were available as vacant for sale and rent.

Table 2-6. Pilgrim Nuclear Power Station Permanent Employee Residence Information by County and Town/City

County and Town/City	PNPS Employees
PLYMOUTH COUNTY (MASSACHUSETTS)	
Abington	3
Bridgewater	9
Brockton	5
Carver	25
Duxbury	19
East Bridgewater	5
Halifax	10
Hanover	9
Hanson	5
Hingham	7
Kingston	21
Lakeville	2
Marion	1
Marshfield	27
Middleboro	13
Norwell	3
Pembroke	18
Plymouth	223
Plympton	2
Rochester	8
Rockland	3
Scituate	6
Wareham	14
West Bridgewater	1
Whitman	5
Total	**444**
BARNSTABLE COUNTY (MASSACHUSETTS)	
Barnstable	21
Bourne	25
Brewster	1
Chatham	1
Dennis	6
Falmouth	9
Harwich	4
Mashpee	13
Sandwich	53
Yarmouth	4
Total	**137**

Table 2-6. (contd)

County and Town/City	PNPS Employees
OTHER COUNTIES	
Norfolk (Massachusetts)	57
Bristol (Massachusetts)	43
Middlesex (Massachusetts)	6
Suffolk (Massachusetts)	6
Worcester (Massachusetts)	3
Providence (Rhode Island)	3
New London (Connecticut)	1
Manatee (Florida)	1
Cheshire (New Hampshire)	1
Oswego (New York)	1
Total	**122**

Source: Entergy 2006a

Table 2-7. Housing Units and Housing Units Vacant (Available) by County During 1990 and 2000

	1990	2000	Approximate Percentage Change
Barnstable County			
Housing Units	135,192	147,083	8.8
Occupied Units	77,586	94,822	22.2
Vacant Units	5,675	2,712	-52.2
Plymouth County			
Housing Units	168,555	181,524	7.7
Occupied Units	149,519	168,361	12.6
Vacant Units	5,229	2,436	-53.4

Sources: USBC, 1990 and 2000

2.2.8.2 Public Services

2.2.8.2.1 Water Supply

Most of the PNPS employees reside in Plymouth and Barnstable counties; with almost one-third residing in the Town of Plymouth. With the exception of Scituate, Abington-Rockland (which obtain their drinking water from both groundwater and surface water), and Brockton (which obtains its drinking water from surface water only), all of the communities in Plymouth County, including the Town of Plymouth, obtain their municipal water supply from groundwater sources (Entergy 2006a). Table 2-8 provides public water supply information for selected Plymouth County water systems, including average consumption and authorized withdrawal volume for the year 2003. Average daily consumption rates exceed the authorized withdrawal limits (capacities) for two of the water systems listed on Table 2-8. Those communities purchase water from communities with excess capacity to meet the residual demand. Overall, the region has excess capacity and has been able to meet total demand (MDEP 2004). In the Town of Plymouth, the Plymouth-Carver aquifer has sufficient water for existing and projected demand (Town of Plymouth 2006a).

Table 2-8. Selected Plymouth County Public Water Supply Systems and Capacities in 2003

Water System	Average Consumption (mgd)	Authorized Withdrawal Volume (Capacity mgd)
Duxbury Water Department	1.35	1.85
Halifax Water Department	0.49	0.68
Kingston Water Department	1.39	1.56
Marshfield Water Department	2.90	3.3
Middleborough Water Department	1.53	3.03
Pembroke Water Division	1.33	1.26
Plymouth Water Division	4.61	6.36
Plymouth Water Co.	0.26	0.22

Sources: MDEP 2004 and Entergy 2005c

Groundwater is the only source of drinking water for most of the communities in Barnstable County (Cape Cod Commission 2003). Table 2-9 provides public water supply information, including average consumption and authorized withdrawal volume for the year 2003, for Barnstable County water systems serving the areas where the majority of the PNPS employees that live in Barnstable County reside. Three of the water systems had average consumption levels slightly in excess of authorized withdrawals. The water systems can buy or sell water to each other in order to meet demand (MDEP 2004). To ensure a sustainable supply of high-quality drinking water, the Cape Cod Commission has identified potential public water supply areas and minimum performance standards designed to protect those areas (Cape Cod Commission 2003).

Table 2-9. Barnstable County Public Water Supply Systems and Capacities in 2003

Water System	Average Consumption (mgd)	Authorized Withdrawal Volume (Capacity mgd)
Barnstable Fire District	0.54	0.66
Barnstable Water Company	2.57	3.42
Bourne Water District	1.17	1.40
Buzzards Bay Water District	0.46	0.53
COMM Water Department	2.74	3.57
Cotuit Water Department	0.49	0.48
Mashpee Water Department	1.26	1.30
North Sagamore Water District	0.51	0.48
Sandwich Water District	1.67	2.64
South Sagamore Water District	0.10	0.09

Sources: MDEP 2004 and Entergy 2005c

2.2.8.2.2 Education

Public school systems in Plymouth County are organized by township, with 27 separate school districts in the county. The Town of Plymouth Public Schools serve over 8800 students (Town of Plymouth 2004c) and rely on a 2004 operating budget of over $70.9 million in expenditures (Town of Plymouth 2004c). School population projections provided by the town indicate a growth by 2010 of 130 students (to 8930 or 1.5 percent over 2004 levels) and to 9413 in 2020 (a growth of 613 or 7 percent over 2004 levels) (Urbanomics 2006).

2.2.8.2.3 Transportation

Figures 2-1 and 2-2 show the PNPS site and highways within a 50-mi radius and a 6-mi radius of PNPS. At the larger regional scale, the major highways serving PNPS are:

(1) Route 3, a four-lane divided highway that generally parallels the coast from Boston to Cape Cod;

(2) I-495, an outer ring road for Boston that extends southeast towards Cape Cod; and

(3) Route 44, much of which has recently been improved to four lanes, that extends west from Plymouth to I-495.

Local road access to PNPS is via Rocky Hill Road or Power House Road (formerly known as Edison Access Road). These are both two-lane paved roads with the latter owned and maintained by Entergy. Rocky Hill Road intersects with Route 3A approximately 1.5 mi west of PNPS, and Power House Road intersects with Route 3A approximately 1.5 mi south of PNPS and 2.5 mi east of the Rocky Hill Road intersection with Route 3A.

Route 3A generally parallels the coast in the Town of Plymouth, providing access to both Rocky Hill Road and Power House Road from downtown Plymouth. Route 3A also connects with Route 3 near downtown Plymouth, and again close to the boundary with Barnstable County and Cape Cod. Route 3 is the major north-south highway in the Town of Plymouth and is used by the PNPS employees traveling south from the towns of Marshfield, Duxbury, Kingston and Pembroke. Employees traveling north to PNPS would likely use either Route 3A to Power House Road or Route 3 to Clark Road/Beaver Dam Road, which intersects Route 3A approximately one-quarter mi east of Power House Road. Employees traveling east to PNPS would use Route 44 to Routes 3 or 3A.

The level of service determination for the intersection of Route 3A and Beaver Dam Road/White Horse Road is C, which describes operations with moderate delay (Vanasse & Associates 2001, in Entergy 2006a). Table 2-10 provides available daily traffic counts for roads in the vicinity of PNPS from the Massachusetts Highway Department.

Old Colony Planning Council (OCPC), at the request of the Town of Plymouth Department of Public Works, recently conducted a traffic study of Rocky Hill Road (OCPC 2006b). This road generally follows the coastline and serves residences both east and west of PNPS. The study was initiated because of safety concerns of residents: specifically, several sharp curves, changes in grade, and limited sight distances, especially in the segment west of PNPS.

Table 2-10. Traffic Counts for Roads in the Vicinity of PNPS

Route No.	Route Location	Estimated Average Daily Traffic Volume	Year
3	North of Clark Road*	30,500	1992
3A	North of Beaver Dam Road	14,400	2003
3A	South of Rocky Hill Road	13,000	1995
3A	South of Route 44	12,700	1998
44	East of Route 3	17,677	1990

* Beaver Dam Road is the continuation of Clark Road north of the intersection with Sandwich Road.
Source: Entergy 2006a

The road is narrow (25 ft), with two 12-ft lanes, without shoulders and with limited (2 to 2.5 ft) width for pedestrians. Traffic volumes counted in August 2005 indicate higher volumes at the western end of the road near its intersection with Route 3A. Here, average 24-hour volumes were 4372 vehicles with an a.m. peak of 274 per hour and p.m. peak of 354 per hour. Volumes east of PNPS are much lower, with a 24-hour average of 2360 vehicles, an a.m. peak of 154, and p.m. peak of 198. The OCPC traffic study notes that the road has adequate capacity for the highest volumes recorded. (OCPC cites the Institute of Transportation Engineers, *Transportation Planning Handbook,* that in excess of 10,000 vehicles per arterial lane usually indicates a need for more capacity.)

The study notes that average speeds exceed the posted 30 miles per hour and that several locations have substandard sight distances. The report makes several recommendations, including: speed warning signs at the curve in the vicinity of 209 to 222 Rocky Hill Road; constructing or widening shoulders; speed humps; and an increase in police speed enforcement. The report makes no mention of PNPS as a specific factor in its safety analysis. Truck traffic accessing the plant is directed by Entergy to use Power House Lane rather than Rocky Hill Road.

2.2.8.3 Off-site Land Use

PNPS is located in the Town of Plymouth. Current land use surrounding PNPS is predominantly residential, with the population concentrated toward Cape Cod Bay (See Figure 2-3). The communities of Priscilla Beach and White Horse Beach are located along the shoreline directly to the southeast of the site; they are in the Town of Plymouth R-20SL/Small Lot Residential zone[c]. The Bay Shore Drive neighborhood along the shoreline to the northwest is zoned R-25/ Residential[c]. The nearest population centers are Manomet to the southeast (approximately 0.5 mi) and Plymouth to the west (approximately 2 mi). Low density residential development and areas of vacant land/open space are located south of the PNPS site, inland from the shoreline. This area is the northern part of the Pine Hills, a north-south oriented ridge of low hills that contain the highest elevations in the town. The current zoning scheme in the Town of Plymouth is designed to guide growth in keeping with the land use objectives presented in the Master Plan (Town of Plymouth 2006a). Based on the zoning currently in place, the future land uses planned for the areas surrounding the site are large lot and medium lot residential, including the Entergy woodlands property, which is zoned for large lot residential development. Future land use for the PNPS site itself is industrial.

The Town of Plymouth has the largest land area of the 26 towns and one city that make up Plymouth County; it is also the largest town in the state, as well as the oldest (incorporated in 1620). The area within the vicinity of PNPS (i.e., within a 6-mi radius of the site) is located entirely in Plymouth County and almost completely in the Town of Plymouth. The Town of Plymouth has 65,920 ac of land. Based on 2004 land use data provided in the Master Plan (Town of Plymouth 2006a), 29 percent of the Town of Plymouth is developed: 21 percent is residential, just over 4 percent is commercial and industrial, and 4 percent is occupied by nonprofit uses. Seventy-one percent of the Town of Plymouth is undeveloped. Publicly owned property and protected open space occupy 36 percent of the town. Myles Standish State Forest, a 12,500-ac recreation area owned by the Commonwealth of Massachusetts, represents approximately half of the publicly owned property in Plymouth. Properties privately held in Chapter 61, 61A, and 61B uses (currently utilized for forestry, agriculture, and outdoor recreation, respectively) occupy 23 percent of Plymouth. Almost all of the agricultural land in the town is used for cranberry production. Nearly 12 percent of land in the town is vacant.

Land use in the Town of Plymouth is regulated by the town, primarily through zoning and preservation incentives. The Town of Plymouth Master Plan (Town of Plymouth 2006a) provides a vision for the future and a framework for both preservation and growth. The characteristics identified by local residents as most important to preserve are small town character, natural resources, historic heritage, and open space. The Master Plan encourages smart growth, which emphasizes development within or near growth areas (primarily “village centers”) and away from preservation areas that Plymouth intends to protect for environmental, scenic, cultural, recreational, and fiscal reasons. Plymouth has implemented village center zoning in which the existing mixed uses of a village (residential, commercial, and civic) are preserved and new

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(c) The R-20SL zoning district has a minimum lot size of 20,000 ft^2 (Small Lot Residential). The R-25 district has a minimum lot size of 25,000 ft^2 (Medium Lot Residential) (Town of Plymouth 2004c).

construction encouraged that is compatible with the village setting. Six village centers have been identified in the town; PNPS lies between the Plymouth Center and Manomet Village Centers.

Approximately 80 percent of the permanent PNPS work force resides in Plymouth County (63 percent) and Barnstable County (19.5 percent) in southeastern Massachusetts, which is the fastest growing region in the state (Entergy 2006a). Sprawl, in the form of large-lot, low-density residential development that consumes open space and costs more in town services than it returns in property taxes, is a critical issue facing towns in southeastern Massachusetts. In the Town of Plymouth, for example, most of the new housing constructed since 1980 has been single family homes, of which 58 percent have been built outside the villages and 82 percent have been built in large lot zoning districts. Average land consumption per single family unit has almost doubled from an average lot size of 0.6 to 1.0 ac. In Fiscal Year (FY) 2001, the average cost to service a single family home in the town’s rural areas exceeded $8600, more than double the cost of servicing a higher density home in the older village centers (Town of Plymouth, 2006a). In Barnstable County, more than 15,000 ac of open land (nearly 6 percent of the land on Cape Cod) was converted to development during the 1990s and the number of housing units increased by approximately 17,000 (Cape Cod Commission 2003).

Vision 2020 is a partnership for southeastern Massachusetts, which includes Plymouth County as well as neighboring Bristol County and southern Norfolk County. It is a regional growth management initiative addressing the rapid growth and change occurring in the area between Boston, Cape Cod, and Rhode Island (OCPC 2000). Vision 2020 is charged with preparing an overall growth and development strategy for southeastern Massachusetts. The project identifies strategies and incentives to (1) encourage compact development and minimize sprawl; (2) preserve and enhance farmland, natural resources and open space; (3) protect historical resources; and (4) encourage economic development that is beneficial to the region.

2.2.8.3.1 Plymouth County

Plymouth County occupies an area of 661 square mi and is located in the Boston-Cambridge-Quincy, Massachusetts-New Hampshire metropolitan area (USCB 2006b). Land use in the county is primarily forest (51 percent) and residential (22 percent). Agriculture and open land each occupy 8 percent of the county land area. Industrial and commercial (3 percent) are minor land uses. Table 2-11 provides the acreage and percent of total for each land use category in Plymouth County.

Table 2-11. Land Use in Plymouth County, 1999

Land Use	Acres	Percent of Total
Residential	96,467	21.9
Commercial	5,892	1.3
Industrial	7,706	1.7
Recreation	7,108	1.6
Transportation	5,069	1.2
Agriculture	37,454	8.5
Forest	223,861	50.8
Open Land	37,423	8.5
Water	19,756	4.5
Total	**440,735**	**100**

Source: MEOEA 2003

Control of land use in Plymouth County rests with the individual towns, which have zoning authority for the lands within their boundaries. OCPC is the regional planning agency responsible for overall coordination of planning in 11 of the communities in Plymouth County, including the Town of Plymouth. The Council was formed in response to a growing need of local communities to be able to address the many issues that cross over local boundaries such as air quality, water supply and quality, transportation, and economic development. The Regional Land Use and Transportation Policy Plan published in October 2000 (OCPC 2000) provides regional land use policies designed to guide future growth into priority development areas; encourage compact, mixed-use community centers; protect outlying areas more suitable to natural resource protection, agricultural, open space and recreation uses, and water supply protection; and increase housing diversity.

In the late 1990s, the Massachusetts Executive Office of Environmental Affairs developed build-out analyses for all the towns and cities in the state, which projected the additional housing units and commercial and industrial space that would be built if the community were to fully develop its land. The build-out study for the Town of Plymouth estimates that 29,043 developable acres are available as of 1999, which represents 44 percent of the total town land area. The study projects a doubling of residential units (from 21,250 to 41,147) and population (from 51,701 to 105,424) at build-out (Town of Plymouth 2006a).

2.2.8.3.2 Barnstable County

Barnstable County, which comprises the towns of Cape Cod, has a separate Regional Policy Plan that is both a planning and a regulatory document (Cape Cod Commission 2003). The Regional Policy Plan develops a growth policy for Cape Cod, identifies key resources of regional importance, and provides the framework for town local comprehensive planning efforts. Its purpose is to guide development on Cape Cod and protect its resources. The Regional Policy Plan is required by the Cape Cod Commission Act of 1990, which calls for an update to the plan every 5 years.

Barnstable County has a land area of 396 square mi and is located in the Town of Barnstable, Massachusetts metropolitan area (USCB 2006a). The county, located southeast of and adjacent to Plymouth County, includes the 15 coastal towns that make up the Cape Cod peninsula. The major land uses in Barnstable County are forest (40 percent), residential (29 percent), and open land (16 percent). The remaining 15 percent of the county is occupied by water (5 percent) and other land uses. Table 2-12 identifies the acres in each land use category in Barnstable County and the percent of the total land area that each category occupies.

Table 2-12. Land Use in Barnstable County, 1999

Land Use	Acres	Percent of Total
Residential	78,049	29.4
Commercial	4,756	1.8
Industrial	3,308	1.2
Recreation	9,344	3.5
Transportation	4,753	1.8
Agriculture	4,195	1.6
Forest	106,250	40.0
Open Land	41,569	15.6
Water	13,492	5.1
Total	**265,717**	**100**

Source: MEOEA 2003

Barnstable County has a county legislative body with the power to enact ordinances. The county is the regional government for Cape Cod (Barnstable County 2006). The Cape Cod Commission, a department of the county, is the regional planning and land use regulatory agency for Barnstable County. The Commission was established in response to an unprecedented growth boom in the 1980s. The Commission's purpose is to prepare and oversee implementation of a regional land use policy plan for all of Cape Cod, review and regulate Developments of Regional Impact, and recommend designation of certain areas as Districts of Critical Planning Concern. Barnstable County adopted the latest update of the Cape Cod Commission's Regional Policy Plan in 2002, which was revised in 2003 (Cape Cod Commission 2003). The Regional Policy Plan includes broad goals that set the direction for the future of the county as well as more detailed Minimum Performance Standards that future development on Cape Cod is required to meet. As in Plymouth County, the towns in Barnstable County guide land use through local zoning bylaws. The Regional Policy Plan provides a growth policy in which development is redirected toward existing village centers and other developed areas and away from outlying areas in order to preserve open space, natural resources, and scenic landscapes.

As of 2000, Barnstable County has 76,973 ac available for development, approximately 31 percent of the land on Cape Cod. A build-out analysis conducted in 2000 by the Cape Cod Commission and the Massachusetts Executive Office of Environmental Affairs determined that Barnstable County could add 37,000 housing units and at least 50,000 people at build-out, which would likely be reached within 30 years (Cape Cod Commission 2003).

2.2.8.4 Visual Aesthetics and Noise

The PNPS plant structures can be seen from Cape Cod Bay, from approximately north-northwest to southeast. Most visible is the 330-ft-tall main stack, with its alternating white and red stripes and aviation lights. For boaters on the bay, the stack serves a useful navigational purpose as a notable landmark. From the land side, PNPS is relatively well screened by natural vegetation from viewers on Rocky Hill Road, the closest public thoroughfare. Motorists traveling on Rocky Hill Road pass two former entrance gates and the main entrance drive to the plant at Power House Road. Overhead transmission lines pass over local roads on their way to connect to the regional grid. Viewers from other vantage spots, such as Priscilla and White Horse Beaches, would see only the plant's stack.

2.2.8.5 Demography

2.2.8.5.1 Regional Population

U.S. Census Bureau (USCB) year 2000 data and geographic information system (GIS) software (ArcView®) were used by the applicant to determine the demographic characteristics in the vicinity of PNPS. Census data reveal that approximately 285,547 people live within 20 mi of PNPS, with a population density of 422 persons per square mi within 20 mi of PNPS and, applying the GEIS sparseness index, falls into the least sparse category, Category 4 (having greater than or equal to 120 persons per square mile within 20 mi). This calculation corrects for the area within the radius that is water (Entergy 2006a).

USCB data indicate approximately 4,629,116 people live within 50 mi of PNPS. This equates to a population density of 1167 persons per square mi within 50 mi. Applying the GEIS proximity index, PNPS is classified as Category 4 proximity (having greater than or equal to 190 persons per square mi within 50 mi). According to the GEIS sparseness and proximity matrix, PNPS ranks of sparseness Category 4 and proximity Category 4 result in the conclusion that PNPS is located in a "high" population area. All or parts of 15 counties (Figure 2-1) and the cities of Boston, Massachusetts, and Providence, Rhode Island, are located within 50 mi of PNPS.

In 2000, Plymouth County and Barnstable County had a combined total population of 695,052 (USCB 2006a, USCB 2006b). Plymouth County extends to metropolitan Boston and comprises 26 towns and one city. Barnstable County is made up of 15 towns on Cape Cod. From 1970 to 2000, Plymouth County had an average annual growth rate of 1.4 percent and Barnstable County had an average annual growth rate of 4.3 percent. Both Plymouth and Barnstable counties have been growing at a rate faster than that of Massachusetts as a whole. From 1970 to 2000, Massachusetts's average annual population growth rate was 0.39 percent (Entergy 2006a).

Table 2-13 shows estimated populations and annual growth rates through 2020 for the two counties with the greatest potential to be socioeconomically affected by license renewal activities. The proposed license renewal term is through 2032; however, the Massachusetts Institute for Social and Economic Research (MISER) projections extend only through 2020. Plymouth, while representing the larger of the two counties in terms of population, is projected to grow at a much slower rate than Barnstable over the period to 2020. Plymouth is projected to grow a total of 16.5 percent over 2000 to 2030, compared to Barnstable's 50.6 percent.

Table 2-13. Population Growth in Plymouth and Barnstable Counties - 1980 to 2020

	Plymouth County		Barnstable County	
	Population	Annual Growth Percent[(a)]	Population	Annual Growth Percent[(a)]
1970[1]	333,314	-	96,656	-
1980[1]	405,437	2.16	147,925	5.3
1990[1]	435,276	0.7	186,605	2.6
2000[1]	472,822.	0.9	222,230	1.9
2010[2]	496,053	0.5	257,844	1.6
2020[2]	517,644	0.4	299,035	1.6
2030[3]	551,005	0.6	334,766	1.2

(a) Annual percent growth rate is calculated over the previous decade.
Sources: (1) USCB 1995, (2) MISER 2003, (3) Entergy 2006a

2.2.8.5.2 Transient Population

Coastal areas of Plymouth and Barnstable counties experience major increases in their summer populations because of the area's attraction as a vacation destination. This is reflected in the number of "vacant for seasonal use" housing units reported in the U.S. Census. For Barnstable County the 2000 Census reports 47,610 units vacant for seasonal use (91 percent of all vacant units and 32.4 percent of all housing units). In Plymouth County, vacant for seasonal use units in 2000 totaled 8865 (67 percent of all vacant units or 4.9 percent of all housing units). In addition, there are numerous hotels, motels and guest houses that serve the tourist/vacation population. The Town Manager of Plymouth reported that the summer population of the town increased to approximately 86,000, from a year-round population of 55,000, i.e., a 56 percent increase (Sylvia 2006). Other indicators of significant seasonal activity are the number of registered boats in Plymouth harbor. The statistics for 2004 indicate that there were 655 moorings in the harbor, 5000 visiting boats that logged in, and an estimated 11,000 boats launched at the boat ramp (Town of Plymouth 2004c).

2.2.8.5.3 Minority and Low-Income Populations

Executive Order 12898 (59 FR 7629), *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, refers to a Federal policy that requires Federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of its actions on minority and low-income populations. Although the Executive Order is not mandatory for independent agencies, the NRC has voluntarily committed to undertake environmental justice reviews and in 2004, the Commission issued a final *Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions* (NRC 2004a).

The guidance requires determining the existence of minority and low-income populations within 50-mi radius of the site and the use of the state as the geographic area for comparative analysis. According to the guidance, a qualified minority population exists in a census block group (a USCB-designated area smaller than a census tract), if the percentage of each minority and aggregated minority category within the census block group exceeds the corresponding percentage of minorities in the state of which it is a part by 20 percentage points, or the corresponding percentage of minorities within the census block group is at least 50 percent. A qualified low-income population exists if the percentage of low-income population within a census block group exceeds the corresponding percentage of low-income population in the state of which it is a part by 20 percent, or if the corresponding percentage of low-income population within a census block group is at least 50 percent.

Using the ArcView® GIS software to combine USCB Topologically Integrated Geographic Encoding and Referencing System (TIGER) line data with USCB 2000 census data to determine minority and low-income characteristics (at the block-group level) within the 50-mi radius of the PNPS site, it was determined that the 50-mi radius includes 3863 block groups in a two-state area, with the largest portion of that area (89 percent) located in Massachusetts and a smaller portion (11 percent) in Rhode Island.

2.2.8.5.4 Minority Populations

The NRC Environmental Justice guidance defines a "minority" population as the racial categories: American Indian or Alaskan Native, Asian, Native Hawaiian or Pacific Islander, Black races, other races, more than 2 races, and the aggregate of all minority races. Hispanic ethnicity is also defined as a minority population category (NRC 2004b, in Entergy 2006a). Hispanic ethnicity is not defined by the USCB as a racial category and, therefore, it is possible to have both white Hispanics and non-white Hispanics (e.g. Black Hispanic, Asian Hispanic). For the purposes of aggregation, a minority population that combines both minority races and Hispanic ethnicity can be defined as all non-white and multiple races plus white Hispanics.

Using 2000 census data, the percentage of the total population in Massachusetts and Rhode Island that belong to each minority category was determined (Table 2-14). This information was then used to calculate minimum thresholds for each minority category. Any block group with a minority category percentage that exceeded the minimum threshold listed in Table 2-14 was defined as a “minority population.”

The percent of the population in each minority category was calculated in each of the 3863 block groups within 50 mi of PNPS, and compared to the corresponding geographic area's minority threshold percentages to determine if a minority population exists. The number of block groups that exceeded minority thresholds is summarized in Table 2-15. The location of the aggregated minority populations within 50 mi of PNPS is shown in Figure 2-11.

Based on the "more than 20 percent" criterion, a Native Hawaiian or other Pacific Islander minority population exists in one block group in Suffolk County, Massachusetts. Black minority populations exist in 261 block groups, with 233 of the block groups in Massachusetts and 28 in Rhode Island. Other minority race populations exist in 135 block groups, with 77 occurring in Massachusetts and 58 in Rhode Island. No block groups exceeded the minimum threshold for more than 2 races. The aggregate of minority racial populations exist in 595 block groups, with 475 of the block groups occurring in Massachusetts and 120 in Rhode Island.

Table 2-14. Percentage of Minority and Low-income Individuals in the 50-mile Radius Study Area and Threshold Criteria for Identifying Minority and Low-income Populations at the Block Group Level. (Source: Entergy 2006f)

State	American Indian Alaska Native	Asian	Native Hawaiian or Other Pacific Islanders	Black Races	Other Races	More than 2 Races	Aggregate of Minority Races	Hispanic Ethnicity	Aggregate of Minority Races and Hispanic Ethnicity	Low-income Population (Individuals)	Low-income Population (Households)
MA	0.2	3.8	0.0	5.4	3.7	2.3	15.5	6.8	18.1	9.3	9.8
RI	0.5	2.3	0.1	4.5	5.0	2.7	15.0	8.7	18.1	11.9	12.4
Minority and low-income population threshold criteria											
MA	20.2	23.8	20.0	25.4	23.7	22.3	35.5	26.8	38.1	29.3	29.8
RI	20.5	22.3	20.1	24.5	25.0	22.7	35.0	28.7	38.1	31.9	32.4
Source: Entergy 2006f											

Minority populations based on Hispanic ethnicity occur in 240 block groups, with 145 of them in Massachusetts and 95 in Rhode Island. Minority populations composed of the aggregate of minority races and Hispanic ethnicity populations exist in 651 block groups, with 514 of the block groups occurring in Massachusetts and 137 in Rhode Island. The locations of these minority populations are shown in Figure 2-11.

Overall, no minority populations were identified within a 6-mi radius of PNPS. The nearest minority population within a 50-mi radius was in west-central Plymouth County near the community of Brockton where several minority thresholds were exceeded. These populations are approximately 25 mi west of the PNPS site. Other minority populations within 50 mi of PNPS were typically clustered in or near the Boston, Massachusetts and Providence, Rhode Island areas.

Table 2-15. Block Groups Exceeding Thresholds for Minority and Low-income Populations in Counties Within a 50-mile Radius of PNPS.

State	County	Number of Block Groups within 50- mile Radius	American Indian Alaska Native	Asian	Native Hawaiian or Other Pacific Islander	Black Races	Other Races	More than 2 Races	Aggregate of Minority Races	Hispanic Ethnicity	Aggregate of Minority Races and Hispanic Ethnicity	Low-income Population (Individuals)	Low-income Population
MA	Barnstable	198	0	0	0	0	0	0	0	0	0	1	0
MA	Bristol	417	0	1	0	0	11	0	22	6	26	34	34
MA	Dukes	20	1	0	0	0	0	0	1	0	1	0	0
MA	Essex	317	0	0	0	1	5	0	33	25	36	12	10
MA	Middlesex	761	0	11	0	14	2	0	52	8	67	9	7
MA	Nantucket	4	0	0	0	0	0	0	0	0	0	0	0
MA	Norfolk	473	0	14	0	5	0	0	20	0	18	3	2
MA	Plymouth	366	0	0	0	17	8	0	43	0	45	11	11
MA	Suffolk	630	0	28	1	196	51	0	304	106	321	120	115
MA	Worcester	18	0	0	0	0	0	0	0	0	0	0	0
RI	Bristol	41	0	0	0	0	0	0	0	0	0	0	0
RI	Kent	83	0	0	0	0	0	0	0	0	0	1	0
RI	Newport	60	0	0	0	1	0	0	2	0	2	1	1
RI	Providence	471	0	3	0	27	58	0	118	95	135	77	73
RI	Washington	4	0	0	0	0	0	0	0	0	0	0	0
	Total	3863	1	57	1	261	135	0	595	595	651	269	253
Minority and low-income thresholds													
MA		3204	20.2	23.8	20.0	25.4	23.7	22.3	35.5	35.5	38.1	29.3	29.8
RI		659	20.5	22.3	20.1	24.5	25.0	22.7	35.0	35.0	38.1	31.9	32.4

Source: Entergy 2006f

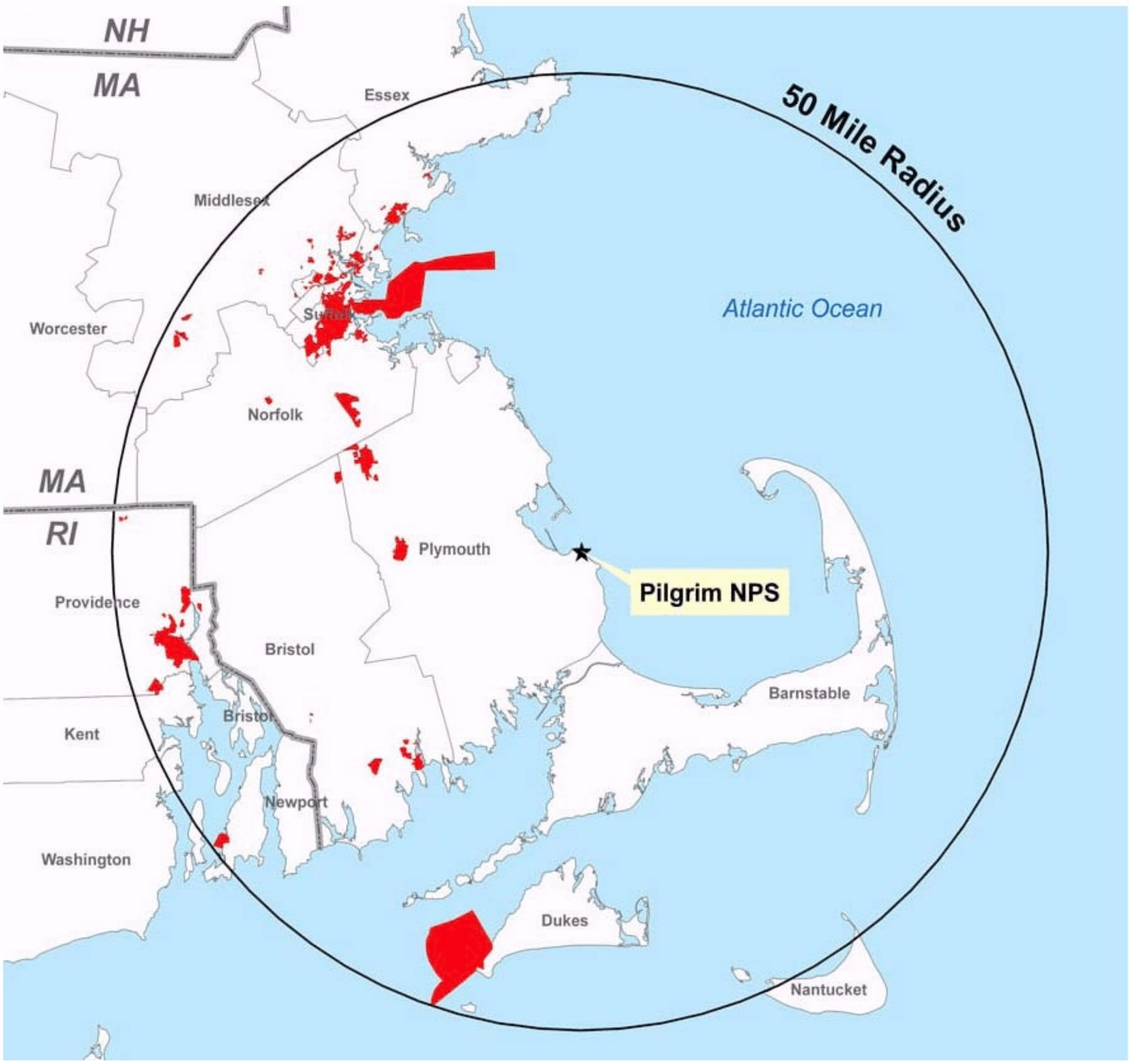

Figure 2-11. Aggregate of Minority Races Population Map (Source: Entergy 2006a)

2.2.8.5.5 Low-Income Populations

NRC guidance defines "low-income" by using USCB statistical poverty thresholds for the year 1999 (NRC 2004b). Low-income populations within the 50-mi radius of PNPS were identified using information on both the number of individuals and number of households below the poverty level in Massachusetts and Rhode Island and block groups within the environmental impact site (50-mi radius). The USCB values for the number of individuals and households below the poverty level in Massachusetts was 9.3 percent and 9.8 percent, respectively (Table 2-14). The number of individuals and households below the poverty level in Rhode Island was 11.9 percent and 12.4 percent, respectively.

The low-income populations within the 50-mi radius were identified using the "greater than 20 percent" criterion (Table 2-14). The number and percentage of block groups that exceeded these thresholds are included in Table 2-15. The locations of these low income populations are shown in Figure 2-12.

Low-income "individual" populations exist in 190 block groups in Massachusetts and 79 in Rhode Island. Low-income populations based on the number of "households" exist in 179 block groups in Massachusetts and 74 block groups in Rhode Island.

No low-income populations were identified within a 6-mi radius of PNPS. The nearest low-income population occurring within a 50-mi radius was in northwest Plymouth County in Brockton where thresholds for both low-income individuals and households were exceeded. These populations are approximately 25 mi northwest of the PNPS site. Other low-income populations within 50 mi of PNPS were clustered near Boston and in Bristol County, near the communities of Fall River and New Bedford, Massachusetts and in Providence County, Rhode Island.

Figure 2-12. Low-Income Population Map (Source: Entergy 2006a)

2.2.8.6 Economy

2.2.8.6.1 Employment

The 10-mi radius surrounding PNPS mostly includes the town of Plymouth; however, small sections of the towns of Carver, Kingston, Plympton, Duxbury and Marshfield are also within this radius. Employment trends data provided by the OCPC is shown in Table 2-16. (The OCPC region includes Plymouth, Kingston and Plympton, among other towns as it extends to the northeast, but does not include Carver, Duxbury and Marshfield.) Plymouth is seen to have increased its employment by 19 percent over the 1990s, greater than the OCPC total employment increase of 11.4 percent over the period.

Services are by far the largest industry sector in Plymouth, accounting for 38 percent of employment in 2000, followed by Trade (22 percent) and Government (16 percent). In the OCPC region, Trade dominates with 32 percent, followed by Services (28 percent) and Government (15.5 percent). Employment projections by OCPC see employment in Plymouth increasing to 22,810 by 2025, a 19 percent growth over employment in 2000. The OCPC region is expected to grow at a similar rate of 19.8 percent over the period.

Table 2-16. Employment Trends: Number of Employees by Industry Sector 1990 and 2000

Industry/ Year	**Plymouth**		**Kingston**		**Plympton**		**OCPC Region**	
	1990	**2000**	**1990**	**2000**	**1990**	**2000**	**1990**	**2000**
Agriculture	253	190	22	53	7	30	864	1,096
Government	2416	3,041	506	531	Conf.	99	16,883	19,274
Construction	562	702	93	187	38	45	6,158	6,197
Manufacturing	1,856	1,500	232	287	273	12	14,622	12,740
TCPU	1,551	1,480	806	95	Conf.	Conf.	7,619	6,618
Trade	3,890	4,225	2,413	3,060	35	29	35,993	39,940
FIRE	1,023	472	116	146	Conf.	8	4,746	3,296
Services	4,503	7,279	468	959	45	36	24,436	34,578
Total Jobs	16,054	19,100	4,656	5,318	398	267	111,321	123,978

TCPU: Transportation, Communications, and Public Utilities.
FIRE: Finance, Insurance and Real Estate.
Conf.: Data suppressed due to confidentiality.
Source: OCPC 2006a

The OCPC report *Keeping Our Region Competitive (*OCPC 2006a) provides data on large employers in the region. In Plymouth, it cites two large manufacturing employers and one hospital:

- Pixley-Richards, Inc. (plastic molds) with 200 estimated employees;
- Tech-Etch (shielding products) with 130 estimated employees; and
- Jordan Hospital with 800 estimated employees.

The only other large employer noted in the OCPC report among the nearby towns is L. Knife & Son, a wholesale liquor distributor in Kingston with 500 estimated employees. Interviews with local officials indicated that government was often the largest local employer, although officials from the following towns also noted: Independence Mall and R.S. Means (cost estimating) in Kingston; Battelle (engineers) in Duxbury; and two supermarkets, two retail stores, and several restaurants in Marshfield. It should also be noted that Entergy is one of Plymouth's largest employers.

Another industry of some note to the coastal towns is commercial and recreational fishing and boating. The mooring data from Plymouth's Harbor Master was noted under Section 2.2.8.5.2, Transient Populations, with 655 moorings in the harbor, 5000 visiting boats logged in, and an estimated 11,000 boats launched at the boat ramp. The Harbor Master also reports: 50 fishing boats and 14 charter boats using Plymouth wharves; 712 shell fishing permits; and that Plymouth has one of the State's top five lobster landings (Town of Plymouth 2004c). In addition, active draggers, gill-netters and other commercial boats work from the harbor. Other important recreational activities include whale watching, party fishing and sport fishing boats. Similar commercial and recreational activities occur in the Towns of Kingston, Duxbury, and Marshfield including: shell fishing, aquaculture farming, lobstering, charter boats, and recreational marinas.

2.2.8.6.2 Migrant Farm Labor

Although agriculture is not a large employment sector in the region, interviews with Plymouth town officials and those of surrounding towns indicated that the extensive cranberry bogs in the area were among the largest cranberry producers in the country. This agricultural activity is particularly significant in Plymouth and Carver, where several hundred seasonal workers were likely to be hired each year, in addition to the 200 to 300 workers at three processing plants in Carver, which operate 6 to 9 months a year(d).

(d) Employment estimates obtained during interview with Town of Carver officials on May 4, 2006.

2.2.8.6.3 Taxes

PNPS pays annual property taxes to the Town of Plymouth. Taxes fund the Town of Plymouth's operations, the school system, public works, the Town General Fund, and the police and fire departments (MA DOR 2002 in Entergy 2006a).

In 1998, the Commonwealth of Massachusetts deregulated its utility industry. As a result, the Massachusetts legislature changed property tax assessment methodologies for utilities from net book value to fair market value. In 1999, Boston Edison Company sold PNPS to Entergy Corporation for significantly less than the assessed values at that time. Consequently, property taxes paid to the Town of Plymouth for PNPS have declined from pre-1999 payments. Boston Edison's parent, NSTAR, retained ownership of all transmission functions and facilities and continues to pay property taxes to the Town of Plymouth for those facilities. As part of the utility industry, the transmission facilities are also subject to the new property tax assessment methodologies, with the effect that NSTAR will pay reduced property taxes to the Town of Plymouth.

In FY 2004 (ending June 30, 2004), the Town of Plymouth collected $86.4 million in property taxes, of which $72.2 million were from real estate taxes (Town of Plymouth 2004a). Total town revenues in that year were $126.96 million, implying that real estate taxes accounted for 57.7 percent of total town revenues.

Entergy paid $1.58 million in property taxes (real and personal property) in the Town's FY 2001 and $1.34 million for FY 2006. Additional data on Entergy’s property tax payments from the “Top Ten Property Taxpayers” in Plymouth over the years 2000-2006 are shown in Table 2-17. Boston Edison’s payments are also shown, although these are for all its transmission facilities, etc., not only those associated with the PNPS transmission lines.

Subsequent to the state’s deregulation law and Entergy’s purchase of PNPS, the Town of Plymouth and Entergy agreed to payments in lieu of taxes (PILOT) of $1 million annually with the potential for payments to increase should Entergy make capital improvements or substantial additions to the plant. The agreement continues through 2012, and would be renegotiated in the event of license renewal (Entergy 2006a). However, in April 2007, the Town of Plymouth reached a new five-year PILOT agreement with Entergy that increases Entergy’s annual payment to an estimated $8.49 million in FY2008 (Town of Plymouth 2007a). The payments decline thereafter, reaching an estimated $6.79 million in FY2012. The agreement includes a reopener provision in the event that PNPS’ current license is renewed. In addition, in order to ameliorate the deregulation impacts on the Town of Plymouth’s revenues, the Massachusetts legislature required NSTAR to make PILOT payments to the Town of Plymouth until the end of PNPS' current license in 2012. NSTAR payments have been reduced from over $15 million in

2001 to $12 million in 2006, and thereafter will decline to $1 million in 2007 and continue at that level through 2012. This is a significant reduction from the $15 million in tax revenues previously received by the town from Boston Edison Company.

Until 1999, PNPS' property taxes provided approximately 22 percent of the Town of Plymouth's total property tax revenues. In FY 2007, PNPS is expected to pay only about 2 percent of the total property taxes received by the Town of Plymouth. However, in FY2008 under the new PILOT agreement, the PNPS payment is expected to increase to about 9 percent of total property taxes revenues (Town of Plymouth 2007b).

Table 2-17. PNPS Contributions to Town of Plymouth Property Tax Revenues

Year	**Town of Plymouth Total Property Tax Revenues ($millions)**	**Property Tax Paid by Entergy**		**Property Tax Paid by Boston Edison/NSTAR***	
		($millions)	**Percent of Total Property Taxes (%)**	**($millions)**	**Percent of Total Property Taxes (%)**
2000	71.83	-	-	15.35	21.37
2001	75.17	1.58	2.10	15.28	20.34
2002	76.38	2.01	2.63	13.03	17.05
2003	78.71	1.59	2.03	13.03	16.56
2004	86.57	1.53	1.77	13.03	15.05
2005	87.54	1.40	1.60	13.03	14.88
2006	93.48	1.34	1.43	12.03	12.87

*NSTAR, the parent company of Boston Edison, retained ownership of all transmission functions and facilities and continues to pay property taxes to the Town of Plymouth.
Source: Town of Plymouth 2006b

2.2.9 Historic and Archaeological Resources

This section presents a brief summary of the region's cultural background and a description of known historic and archaeological resources at the PNPS site and its immediate vicinity. The information presented was collected from area repositories, the Massachusetts Historical Commission (MHC), and the applicant's Environmental Report (Entergy 2006a).

2.2.9.1 Cultural Background

Native Americans first settled in southern New England following the recession of the Wisconsin glacier approximately 10,000 years before present. Little information is available concerning the population or subsistence strategies of these earliest groups, perhaps because the earliest sites have been inundated by gradually rising sea levels or destroyed by development (Anderson and Gillam 2000). Over the following several thousand years prehistoric people in this region gradually adapted to a slowly warming environment, although environmental change was periodically more abrupt (McWeeney 1999; ENSR 2000). As the environment changed, so did the available resource base and the tool kit utilized to exploit those resources. During the most recent portion of prehistory, beginning a few thousand years before the present, indigenous populations began to settle in semi-permanent villages based in part on agriculture and fishing and to use pottery for both food preparation and storage.

Historically attested groups such as the Wampanoag inhabited the region at the time of European contact during the 17th century. Documentary evidence indicates that the 17th century Wampanoag would spend the warmer months of the year living along the coast to fish and grow a variety of crops and the winter months inland where hunting and gathering would be more abundant (Hasenstab 1999). Contact with Europeans led to a dramatic population decrease due to lack of immunity to disease and later political conflicts and war led to additional depopulation and displacement.

Among the separatists leaving England seeking religious autonomy during the 17th century was a group, eventually known as the Pilgrims, which ultimately established a colony in Plymouth, Massachusetts, a few miles northwest of PNPS in 1620. These colonists initially found survival very difficult and were famously assisted by members of the Wampanoag. Additional groups settled the region swelling the population to 7000 by the time Plymouth joined the Province of Massachusetts Bay in 1691.

During the 18th and 19th centuries regional populations dramatically increased. The primary economic engines of the region were agriculture and maritime-industries, which were replaced by tourism during the 20th century.

2.2.9.2 Historic and Archaeological Resources at the PNPS Site

2.2.9.2.1 Previously Identified Resources

The MHC houses the state's archaeological site files and information on historic resources such as buildings and houses, including available information concerning the National or State Register eligibility status of these resources. The NRC staff visited the MHC and collected site files on five archaeological sites located within or nearby the PNPS property. The first of these sites, listed as Manomet Site (MHC No. 19-PL-68), is described as being located "left of [the] access road to PNPS off Route 3A" (Turner 1976), apparently at the edge of the wetland area immediately south of the station (Figure 2-13). No additional information was provided on this site except that it was prehistoric and was investigated in 1972 by Dr. James Deetz of Brown University. The second of these sites, listed as Forges Field P4 (MHC No. 19-PL-816), consisted of two prehistoric artifacts collected from the ground surface within "highly disturbed powerline corridor" (Donahue-Putnam 1997), several thousand feet southwest of PNPS. The remaining three sites were discovered within a mile of the transmission line ROW, southwest of PNPS, and were also prehistoric.

A review of the MHC files to identify above-ground cultural resources in Plymouth County revealed 109 resources listed on the National Register of Historic Places (Entergy 2006a). Within the Town of Plymouth there are 21 historic locations listed on the National Register and/or State Register of Historic Places (Entergy 2006a). None of these sites are located within the boundaries of the PNPS site or the associated transmission line ROW.

In 1972, in advance of construction of the station, an archaeological survey was conducted of the 517 ac parcel of land on which the PNPS facility and the Jordan Road transmission line were proposed (AEC 1974). This survey was conducted by the Archaeological Research Department of Plimoth Plantation and the Brown University Department of Anthropology. This survey identified a total of 25 archaeological sites: 24 historic sites and one prehistoric site. The 24 historic sites were determined to not be significant and no further work was recommended. The one prehistoric site was the subject of a more intensive investigation, which concluded that the site was not eligible for listing (AEC 1974). This more intensive archaeological survey, conducted by the two previously mentioned groups in collaboration with the Massachusetts Archaeological Society, further concluded that the land around the proposed power station site showed no evidence of prehistoric occupation. It appears that this prehistoric site is Manomet Site (MHC No. 19-PL-68), described above. A search at the MHC and the Massachusetts Archaeological Society failed to locate any documentation of the 1972 surveys.

2.2.9.2.2 Results of Walkover Survey

The NRC staff performed an informal walkover survey of the PNPS property during the site audit, including the power block area, the former recreation area, the Entergy Woodlands area, and a portion of the transmission line ROW. During this walkover it was observed that the power block area has been extensively disturbed and graded while much of the former recreation area, woodlands, and transmission ROW appear to have been only minimally disturbed. All of the buildings and structures that comprise the station have been constructed since the early 1970s. A surface scattering of late 19th century to early 20th century domestic refuse such as bottles and ceramics was observed on the east side of the access road to the former recreation area.

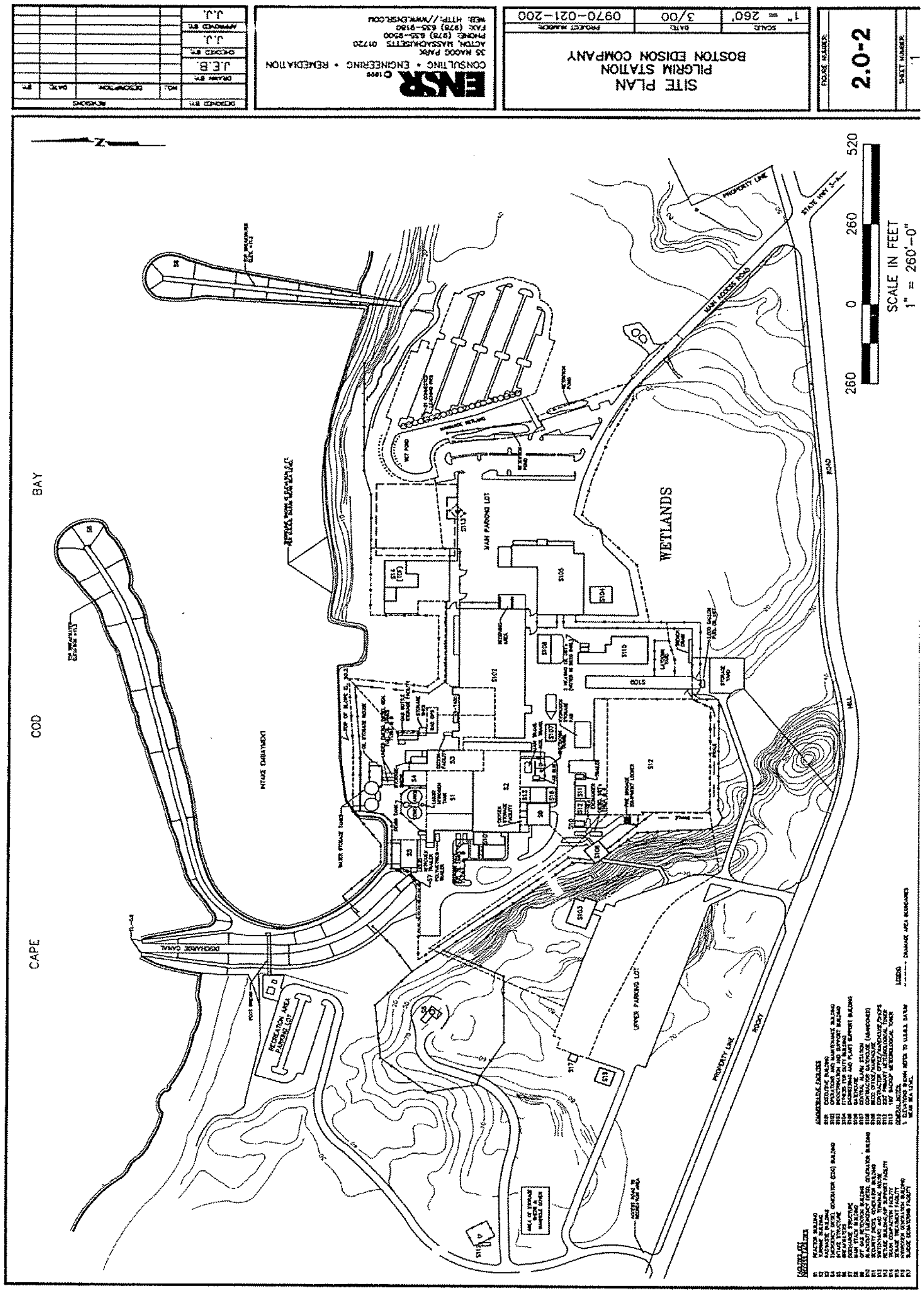

Figure 2-13. Expanded Facility Layout: Source: Entergy 2006a

The topography in the vicinity of these remains suggests gravel or sand mining and the area may have also been used as a dump site. NRC staff examined two potential historic resources in the woodlands area: a concrete and cinder block house foundation, apparently dating to the early 20th century; and a granite quarrying site (Benjamin 2006).

2.2.9.2.3 Potential Archaeological Resources

Due to disturbances associated with site preparation and construction of the station, the power block area has no potential for archaeological resources. There is the potential for archaeological resources to be present in the former recreation area, the woodlands area, and within the transmission line corridor. These areas appear to have been only minimally disturbed and are comprised of landforms that may have been attractive during prehistory for varied resource exploitation. A review of historic maps dating from 1879 (Walker 1879), 1895 (USGenNet.org 2006), and 1903 (Richards 1903) show very sparse development in the former recreation area, the woodlands area, and within the transmission line corridor, but there is the potential for the presence of historic resources, particularly in light of the resources observed in the former recreation area and woodlands area during the walkover described above.

2.2.10 Related Federal Project Activities and Consultations

The NRC staff reviewed the possibility that activities of other Federal agencies might impact the renewal of the OL for PNPS. Any such activities could result in cumulative environmental impacts and the possible need for the Federal agency to become a cooperating agency for preparation of this SEIS.

The NRC staff has reviewed local Federally owned facilities and Federally permitted industrial facilities in the local area near Plymouth and Cape Cod Bay, and has determined that there are no Federal project activities that would make it desirable for another Federal agency to become a cooperating agency for preparing this SEIS. The only proposed Federal project in the local area is dredging for the Plymouth Harbor Federal Navigation Project by the U.S. Army Corps of Engineers (USACE 2006). Pending applications for Federal permits in the area include the filling of 26 ac within Plymouth Bay by the Town of Plymouth, the construction of a pile-supported, fixed pier and floating docks in the Federal anchorage in Plymouth Harbor, dredging to reestablish the entrance to Ellisville Harbor in Plymouth, and the ability to retain and maintain the Cordage Park Marina in Plymouth Bay (USACE 2006). The Mirant Canal Station power plant in Sandwich, on Cape Cod Canal, is the nearest power facility that extracts and discharges cooling water under a Federally issued NPDES permit (EPA 2006b).

An additional Federal action in the area is the proposed implementation of NMFS's Ship Strike Reduction Strategy to reduce vessel strikes to the endangered North Atlantic right whale. Implementation of this strategy would involve establishment of a Seasonal Management Area in

Cape Cod Bay in the winter and spring, routing measures in Cape Cod Bay to deflect major vessel traffic away from right whale aggregations, and the establishment of as-needed Dynamic Management Areas when whales are sighted (NOAA 2006).

NRC is required under Section 102(c) of NEPA to consult with and obtain the comments of any Federal agency that has jurisdiction by law or special expertise with respect to any environmental impact involved. NRC consulted with EPA, NMFS, and FWS. Consultation correspondence is included in Appendix E. Additionally, EPA and NMFS submitted written comments; their comments are addressed in Appendix.

2.3 References

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

10 CFR Part 50. Code of Federal Regulations, Title 10, *Energy,* Part 50, Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operations to Meet the Criterion 'As Low As is Reasonably Achievable' for Radiological Material in Light-Water-Cooled Nuclear Power Reactor Effluents."

40 CFR Part 82. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 82, "Protection of Stratospheric Ozone."

40 CFR Part 190. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations."

40 CFR Part 260. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 260, "Hazardous Waste Management System: General."

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

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

40 CFR Part 370. Code of Federal Regulations, Part 370, "Hazardous Chemical Reporting: Community RIght-to-Know."

50 CFR Part 17. Code of Federal Regulations, Title 50, *Wildlife and Fisheries*, Part 17, "Endangered and Threatened Wildlife and Plants."

310 CMR 10.00. Code of Massachusetts Regulations, Title 310, *Department of Environmental Protection*, Section 10, "Wetlands Protection."

310 CMR 30.1000. Code of Massachusetts Regulations, Title 310, *Department of Environmental Protection*, Section 30.1000, "Standards for Universal Waste Management."

310 CMR 30.000. Code of Massachusetts Regulations, Title 310, *Department of Environmental Protection*, Section 30, "Hazardous Waste Regulations."

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3.0 Environmental Impacts of Refurbishment

Environmental issues associated with refurbishment activities are discussed in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437, Volumes 1 and 2 (NRC 1996; 1999).(a) The GEIS includes a determination of whether the analysis of the environmental issues could be applied to all plants and whether additional mitigation measures would be 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:

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

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

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

For issues that meet the three Category 1 criteria, no additional plant-specific analysis is required in this Supplemental Environmental Impact Statement 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.

License renewal actions may require refurbishment activities 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 that were determined to be Category 1 issues are listed in Table 3-1.

Environmental issues related to refurbishment considered in the GEIS for which these conclusions could not be reached for all plants, or for specific classes of plants, are Category 2 issues. These are listed in Table 3-2.

(a) 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 3-1. Category 1 Issues for Refurbishment Evaluation

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections
SURFACE WATER QUALITY, HYDROLOGY, AND 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
GROUND-WATER USE AND QUALITY	
Impacts of refurbishment on ground-water use and quality	3.4.2
LAND USE	
On-site 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 and recreation	3.7.4; 3.7.4.3; 3.7.4.4; 3.7.4.6
Aesthetic impacts (refurbishment)	3.7.8

Category 1 and Category 2 issues related to refurbishment that are not applicable to Pilgrim Nuclear Power Station (PNPS) because they are related to plant design features or site characteristics not found at PNPS are listed in Appendix F.

The potential environmental effects of refurbishment actions would be identified, and the analysis would be summarized within this section, if such actions were planned. Entergy Nuclear Operations, Inc. (Entergy) indicated that it has performed an evaluation of structures and components pursuant to Title 10 of the Code of Federal Regulations (CFR), Part 54, Section 54.21 to identify activities that are necessary to continue operation of PNPS during the requested 20-year period of extended operation. These activities include replacement of certain components as well as new inspection activities, and are described in the Environmental Report (Entergy 2006).

Table 3-2. Category 2 Issues for Refurbishment Evaluation

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	**GEIS Sections**	**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 and 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
Off-site land use (refurbishment)	3.7.5	I
Public services, transportation	3.7.4.2	J
Historic and archaeological resources	3.7.7	K
ENVIRONMENTAL JUSTICE		
Environmental justice	Not addressed[(a)]	Not addressed[(a)]

(a) Guidance related to environmental justice was not in place at the time the GEIS and the associated revision to 10 CFR Part 51 were prepared. If an applicant plans to undertake refurbishment activities for license renewal, environmental justice must be addressed in the applicant's environmental report and the staff's environmental impact statement. The Commission issued a Final *Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions* in 2004 (NRC 2004).

However, Entergy stated that the replacement of these components and the additional inspection activities are within the bounds of normal plant component replacement and inspections; therefore, they are not expected to affect the environment outside the bounds of plant operations as evaluated in the final environmental statement (AEC 1972). In addition, Entergy's evaluation of structures and components as required by 10 CFR 54.21 did not identify any major plant refurbishment activities or modifications necessary to support the continued operation of PNPS beyond the end of the existing operating licenses. Therefore, refurbishment is not considered in this Supplemental Environmental Impact Statement.

3.1 References

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

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

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Nuclear Regulatory Commission (NRC). 1999. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Main Report*, “Section 6.3 – Transportation, Table 9.1, Summary of findings on NEPA issues for license renewal of nuclear power plants,” Final Report. NUREG-1437, Volume 1, Addendum 1, Washington, DC.

Nuclear Regulatory Commission (NRC). 2004. “Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions,” Final. *Federal Register*: Volume 69, Number 163, pgs. 52040-52048. August 24, 2004.

4.0 Environmental Impacts of Operation

Environmental issues associated with operation of a nuclear power plant 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).(a) The GEIS includes a determination of whether the analysis of the environmental issues could be applied to all plants and whether additional mitigation measures would be 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:

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

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

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

For issues that meet the three Category 1 criteria, no additional plant-specific analysis is required 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, and therefore, additional plant-specific review of these issues is required.

This chapter addresses the issues related to operation during the renewal term that are listed in Table B-1 of Title 10 of the Code of Federal Regulations (CFR) Part 51, Subpart A, Appendix B and are applicable to Pilgrim Nuclear Power Station (PNPS). Section 4.1 addresses issues applicable to the PNPS cooling system. Section 4.2 addresses issues related to transmission lines and on-site land use. Section 4.3 addresses the radiological impacts of normal operation, and Section 4.4 addresses issues related to the socioeconomic impacts of normal operation during the renewal term. Section 4.5 addresses issues related to groundwater use and quality, while Section 4.6 discusses the impacts of renewal-term operations on threatened and endangered species. Section 4.7 addresses potential new information that was raised during the scoping period, and Section 4.8 discusses cumulative impacts. The results of the evaluation of environmental issues related to operation during the renewal term are summarized

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

in Section 4.9. Finally, Section 4.10 lists the references for Chapter 4. Category 1 and Category 2 issues that are not applicable to PNPS because they are related to plant design features or site characteristics not found at PNPS are listed in Appendix F.

4.1 Cooling System

Category 1 issues in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, that are applicable to PNPS cooling system operation during the renewal term are listed in Table 4-1. Entergy Nuclear Operations, Inc. (Entergy) stated in its Environmental Report (ER) (Entergy 2006a) that it is not aware of any new and significant information associated with the renewal of the PNPS operating license (OL). The U.S. Nuclear Regulatory Commission (NRC) staff has not identified any new and significant information during its independent review of the Entergy ER, the staff's site visit, the scoping process, evaluation of other available information, or consideration of public comments. For all of the Category 1 issues, the staff concluded in the GEIS that the impacts would be SMALL, and additional plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

Table 4-1. Category 1 Issues Applicable to the Operation of the PNPS Cooling System During the Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections
SURFACE WATER QUALITY, HYDROLOGY, AND USE (FOR ALL PLANTS)	
Altered current patterns at intake and discharge structures	4.2.1.2.1
Altered salinity gradients	4.2.1.2.2
Temperature effects on sediment transport capacity	4.2.1.2.3
Scouring caused by discharged cooling water	4.2.1.2.3
Discharge of chlorine or other biocides	4.2.1.2.4
Discharge of other metals in wastewater	4.2.1.2.4
Water use conflicts (plants with once-through cooling systems)	4.2.1.3

Table 4-1. (contd)

AQUATIC ECOLOGY (FOR ALL PLANTS)	
Accumulation of contaminants in sediments or biota	4.2.1.2.4
Entrainment of phytoplankton and zooplankton	4.2.2.1.1
Cold shock	4.2.2.1.5
Thermal plume barrier to migrating fish	4.2.2.1.6
Distribution of aquatic organisms	4.2.2.1.6
Gas supersaturation (gas bubble disease)	4.2.2.1.8
Low dissolved oxygen in the discharge	4.2.2.1.9
Losses from predation, parasitism, and disease among organisms exposed to sublethal stresses	4.2.2.1.10
Stimulation of nuisance organisms	4.2.2.1.11
Human Health	
Noise	4.3.7

A brief description of the staff's review and the GEIS conclusions, as codified in Table B-1, for each of these Category 1 issues follows:

- Altered current patterns at intake and discharge structures. Based on information in the GEIS, the Commission found that:

  > Altered current patterns have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.

  The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of altered current patterns at intake and discharge structures during the renewal term beyond those discussed in the GEIS.

- Altered salinity gradients. Based on information in the GEIS, the Commission found that:

> Salinity gradients have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of altered salinity gradients during the renewal term beyond those discussed in the GEIS.

- Temperature effects on sediment transport capacity. Based on information in the GEIS, the Commission found that:

> These effects have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of temperature effects on sediment transport capacity during the renewal term beyond those discussed in the GEIS.

- Scouring caused by discharged cooling water. Based on information in the GEIS, the Commission found that:

> Scouring has not been found to be a problem at most operating nuclear power plants and has caused only localized effects at a few plants. It is not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, its review of monitoring programs, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts regarding sediment transportation due to scouring caused by discharged cooling water during the renewal term beyond those discussed in the GEIS.

Scouring also affects submerged aquatic vegetation in the immediate vicinity of the discharge at PNPS. Such minor, localized effects of scouring are discussed in Section 4.1.3.

- Discharge of chlorine or other biocides. Based on information in the GEIS, the Commission found that:

  > Effects are not a concern among regulatory and resource agencies, and are not expected to be a problem during the license renewal term.

  The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other available information including the National Pollutant Discharge Elimination System (NPDES) permit for PNPS, discussion with the U.S. Environmental Protection Agency (EPA) NPDES compliance office, or consideration of public comments. To evaluate the potential impacts to water quality, the staff evaluated the discharge data presented in the applicant's April 2005 to March 2006 monthly Discharge Monitoring Reports (DMRs) for the PNPS facility. During this time period, an effluent limitation was outside of the permit requirement on three occasions. One exceedence was for total suspended solids. On one occasion in January 2006 and another in February 2006, there was a problem with the screenwash dechlorination system (outfall 003) in which chlorine was detected in the screenwash sluiceway. In each instance, one of the dechlorination pumps was not pumping adequately. One pump was repaired and the other replaced, and the system was restored to normal operation. Although exceedences of the chlorine permit limits have been observed at PNPS, no notices of violation have been issued by the Commonwealth. The staff has determined that there would be no significant impacts of discharge of chlorine or other biocides during the renewal term beyond those discussed in the GEIS.

- Discharge of other metals in wastewater. Based on information in the GEIS, the Commission found that:

  > These discharges have not been found to be a problem at operating nuclear power plants with cooling-tower-based heat dissipation systems and have been satisfactorily mitigated at other plants. They are not expected to be a problem during the license renewal term.

  The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other available information including the NPDES permit for PNPS, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of discharges of other metals in wastewater during the renewal term beyond those discussed in the GEIS.

- Water-use conflicts (plants with once-through cooling systems). Based on information in the GEIS, the Commission found that:

  > These conflicts have not been found to be a problem at operating nuclear power plants with once-through heat dissipation systems.

  The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of water-use conflicts for plants with once-through cooling systems during the renewal term beyond those discussed in the GEIS.

- Accumulation of contaminants in sediments or biota. Based on information in the GEIS, the Commission found that:

  > Accumulation of contaminants has been a concern at a few nuclear power plants but has been satisfactorily mitigated by replacing copper alloy condenser tubes with those of another metal. It is not expected to be a problem during the license renewal term.

  The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of accumulation of contaminants in sediments or biota during the renewal term beyond those discussed in the GEIS.

- Entrainment of phytoplankton and zooplankton. Based on information in the GEIS, the Commission found that:

  > Entrainment of phytoplankton and zooplankton has not been found to be a problem at operating nuclear power plants and is not expected to be a problem during the license renewal term.

  The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, review of monitoring programs, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of entrainment of phytoplankton and zooplankton during the renewal term beyond those discussed in the GEIS.

- Cold shock. Based on information in the GEIS, the Commission found that:

> Cold shock has been satisfactorily mitigated at operating nuclear plants with once-through cooling systems, has not endangered fish populations or been found to be a problem at operating nuclear power plants with cooling towers or cooling ponds, and is not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of cold shock during the renewal term beyond those discussed in the GEIS.

- Thermal plume barrier to migrating fish. Based on information in the GEIS, the Commission found that:

> Thermal plumes have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of thermal plume barriers to migrating fish during the renewal term beyond those discussed in the GEIS.

- Distribution of aquatic organisms. Based on information in the GEIS, the Commission found that:

> Thermal discharge may have localized effects but is not expected to affect the larger geographical distribution of aquatic organisms.

The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, review of monitoring programs, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts on larger geographical distribution of aquatic organisms during the renewal term beyond those discussed in the GEIS. Minor, localized effects of thermal discharge on submerged aquatic vegetation are discussed in Section 4.1.3.

- Gas supersaturation (gas bubble disease). Based on information in the GEIS, the Commission found that:

> Gas supersaturation was a concern at a small number of operating nuclear power plants with once-through cooling systems but has been satisfactorily mitigated. It has not been found to be a problem at operating nuclear power plants with cooling towers or cooling ponds and is not expected to be a problem during the license renewal term.

Several incidents of gas bubble disease occurred at PNPS in the mid 1970s (Lawton et al:, 1986). In response to these incidents, a fish barrier net was installed in the discharge canal to lessen the magnitude of the mortality events, should supersaturated conditions occur in the discharge. There have been no additional incidents of gas bubble disease since that time, and the fish barrier net has been removed from the discharge canal and is currently stored on site.

The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, review of monitoring programs, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of gas supersaturation during the renewal term beyond those discussed in the GEIS.

- Low dissolved oxygen in the discharge. Based on information in the GEIS, the Commission found that:

> Low dissolved oxygen has been a concern at one nuclear power plant with a once-through cooling system but has been effectively mitigated. It has not been found to be a problem at operating nuclear power plants with cooling towers or cooling ponds and is not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, review of monitoring programs, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of low dissolved oxygen during the renewal term beyond those discussed in the GEIS.

- Losses from predation, parasitism, and disease among organisms exposed to sublethal stresses. Based on information in the GEIS, the Commission found that:

  > These types of losses have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.

  The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of losses from predation, parasitism, and disease among organisms exposed to sub-lethal stresses during the renewal term beyond those discussed in the GEIS.

- Stimulation of nuisance organisms. Based on information in the GEIS, the Commission found that:

  > Stimulation of nuisance organisms has been satisfactorily mitigated at the single nuclear power plant with a once-through cooling system where previously it was a problem. It has not been found to be a problem at operating nuclear power plants with cooling towers or cooling ponds and is not expected to be a problem during the license renewal term.

  The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of stimulation of nuisance organisms during the renewal term beyond those discussed in the GEIS.

- Noise. Based on information in the GEIS, the Commission found that:

  > Noise has not been found to be a problem at operating plants and is not expected to be a problem at any plant during the license renewal term.

  The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of noise during the license renewal term beyond those discussed in the GEIS.

The Category 2 issues related to cooling system operation during the renewal term that are applicable to PNPS are discussed in the sections that follow, and are listed in Table 4-2. Additionally, PNPS operations are not expected to affect any marine mammals.

Table 4-2. Category 2 Issues Applicable to the Operation of the PNPS Cooling System During the Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections	10 CFR 51.53(c)(3)(ii) Subparagraph	SEIS Section
AQUATIC ECOLOGY (FOR PLANTS WITH ONCE-THROUGH AND COOLING POND HEAT-DISSIPATION SYSTEMS)			
Entrainment of fish and shellfish in early life stages	4.2.2.1.2	B	4.1.1
Impingement of fish and shellfish	4.2.2.1.3	B	4.1.2
Heat shock	4.2.2.1.4	B	4.1.3

4.1.1 Entrainment of Fish and Shellfish in Early Life Stages

For plants with once-through cooling systems such as PNPS, entrainment of fish and shellfish in early life stages into nuclear power plant cooling water systems is considered a Category 2 issue, thus requiring a site-specific assessment for the license renewal review. The staff reviewed the PNPS ER, visited the site, consulted with Federal and State resource agencies, reviewed the applicant's existing NPDES permit and existing literature related to fish and shellfish populations of Cape Cod Bay, and considered public comments with particular regard to entrainment studies conducted at the PNPS.

Section 316(b) of the Clean Water Act of 1977 (CWA), common name of the Federal Water Pollution Control Act, requires that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impacts (33 U.S.C. 1326). Entrainment of fish and shellfish into the cooling water system is a potential adverse environmental impact that can be minimized by the use of best technology available. Licensees may be required as part of the NPDES permit renewal to alter the intake structure, redesign the cooling system, modify facility operation, or take other mitigative measures. Licensees must comply with Section 316(b) of the CWA. However, EPA’s 316(b) Phase II Rule has been suspended and compliance with the rule is currently based on EPA’s best professional judgment.

4.1.1.1 Environmental Monitoring

The potential impacts to the marine environment have been actively monitored since the station first went on line in 1972. The majority of the monitoring program has been conducted in response to requests of Massachusetts Department of Environmental Protection (MDEP) and the environmental monitoring and permitting requirements of the facility's NPDES permit from the EPA. As of the writing of this Supplemental Environmental Impact Statement (SEIS), a total of 67 semi-annual reports has been developed by the owners of PNPS addressing all aspects of the nearshore environment surrounding PNPS, including impingement, entrainment, marine fisheries, plankton, aquatic plants, the benthic community, temperature and oceanographic studies, and mitigation strategies. The 316 demonstration report (ENSR 2000) contains a detailed overview of the studies that were performed through 1999.

Marine algal studies were conducted periodically from the mid 1970s, up through the late 1990s, primarily to evaluate impacts of the thermal discharge on algal species, in particular Irish moss (*Chondrus crispus*). Studies of the benthic fauna, including the American lobster (*Homarus americanus*), were conducted from the early 1970s up through the late 1980s, while plankton studies were conducted primarily in the mid 1970s. Several temperature and oceanographic studies have also been conducted by the applicant throughout the operating history of PNPS. Thermal plume studies have included dye studies, boat-based thermal plume surveys, and aerial infrared surveys. These studies were used as input to develop a thermal plume model. Several studies of the current structure and velocities in the immediate area surrounding PNPS have also been conducted by the applicant, universities, and Federal government agencies (ENSR 2000).

Monitoring of marine fisheries in the area surrounding PNPS has taken place since the early 1970s. Many of these studies were performed by the Massachusetts Division of Marine Fisheries (MDMF) and have included overflights of the nearshore environment; diving surveys; sampling including bottom trawling, gill netting, and haul seining; and recreational creel surveys (ENSR 2000). In addition, several species-specific studies have been performed to evaluate impacts to winter flounder (*Pseudopleuronectes americanus*), cunner (*Tautogolabrus adspersus*), and rainbow smelt (*Osmerus mordax*).

For the past 11 years, annual area-swept surveys have been conducted in the form of trawls to assess the population status of the winter flounder stock in northwestern Cape Cod Bay, as this species is very important to commercial and recreational fishermen in the area and the waters around PNPS serve as a spawning, nursery, and feeding grounds (MRI 2005a). The studies were initially conducted by the MDMF. More recently, the work has been conducted by Marine Research, Inc. (MRI) under contract to PNPS. The target approach for each of these surveys is at least 84 tows, of at least 30 minutes in duration (MRI 2005a).

For the 2005 sampling event, 75 tows were completed between mid April and early May, resulting in a total catch of 4206 winter flounder. Population size (expressed as instantaneous absolute abundance) was determined using an area/density approach. After accounting for efficiency of the sampling gear, estimates of winter flounder abundance in the study area were approximately 126,000 adults and 230,000 total winter flounder (MRI 2005a). These 2005 abundance estimates were less than 50 percent of the corresponding means for the 1995-2004 time series. However, this decline may be due, in part, to the natural and fishing induced decline in the strong 1997 and 1998 year classes (MRI 2005a).

Larval transport studies were conducted in May 2000, May 2002, and May to June 2004 for the purposes of determining the flux of winter flounder larvae moving along the coast and the flux of winter flounder larvae entering PNPS through entrainment (ENSR and MRI 2005). The studies consisted of larval sampling at five offshore locations in Cape Cod Bay and entrainment sampling in the discharge canal. Water velocity measurements were also conducted at various locations to correlate larval density with water movements. Sampling in 2004 included two larval-sampling surveys conducted on May 26-27 and June 3-4 (ENSR and MRI 2005).

In 2000, entrainment rates up to 5 percent were observed for stage 4 winter flounder larvae while the entrainment rates for all other larvae were less than 1 percent (ENSR and MRI 2000). Of the four surveys conducted for the 2002 winter flounder entrainment study, stage 4 larval entrainment rates were 4 percent in one survey and less than 1 percent in another, and the entrainment rate for the other two surveys could not be calculated due to the fact that no stage 4 larvae were collected in the open water stations. Two of the surveys also showed relatively high entrainment rates for stage 3 larvae (26 percent and 3 percent), whereas the remainder of the larval stages had an entrainment rate of less than 1 percent(ENSR and MRI 2002). The 2000 and 2002 reports state that the periodic high entrainment rates observed for stages 3 and 4 larvae were likely due to difficulties in collecting the stages 3 and 4 larvae, as these larval stages generally are associated with the bottom sediments (ENSR and MRI 2000, 2002). For example, the 2002 study included an evaluation of larval sampling methods that found that densities of stage 3 larvae in samples from a bottom sled were 10 times higher than in net samples from higher in the water column. However, the bottom sled was not used for the sampling to calculate entrainment rates in 2000 and 2002. As a result, the stages 3 and 4 larval transport values calculated for the bay in those years may underestimate actual values by approximately an order of magnitude and may similarly overestimate the percentages of stage 3 and 4 larvae entrained (ENSR and MRI 2000, 2002).

The surveys used plankton nets to sample the water column from two layers, surface to mid-depth and mid-depth to near-bottom. In addition, a bottom sled rigged with a net was used to sample the epibenthic layer closer to the bottom than the other nets could be towed. During the first survey, the sled was damaged in the third of four sampling events. As a result, bottom samples were not obtained for two of the four sampling locations in the third event, and no bottom samples were collected with the sled in the fourth sampling event. When calculating larval transport, the net samples from the mid-depth to near-bottom interval were used for the deepest water column interval in place of these missing sled data. Because stage 4 larvae tend to remain near the bottom, the sled samples routinely yielded the highest counts of these larvae. Consequently, the reduced bottom sled samples in the first survey likely resulted in an underestimation of the density of stage 4 larvae in the bay and an overestimation of entrainment when the estimated larval transport was used to calculate the percentage entrained (based on the number of larvae entrained in a day divided by the number of larvae carried past PNPS in the net longshore current). The sled was repaired and used to collect bottom samples at all stations and in all events of the second survey one week later. The second survey collected almost 14 times as many stage 4 larvae in the bay as the first survey, resulting in a percentage entrained of 0.44 (ENSR and MRI 2005).

Results from the most recent entrainment sampling in 2004 indicate that PNPS likely entrains a small percentage (less than 2 percent) of stages 1, 2, and 3 winter flounder larvae (ENSR and MRI 2005). Results for stage 4 winter flounder larvae were mixed, with one of the surveys indicating almost a 20-percent entrainment rate and the other survey indicating less than 1 percent entrainment. The report discussing the results of the 2004 study (ENSR and MRI 2005) attributed the exceptionally high percentage of stage 4 larvae collected in the first survey to difficulties with the sampling equipment in conjunction with the benthic lifestyle of stage 4 larvae.

According to the authors, the results of the 2004 study were similar to those of 2000 and 2002 in indicating that overall there appeared to be a consistent net flow of water and winter flounder larvae to the south in near shore waters off PNPS. They also concluded that less than 0.1 percent of the net volumetric flow of water in western Cape Cod Bay offshore of PNPS and within 6 mi of the shoreline passes through PNPS, and they estimated that the amount of winter flounder larvae in northwestern Cape Cod Bay entrained by PNPS is less than 1.3 percent of the net larval transport (ENSR and MRI 2005).

Through the early years of operation of the PNPS, cunner have had relatively high entrainment rates based on comparisons to other species entrained at PNPS. A tagging study was initiated in 1990 to evaluate the absolute abundance of this species in the PNPS area, as the near shore waters around the plant serve as spawning, nursery, and adult feeding grounds. The data, although not conclusive, indicated that the PNPS has a minor effect on recruitment success to the local population (Lawton et al. 2000a).

Rainbow smelt have periodically had high impingement rates throughout the history of PNPS based on comparison to other species impinged at the plant. After a large impingement event in

1978, a study was initiated to obtain site-specific population data in order to assess impacts on the local smelt population. This study was focused on the Jones River, which is the principal spawning ground for smelt in the Plymouth area. This study evaluated egg production, population structure and size, as well as the degree of parasitic infestation in the stock. Based on this study, the spawning stock abundance for the Jones River population was calculated to have been 4.18×10^6 adult smelt in 1981. Comparison of these population data to impingement data at PNPS indicated that PNPS had reduced the Jones River spawning population by less than 1 percent (Lawton et al. 1990). The Jones River spawning run along with other runs in the western North Atlantic have been depressed for many years. According to the MDMF, the Jones River population is still at depressed levels (Chase 2006).

4.1.1.2 Entrainment Monitoring

Entrainment sampling was initiated in 1974 and was initially conducted twice per month from January to February and from October to December and conducted weekly from March through September. During these events, sampling was conducted in triplicate. Beginning in 1994, the sampling program was modified to focus on better temporal coverage. During the January to February and October to December time periods, samples are collected every other week on three separate days for a total of approximately six samples per month. During the March through September time frame, three separate samples have been collected every week for a total of approximately 12 samples per month (Normandeau 2006a).

Entrainment sampling is conducted by suspending a 60-centimeter (cm) (2-ft) diameter plankton net (with flowmeter) in the discharge canal approximately 30 meters (m) (98 ft) from the headwall. Typically a standard mesh of 0.333 millimeters (mm) [0.013 inches (in.)] is used, with the exception of the late March through late May time period, when a 0.202-mm (0.007-in.) mesh is used to capture early stage larval winter flounder. The sampling period typically ranges from 8 to 30 minutes depending upon the tide; the higher tide requiring a longer interval due to lower discharge stream velocities. The target is to sample a minimum quantity of 100 m^3 (3531 ft^3) of water. Upon termination of the sampling period, samples are preserved in 10 percent formalin prior to laboratory identification and enumeration (Normandeau 2006a).

Sixty-three different fish species have been collected over the last 30 years of entrainment monitoring at PNPS (Table 4-3) (Normandeau 2006a). Additionally, Irish moss spores have been identified in entrainment samples.

In this area of Cape Cod Bay, there are three primary spawning seasons: winter to early spring, late spring to early summer, and late summer to autumn. Many of the species that spawn during the winter to early spring period have demersal, adhesive eggs that are not normally entrained, and as a result, more species are typically represented by larvae than by

Table 4-3. Species Entrained or Impinged During the Operating History of PNPS

Species Common Name	Scientific Name	
alligatorfish	*Aspidophoroides monopterygius*	E
alewife	*Alosa pseudoharengus*	I
American eel	*Anguilla rostrata*	E, I
American plaice	*Hippoglossoides platessoides*	E, I
American shad	*Alosa sapidissima*	I
anchovy	*Anchoa* spp.	E
Atlantic cod	*Gadus morhua*	E, I
Atlantic herring	*Clupeas harengus*	E, I
Atlantic mackerel	*Scomber scombrus*	E, I
Atlantic menhaden	*Brevoortia tyrannus*	E, I
Atlantic moonfish	*Selene setapinnis*	I
Atlantic needlefish	*Strongylura marina*	E
Atlantic seasnail	*Liparis atlanticus*	E, I
Atlantic silverside	*Menidia menidia*	E, I
Atlantic tomcod	*Microgadus tomcod*	E, I
bay anchovy	*Anchoa mitchilli*	E, I
bigeye	*Priacanthus arenatus*	I
black ruff	*Centrolophorus niger*	I
black sea bass	*Centropristis striata*	E, I
black spotted stickleback	*Gasterosteus wheatlandi*	I
blueback herring	*Alosa aestivalis*	I
bluefish	*Pomatomus saltatrix*	I
butterfish	*Peprilus triacanthus*	E, I
conger eel	*Conger oceanicus*	E
cunner	*Tautogolabrus adspersus*	E, I
cusk	*Brosme brosme*	E
flying gurnard	*Dactylopterus volitans*	I
fourbeard rockling	*Enchelyopus cimbrius*	E, I
fourspine stickleback	*Apeltes quadracus*	I
fourspot flounder	*Paralichthys oblongus*	E, I
gizzard shad	*Dorosoma cepedianum*	I
golden redfish	*Sebastes norvegicus*	E
goosefish	*Lophius americanus*	E, I
grubby	*Myoxocephalus aenaeus*	E, I
gulf snailfish	*Liparis coheni*	E
Gulf Stream flounder	*Citharichthys arctifrons*	I
haddock	*Melanogrammus aeglefinus*	E
hakes	*Urophycis* spp.	E, I
hogchoker	*Trinectes maculatus*	E, I
killifish	*Fundulus* spp.	E
little skate	*Leucoraja erinacea*	I
longhorn sculpin	*Myoxocephalus octodecemspinosus*	E, I
lumpfish	*Cyclopterus lumpus*	E, I
mummichog	*Fundulus heteroclitus*	E, I
northern kingfish	*Menticirrhus saxatilis*	E, I
northern pipefish	*Syngnathus fuscus*	E, I
northern puffer	*Sphoeroides maculatus*	E, I

Table 4-3. (contd)

Species Common Name	Scientific Name	
northern searobin	*Prionotus carolinus*	I
ocean pout	*Zoarces americanus*	I
orange filefish	*Aluterus schoepfi*	I
Weitzman's pearlside	*Maurolicus weitmani*	I
planehead filefish	*Monacanthus hispidus*	I
pollock	*Pollachius virens*	E, I
radiated shanny	*Ulvaria subbifurcata*	E, I
rainbow smelt	*Osmerus mordax*	E, I
river herring	*Alosa* spp.	E
rock gunnel	*Pholis gunnellus*	E, I
round scad	*Etrumeus teres*	I
sand lance	*Ammodytes* sp.	E, I
sculpins	*Myoxocephalus* spp.	E, I
scup	*Stenotomus chrysops*	E, I
sea raven	*Hemitripterus americanus*	E, I
seaboard goby	*Gobiosoma ginsburgi*	E
searobins	*Prionotus* spp.	E
shorthorn sculpin	*Myoxocephalus scorpius*	E, I
silver hake	*Merluccius bilinearis*	E, I
silver-rag	*Ariomma bondi*	I
silversides	*Menidia* spp.	E
smallmouth flounder	*Etropus microstomus*	E, I
smooth dogfish	*Mustelus canis*	I
smooth flounder	*Pleuronectes putnami*	E, I
snailfishes	*Liparis* spp.	E
snakeblenny	*Lumpenus lumpretaeformis*	E
spiny dogfish	*Squalus acanthus*	I
spot	*Leiostomus xanthurus*	I
striped bass	*Morone saxatilis*	I
striped cusk eel	*Ophidion marginatum*	E, I
striped killifish	*Fundulus majalis*	E, I
striped searobins	*Prionotus evolans*	I
summer flounder	*Paralichthys dentatus*	E, I
tautog	*Tautoga onitis*	E, I
threespine stickleback	*Gasterosteus aculeatus*	I
weakfish	*Cynoscion regalis*	E, I
white perch	*Morone americana*	I
windowpane	*Scophthalmus aquosus*	E, I
winter flounder	*Pleuronectes americanus*	E, I
winter skate	*Leucoraja ocelata*	I
witch flounder	*Glyptocephalus cynoglossus*	E
wrasses	Labridae	E
wrymouth	*Cryptacanthodes maculatus*	E
yellowtail flounder	*Pleuronectes ferrugineus/Limanda ferrugineus*	E, I

Notes:
E = Entrained (1975-2005)
I = Impinged (1980-2005)
Adapted from Normandeau 2006a and 2006b.

eggs during this time period (Normandeau 2006a). During the 2005 winter to early spring season (generally January to April), egg collections are dominated by Atlantic cod (*Gadus morhua*), while larvae collections are dominated by the sand lance (*Ammodytes americanus*) (Normandeau 2006a). In 2004, the sand lance also dominated the larvae collection while the egg collection was dominated by American plaice (*Hippoglossoides platessoides*), followed by Atlantic cod (MRI 2005b).

The late spring to early summer season is typically the most active reproductive period among the temperate fishes in the PNPS area (Normandeau 2006a). In both the 2004 and 2005 late spring to early summer seasons (May to July), the egg species were dominated by tautog (*Tautoga onitis*), cunner, and yellowtail founder (*Pleuronectes ferruginea*), while the larvae were dominated by winter flounder (MRI 2005a; Normandeau 2006a).

The late summer to early autumn season in the PNPS area typically shows a decline in overall ichthyoplankton density and number of species collected (Normandeau 2006a). The 2004 and 2005 late summer to early autumn seasons (August to December) are dominated by tautog, cunner, and yellowtail flounder eggs, closely followed by fourspot flounder (*Paralichthyus oblongus*) and windowpane flounder (*Scopthalmus aquosus*) eggs (MRI 2005b; Normandeau 2006a). In 2005, the larval collections were dominated by fourbeard rockling (*Enchelyopus cimbrius*), whereas 2004 larval collections were dominated by cunner with the fourbeard rockling showing a much lower entrainment percentage than in 2005 (MRI 2005b; Normandeau 2006a).

According to Entergy (2006b), ichthyoplankton densities obtained in 2005 are consistent with the data from the 1975 to 2004 time series, with the exception of Atlantic cod and Atlantic mackerel (*Scomber scrombrus*) eggs and larval winter flounder and rock gunnel (*Pholis gunnellus*). Both the Atlantic cod egg and larval winter flounder abundance estimates appear to have increasing long-term trends, whereas Atlantic mackerel egg and larval rock gunnel estimates appear to be relatively low compared to historic data (Normandeau 2006a).

Periodically since PNPS began operation, there have been periods when the rate of entrainment of fish eggs and larvae was unusually high relative to historical levels. Reporting of these periods of exceptionally high entrainment is required by the facility's NPDES permit. Identification of these occurrences was thought to be necessary so that it could be determined whether high ichthyoplankton entrainment rates were being caused by conditions that are attributable to operation of PNPS or attributable to naturally occurring high population levels in the bay (i.e., during spawning season) (Normandeau 2006a). These periods of high entrainment levels can contribute a large proportion of the overall annual entrainment numbers for certain species. For example, during the 2005 sampling season, there were 54 separate occasions when entrainment levels were unusually high as defined by comparison to historical data sets. These included a total of 12 species of eggs and larvae, including American plaice, Atlantic menhaden, Atlantic herring (*Clupea harengus*), sand lance, seasnail (*Liparis atlanticus*), winter flounder, radiated shanny (*Ulcaria subbifurcata*), cunner, fourbeard rockling, tautog, Atlantic mackerel, and red hake (*Urophycis chuss*) (Normandeau 2006a).

Table 4-4 presents ichthyoplankton entrainment data for six species of fish that are of concern in this area (cunner, Atlantic mackerel, Atlantic menhaden, Atlantic herring, Atlantic cod, and winter flounder). There is a high level of variability in the degree of entrainment from year to year. This is also true for many other fish species entrained at PNPS (Normandeau 2006a).

Cunner larval abundance as of 2005 continues to be below the 1981 to 2004 time series average; however, no overall trends in the entrainment collections are apparent (Normandeau 2006a).

There were high entrainment densities of Atlantic mackerel eggs from the mid 1980s to mid 1990s, but no clear trends are apparent over the last decade (Normandeau 2006a). Abundance indices of mackerel larvae in the entrainment collections have dropped since 1995 (Normandeau 2006a).

For the Atlantic menhaden, the abundance index of eggs entrained at PNPS appears to have dropped, but there was a significant amount of variability (Normandeau 2006a). Abundance of larval menhaden has varied significantly over the last few years with 2004 having the lowest abundance on record and 2005 having a relatively high abundance (compared to the last five years) (Normandeau 2006a). The overall stock appears to be healthy (ASMFC 2006a).

No trends are apparent in Atlantic herring larvae entrainment data (Normandeau 2006a). However, the overall stock appears to be healthy (ASMFC 2006a).

For Atlantic cod, there are no clear trends in the abundance index of eggs and larvae. However, there has been an increase in stock biomass and spawning biomass observed since the late 1990s (Normandeau 2006a).

Table 4-4. Number of Eggs and Larvae Entrained for Six Species of Fish at PNPS from 1980 to 2005

	Winter Flounder						Cunner				
		Number of Larvae Entrained						Number of Larvae Entrained			
Year	Number of Eggs Entrained	Stage 1	Stage 2	Stage 3	Stage 4	Total Larvae Entrained	Number of Eggs Entrained	Stage 1	Stage 2	Stage 3	Total Larvae Entrained
1980	3,513,717	8,694,456	12,714,822	7,317,129	0	28,726,407	3,257,891,776	76,282,260	40,480,032	4,229,248	120,991,540
1981	9,674,954	7,606,942	19,133,121	3,073,126	43,304	29,856,493	6,576,294,915	316,245,739	256,567,950	3,508,876	576,322,565
1982	7,001,776	2,706,834	6,724,795	11,583,134	425,011	21,439,774	2,010,779,150	6,351,445	3,187,760	597,356	10,136,561
1983	1,305,735	1,933,453	2,246,172	7,558,534	260,350	11,998,509	5,895,329,347	10,961,646	27,571,530	3,955,802	42,488,978
1984	341,424	248,082	0	7,570,145	516,247	8,334,474	1,766,764,864	0	176,682	1,029,352	1,206,034
1985	32,717,535	1,039,001	2,312,789	8,025,452	130,786	11,508,028	2,021,886,071	17,182,039	20,392,615	2,307,617	39882271
1986	5,118,035	5,397,403	5,783,669	3,963,747	77,005	15,221,824	1,493,653,289	4,419,092	22,197,318	297,368	26,913,778
1987	20,857,334	0	437,608	3,088,405	0	3,526,013	4,465,564,080	40,247,222	314,474	248,738	40,810,434
1988	3,494,771	1,995,968	1,656,376	15,079,960	511,009	19,243,313	1,539,089,318	2,290,972	2,624,077	2,461,452	7,376,501
1989	6,423,987	1,668,823	5,755,240	2,224,675	39,114	9,687,852	4,469,416,004	34,100,052	15,224,141	2,863,938	52,188,131
1990	48,501	643,683	1,155,404	6,846,718	33,002	8,678,807	1,336,048,112	65,705,970	62,378,298	44,014,528	172,098,796
1991	1,217,178	3,471,022	3,908,488	5,188,056	37,717	12,605,283	675,000,390	5,790,172	3,701,490	7,243,966	16,735,628
1992	4,124,308	873,660	876,914	7,034,690	26,192	8,811,456	2,174,661,078	0	1,186,819	1,605,055	2,791,874
1993	3,078,941	1,595,700	3,540,750	4,934,952	88,617	10,160,019	3,235,317,207	148,674	7,178,133	7,923,303	15,250,110
1994	2,530,707	1,034,617	6,433,716	13,060,373	172,606	20,701,312	1,558,253,667	0	5,545,977	4,440,095	9,986,072
1995	2,766,716	1,632,907	2,820,023	8,826,496	375,857	13,655,283	4,116,491,874	7,961,638	29,910,748	9,257,792	47,130,178
1996	4,896,687	504,810	5,818,499	11,329,855	995,127	18,648,291	2,807,124,109	3,765,455	8,094,509	5,558,849	17,418,813
1997	3,609,393	2,225,634	9,537,788	41,484,016	2,126,280	55,373,718	1,718,289,720	6,444,923	51,895,511	41,294,559	99,634,993
1998	1,035,001	3,111,891	20,282,772	58,546,916	4,904,482	86,846,061	4,341,664,826	104,908,332	211,248,501	54,060,618	370,217,451
1999	1,409,453	2,031,988	588,974	1,936,648	123,103	4,680,713	1,717,578,656	36,934,878	11,960,388	7,510,427	56,405,693
2000	1,693,672	33,482	170,475	5,391,088	0	5,595,045	1,349,685,330	22,411,361	39,293,994	1,388,620	63,093,975
2001	330,283	4,638,546	13,093,697	37,019,304	263,144	55,014,691	2,744,377,803	1,044,260	34,542,919	35,707,859	71,295,038
2002	28,637	1,389,319	6,911,151	14,802,848	1,232,865	24,336,183	580,954,607	537,068	4,771,751	10,257,985	15,566,804
2003	1,977,333	722,030	480,190	2,966,524	76,394	4,245,138	759,226,058	352,721	1,783,511	1,865,231	4,001,463
2004	246,468	159,859	10,431,901	49,597,823	1,988,421	62,178,004	1,452,433,321	462,728	7,927,232	8,369,181	16,759,141
2005	243,151	158,986	7,470,964	20,441,584	4,277,092	32,348,626	816,334,983	820,862	10,225,681	5,504,981	16,551,524

Table 4-4. (contd)

Year	Atlantic Mackerel		Atlantic Menhaden		Atlantic Herring		Atlantic Cod	
	Total Number Entrained		Total Number Entrained		Total Number Entrained		Total Number Entrained	
	Eggs	Larvae	Eggs	Larvae	Eggs[a]	Larvae	Eggs	Larvae
1980	81,599,432	22,293,108	16,468,408	12,060,791	NA	1,068,466	20,388,850	1,450,522
1981	183,959,791	320,135,596	3,473,080	40,076,799	NA	2,471,492	11,620,588	2,173,076
1982	108,234,931	9,388,143	365,091,471	1,845,849	NA	732,857	2,582,984	222,721
1983	148,616,621	41,333,673	869,580	1,227,190	NA	5,880,315	9,349,728	142,136
1984	22,486,619	78,315	4,751,607	0	NA	468,840	11,726,579	587,054
1985	1,867,648,438	45,711,343	41,131,470	9,190,654	NA	1,580,435	5,071,151	1,441,442
1986	219,488,066	58,333,520	21,112,802	3,654,854	NA	1,811,101	2,788,767	1,035,987
1987	71,222,294	215,561	311,687	1,560,529	NA	5,142,045	5,623,282	122,579
1988	2,663,608,568	3,401,489	9,273,771	2,713,857	NA	639,089	2,747,034	254,239
1989	4,673,915,938	65,562,469	11,212,165	4,411,807	NA	911,487	3,395,726	119,436
1990	2,313,416,455	4,627,282	7,057,041	3,263,718	NA	2,079,483	2,406,536	1,566,291
1991	479,761,865	66,009,482	5,744,115	512,319	NA	1,280,273	3,668,649	239,746
1992	377,610,764	8,086,393	392,533	1,117,881	NA	3,970,208	2,819,673	469,713
1993	1,801,378,418	8,325,789	947,815,345	11,833,443	NA	2,098,952	1,268,748	446,489
1994	520,917,221	3,419,299	10,221,752	2,361,834	NA	16,351,765	3,119,312	1,904,519
1995	1,767,609,278	197,689,693	3,280,481	12,419,886	NA	43,247,883	2,549,370	602,594
1996	1,507,370,682	70,947,053	4,861,265	8,660,874	NA	9,265,826	8,542,922	2,369,255
1997	316,969,390	25,778,062	48,899,715	48,283,152	NA	24,445,056	1,800,711	1,101,118
1998	530,017,006	56,622,648	44,730,447	33,280,806	NA	4,026,783	4,971,621	735,301
1999	34,498,141	483,595	14,395,648	19,324,314	NA	11,379,446	1,932,894	464,125
2000	619,863,003	16,496,664	882,086	809,127	NA	12,306,502	18,525,824	325,095
2001	150,613,190	4,868,686	4,025,648	1,251,898	NA	4,062,977	6,869,977	4,215,642
2002	280,852,511	3,704,444	14,464,446	5,164,308	NA	3,468,890	4,698,000	1,299,393
2003	314,571,725	2,790,425	6,027,864	5,364,766	NA	1,045,853	7,032,420	2,114,930
2004	70,227,928	10,894,804	613,682	176,011	NA	4,722,708	5,231,113	1,550,052
2005	85,750,499	2,782,044	1,402,677	17,566,121	NA	9,860,824	14,966,375	950,164

(a) Data are not reported for entrainment of Atlantic Herring eggs, as this species is a riverine spawner
Source: Entergy 2006b.

For winter flounder, larval abundance in 2005 was slightly lower than the 1981 to 2004 time series data (Normandeau 2006a), while the number of eggs entrained in 2005 was almost identical to that entrained in 2004 but significantly less than the quantities entrained in 2003 and in the 1991 to 2000 time series average (Normandeau 2006a).

In addition to ichthyoplankton, periodically American lobster larvae are also entrained at PNPS. In 2005, 32 lobster larvae were found in the entrainment samples. This is the highest number of lobster larvae collected in a single year. In fact, up until 2005, only 46 larvae had been collected at PNPS since monitoring began in 1974 (Normandeau 2006a). Apparent causes of the high entrainment for lobsters in 2005 are unclear, but could be due to the implementation of a security zone around the plant and, hence, a reduction in lobster fishing pressure (Normandeau 2006a).

4.1.1.3 Assessment of Entrainment Impact

The staff reviewed the PNPS ER, visited the site, consulted with Federal and State resource agencies, reviewed the applicant's existing NPDES permit and existing literature related to fish and shellfish populations of Cape Cod Bay, and considered public comments with particular regard to entrainment studies conducted at the PNPS. NRC staff also consulted with Federal and State resource agencies that issue permits required for operation of PNPS (EPA, Massachusetts Coastal Zone Management Office), or that have responsibility for biological resources potentially affected by operation of PNPS (MDMF, National Marine Fisheries Service [NMFS]) (Earth Tech 2006a; Earth Tech 2006b).

The 316 demonstration report concludes that impingement and entrainment have caused no adverse impacts to any representative important species population or to the integrity of the aquatic ecosystem of Cape Cod Bay (ENSR 2000). However, EPA Region 1, in discussions with the NRC staff, indicated that there was some debate over the conclusions of the report. The 316 demonstration report evaluated impacts on essential fish habitat (EFH) and representative important species including:

- Irish moss (*Chondrus crispus*)
- American lobster (*Homarus americanus*)
- Winter flounder (*Pseudopleuronectes americanus*)
- Rainbow smelt (*Osmerus mordax*)
- Cunner (*Tautogolabrus adspersus*)
- Alewife (*Alosa pseudoharenqus*)
- Atlantic silverside (*Menidia menidia*)
- Atlantic cod (*Gadus morhua*)
- Haddock (*Melanogrammus aeglefinus*)
- Pollock (*Pollachius virens*)
- Silver hake / whiting (*Merluccius bilinearis*)
- Red hake (*Urophycis chuss*)
- White hake (*Urophycis tenuis*)
- Yellowtail flounder (*Pleuronectes ferruginea*)
- Windowpane flounder (*Scopthalmus aquosus*)
- American plaice (*Hippoglossoides platessoides*)
- Ocean pout (*Macrozoarces americanus*)
- Atlantic halibut (*Hippoglossus hippoglossus*)

- Atlantic sea scallop (*Placopecten magellanicus*)
- Atlantic herring (*Clupea harengus*)
- Monkfish (*Lophius americanus*)
- Bluefish (*Pomatomus salatrix*)
- Longfin squid (*Loligo pealei*)
- Shortfin squid (*Illex illecbrosus*)
- Atlantic butterfish (*Peprilus triacanthus*)
- Atlantic mackerel (*Scomber scombrus*)
- Summer flounder (*Paralicthys dentatus*)
- Scup (*Stenotomus chrysops*)
- Surf clam (*Spisula solidissima*)
- Spiny dogfish (*Squalus acanthias*)
- Bluefin tuna (*Thunnus thynnus*)

With the exception of the winter flounder, ENSR (2000) estimated that losses due to entrainment at PNPS were less than 1 percent of the adult population in western Cape Cod Bay of five of these species: cunner, Atlantic mackerel, rainbow smelt, alewife and Atlantic silverside. ENSR (2000) estimated that entrainment effects on the remaining species also were minor. Since the publication of the 316 report in 2000, Entergy has continued to evaluate in detail the effects of entrainment and impingement on six species: cunner, Atlantic mackerel, Atlantic menhaden, Atlantic herring, Atlantic cod, and winter flounder. Winter flounder, herring, and cod were selected because they are commercially and recreationally important in the area, while cunner, mackerel, and menhaden were selected because they historically have had high entrainment and impingement rates (Normandeau 2006a).

Entergy commonly uses the equivalent adult procedure (Goodyear 1978) to evaluate effects of entrainment and impingement on local fish populations. This methodology applies estimated survival rates to eggs and larvae that have been lost to entrainment and impingement to calculate the number of adult fish that might have been recruited to the local populations (Normandeau 2006a). Many assumptions are included in the equivalent adult procedure, and uncertainty is inherent in the process. For example, it is conservatively assumed that no eggs or larvae survive entrainment, that the fish population is in equilibrium (each female replaced only herself and one male), and that no density-dependent compensation (increased survival and fecundity) occurs among unaffected individuals as a result of reduced competition (Normandeau 2006a).

For cunner, the numbers of equivalent adults lost to entrainment have been well below the mean for the 1980 to 2004 time series over the last four years and have declined in comparison to historical data (Normandeau 2006a). There is no management of the cunner fishery; consequently, landings data and stock status information are limited. Based on an analysis by Normandeau (2006a), cunner appear to be abundant in the vicinity of PNPS, and the loss to the local adult population due to entrainment by PNPS appears to be less than 1 percent.

Atlantic mackerel equivalent adult numbers tend to follow the same trend as cunner (Normandeau 2006a). The loss to the local population due to entrainment and impingement by PNPS appears to be less than 1 percent (Normandeau 2006a). As of the 1999 stock assessment, the spawning stock biomass (SSB) was believed to be at historically high levels

(Normandeau 2006a). Based on the 2006 stock assessment, the northwest Atlantic mackerel stock is considered to be healthy (NEFSC 2006).

For Atlantic menhaden, there is significant variability in year-to-year numbers of eggs and larvae entrained (Normandeau 2006a). The Atlantic menhaden stock is considered to be healthy (ASMFC 2006a), and based on the 2005 Pilgrim monitoring data, the loss to the stock due to entrainment by PNPS appears to be less than 1 percent (Normandeau 2006a).

The number of Atlantic herring equivalent adults lost to entrainment increased in 2005, exceeding the 25-year mean for the first time since 2000 (Normandeau 2006a). The Atlantic herring stock is considered to be healthy (ASMFC 2006a), and based on the 2005 Pilgrim monitoring data, the loss to the stock due to entrainment by PNPS appears to be significantly less than 1 percent (Normandeau 2006a).

Atlantic cod entrainment losses of equivalent adults in recent years (2001 to 2005) have been above the 25-year mean (Normandeau 2006a). Less recent stock assessments have indicated that the stock is depressed (Fahay et. al. 1999). However, Normandeau (2006a) concluded that the numbers of equivalent adults entrained at PNPS are low relative to recent landings information for the Cape Cod Bay area.

The winter flounder is a species of significant commercial and recreational value in the area and has been intensively studied at PNPS. The 316 demonstration report (ENSR 2000) utilized three procedures to evaluate the significance of entrainment losses on the local population: the Stone and Webster model, equivalent adult analysis, and the Risk Analysis Management Alternative System (RAMAS) model. ENSR (2000) concluded that the conditional mortality from entrainment is uncertain but is less than 5 percent.

The Stone and Webster Model is a life cycle model used to evaluate potential PNPS effects on the winter flounder population in Cape Cod Bay. The model was used to simulate the population over a 40-year period under two scenarios: without the presence of PNPS, and with the presence of PNPS and its associated mortality due to entrainment and impingement. Based on comparison of the results, a 3 percent reduction in the adult winter flounder population in Cape Cod Bay was conservatively predicted (ENSR 2000).

Figure 4-1 presents a summary of the numbers of equivalent adult winter flounder estimated to have been removed from the local stock over the last 25 years as a result of entrainment and impingement of eggs and larvae at PNPS. As can be seen from this figure, the numbers of equivalent adult winter flounder potentially removed from the local stock over the last two years are the second and third highest levels observed at PNPS. This contrasts with near record low levels observed in 1999, 2000, and 2003.

Comparison of the equivalent adult numbers to the area-swept population estimates may provide an indication of effects on the local stock of winter flounder. Normandeau (2006a) compared recent estimates of the loss of age 3 adults (age at which flounder become sexually mature) using the equivalent adult method to the total numbers of adult winter flounder in the area derived from the area-swept population estimates. As can be seen from Table 4-5, the predicted losses from the local stock due to entrainment and impingement at PNPS as a percentage of the estimated number of adults range from less than 0.5 percent to approximately 12 percent.

An estimate of the potential loss of the 2003 year class due to entrainment and impingement will be estimated upon conducting the 2006 area-swept surveys, results of which were not available to the NRC staff at the time of the preparation of this SEIS. However, an estimate of the potential losses can be derived by comparing the equivalent adult loss to the average of the numbers estimated by the area-swept surveys. Based on the 2005 entrainment and impingement data, there was a loss of 29,852 equivalent adult fish. Comparison of this estimate to the average area-swept estimate for the last three years indicates a 16.4 percent take of the local population (Normandeau 2006a).

The loss estimates presented in Table 4-5 contrast with other estimates. For instance the RAMAS model was also run as an alternative means of assessing effects to the local winter flounder population from entrainment and impingement. This analysis indicated that stock reductions ranging from 2.3 to 5.2 percent might occur as a result of entrainment at PNPS (Normandeau 2006a).

Based on the larval transport studies described in Section 4.1.1.1, the amount of winter flounder larvae (based on all four larval stages combined) in northwestern Cape Cod Bay entrained by PNPS is estimated at less than 1 percent of the net larval transport (ENSR and MRI 2005). Estimates of loss due to entrainment of stages 3 and 4 larvae have ranged up to 20 percent of the net larval transport for those stages; however, there were several methodological difficulties, as discussed in Section 4.1.1.1, which impart a high degree of uncertainty to these estimates (ENSR and MRI 2005).

Figure 4-1. Equivalent Adult Summary of Entrained and Impinged Winter Flounder from PNPS (Source: Normandeau 2006a)

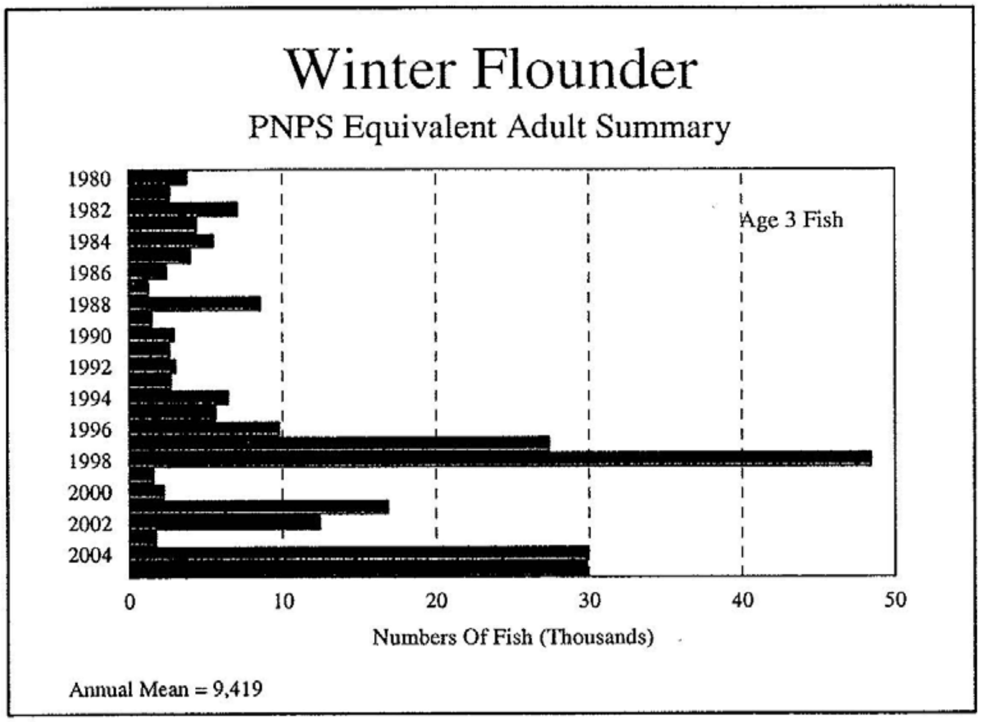

Table 4-5. Equivalent Adult Losses of Winter Flounder

Year Entrainment/ Impingement Data Collected	Predicted Numbers of Age 3 Adults Lost Due to Entrainment and Impingement*	Year Trawl Data Collected	Estimated Numbers of Adults in Western Cape Cod Bay**	Predicted Age 3 Adults Lost as Percent of Estimated Number of Adults
1997	27,398	2000	464,176	5.9
1998	48,483	2001	400,182	12.1
1999	1,615	2002	476,263	0.3
2000	2,275	2003	262,604	0.9
2001	16,883	2004	157,532	10.7
2002	12,450	2005	126,117	9.9

*Numbers of age 3 adults predicted based on the equivalent adult approach. Values shown are averages of results from the different procedures used to estimate equivalent adult numbers.

**Estimated abundance of adults (age 3 and older and >280 mm total length) based on area-swept surveys by trawl in spring.

Source of values: Adapted from Normandeau 2006a

Geographical range of the local winter flounder population is a key consideration in evaluating the extent of impacts of entrainment at PNPS. Winter flounder in the PNPS area are managed as the Gulf of Maine stock complex; however, more localized populations may exist, as adults express a high degree of spawning site fidelity, and spawning populations can be highly localized (Nitschke et al. 2000, Lawton et al. 1999a, Lawton et al. 2000b).

According to the Atlantic States Marine Fisheries Commission (ASMFC) (2006a), the Gulf of Maine winter flounder population is healthy. The 2003 Regional Stock Assessment noted that recruitment to the stock has been near or above average since 1995 (NEFSC 2003). The 2005 stock assessment (NEFSC 2005) concluded that the stock is not overfished and overfishing is not currently occurring, but also noted that there is considerable uncertainty in the current estimates of fish mortality and SSB. This contrasts with data collected by MDMF and the NMFS that indicate a sharp decline in stock abundance over the last several years (as measured by catch per unit effort) (Figures 2-9 and 2-10).

The area-swept data for winter flounder (MRI 2005a), which are collected in northwestern Cape Cod Bay in the waters surrounding PNPS, can provide an estimate of the status of local stocks. As can be seen from Figure 2-9, the annual abundance estimates have steadily decreased from 2002. These data also track the NMFS and MDMF data noted above, perhaps suggesting that the decline observed in Cape Cod Bay is not exclusive to the PNPS area (MRI 2005a).

An independent analysis conducted by Szal (2005), a biologist with MDEP, calculated the entrainment loss of adult winter flounder, using age 4 equivalent adults and local population estimates from the area-swept surveys. The average loss of age 4 equivalent adults over the 10-year period ending in 2004 was approximately 6 percent. The maximum loss of age 4 equivalent adults over this time period was observed in 2004 and estimated to be 20 percent (Szal 2005).

Stocks of rainbow smelt in Massachusetts are significantly depressed compared to historical levels (Chase 2006). However, entrainment of rainbow smelt eggs is not expected to be a significant concern at PNPS because rainbow smelt are riverine spawners, and eggs reaching the bay and PNPS would not be viable due to ambient salinity levels surrounding PNPS that are greater than lethal tolerance levels of the eggs (ENSR 2000). Based on an analysis of data from the 1970s, entrainment of smelt larvae at PNPS would account for significantly less than 1 percent of the local smelt population (ENSR 2000). Even considering recent declines in the Jones River population, the impacts of entrainment on rainbow smelt populations would likely be minimal (ENSR 2000).

4.1.1.4 Summary of Entrainment Impacts

Due to the lack of recent information describing the status of several local populations, it is difficult to quantify entrainment impacts. Effects of entrainment on winter flounder likely affect only the local population. Historical data have indicated no clear correlation between entrainment rates at PNPS and Gulf of Maine stock trends. However, available data indicate that there are high levels of larval entrainment at PNPS, with particular concern being the high larval entrainment rates for late-stage larvae (stages 3 and 4). Based on the decline of the local population, the percentage take of the local population, and the considerable uncertainties in the stock status, the staff's conclusion is that continued operation of PNPS would have a MODERATE impact on the local winter flounder population due to entrainment over the course of the license renewal term. However, the staff has concluded that continued operation of PNPS during the renewal term would have a SMALL to MODERATE impact on the overall Gulf of Maine winter flounder stock as well as on all other marine aquatic resources due to entrainment.

Due to the potential for impacts on marine aquatic resources in Cape Cod Bay over the course of the license renewal term, additional mitigation measures may further reduce entrainment impacts. Section 4.1.4 of this SEIS discusses the potential mitigation measures that may be applicable to PNPS. Additionally, EPA's evaluation of the PNPS NPDES permit renewal application would likely address any applicable site-specific mitigation measure that may reduce entrainment impacts.

4.1.2 Impingement of Fish and Shellfish

For plants with once-through cooling systems, such as PNPS, impingement of fish and shellfish on traveling screens is considered a Category 2 issue, thus requiring a site-specific assessment for license renewal review. To assess impingement impacts the staff independently reviewed the PNPS ER, visited the site, consulted with Federal and State resource agencies, reviewed the applicant's existing NPDES permit and existing literature related to fish and shellfish populations of Cape Cod Bay, and considered public comments.

Section 316(b) of the Clean Water Act of 1977 (CWA), common name of the Federal Water Pollution Control Act, requires that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impacts (33 U.S.C. 1326). Entrainment of fish and shellfish into the cooling water system is a potential adverse environmental impact that can be minimized by the use of best technology available. Licensees may be required as part of the NPDES permit renewal to alter the intake structure, redesign the cooling system, modify facility operation, or take other mitigative measures. Licensees must comply with Section 316(b) of the CWA. However, EPA's 316(b) Phase II Rule has been suspended and compliance with the rule is based on EPA's best professional judgment. Entergy is currently conducting a Comprehensive Demonstration Study (CDS) as part of the 316(b) evaluation. This study is due to the EPA by January 2008.

4.1.2.1 Impingement Monitoring

Impingement sampling consists of monitoring three scheduled screen-wash periods each week throughout the year. The screens are not continuously turned. However, in general they are turned for 8 hours prior to conducting the impingement sampling. If the screens were turned prior to sampling, a 60-minute sample is obtained. If the screens were not turned prior to arrival of the sampling crew, a 30-minute sample is scheduled (Normandeau 2006b). While the screens are turning, low- and high-pressure sprays continuously rinse debris and organisms off the screens into a sluiceway, which is sampled by inserting a stainless steel collection basket into the sluiceway entrance adjacent to the traveling screens. Fish are considered to be alive if opercular movement is noted and there are no obvious signs of injury. However, Entergy has not conducted any latent mortality studies. Living fauna are noted and measured for total length and then returned to the sluiceway. Dead or injured specimens are preserved for later analysis in the lab (Normandeau 2006b).

After being rinsed off of the screens and being washed into the east sluiceway, all debris and organisms are diverted via a seamless concrete sluiceway into the intake embayment, approximately 300 feet (ft) from the screens. A re-impingement study was attempted in the early 1980s, but due to methodological difficulties, the study was never completed. During storm events, a portion or all of the flow from the screens is diverted to the discharge canal via the west sluiceway.

Impingement rates are calculated by dividing the number of individuals of a given species that are collected by the number of hours in the collection period. If impingement rates of greater than 20 fish per hour are noted, additional samples are collected. If impingement rates continue to be elevated after the second sampling period then the plant operator is notified and advised to leave the screens operating until further notice (Normandeau 2006b).

Since 1980, a total of 73 species of fish has been collected in the impingement sampling (Table 4-3) (Normandeau 2006b). In 2005, impingement samples were collected for a total of 440 hours spread out over the entire year. Over 300,000 fish consisting of 38 species were collected (Normandeau 2006b). Atlantic menhaden, Atlantic silverside *(Menidia menidia*), rainbow smelt, winter flounder, and Atlantic tomcod (*Microgadus tomcod*) accounted for 98 percent of the annual total of impinged fish (Normandeau 2006b). Atlantic menhaden were the most dominant at 97 percent, followed by Atlantic silverside (3.8 percent), rainbow smelt (1.3 percent), and winter flounder (1.2 percent) (Normandeau 2006b). Approximately 23,000 invertebrates representing 18 taxa were also collected. Sevenspine bay shrimp (*Crangon septemspinosa*) was the dominant taxon, followed by cancer crabs (*Cancer* spp.) and then

American lobster (Normandeau 2006b).

Atlantic menhaden impingement rates in 2005 were 25 times greater than the historical mean (Table 4-6). Impingement rates for Atlantic silversides in 2005 were similar to the historical mean. Winter flounder and rainbow smelt were impinged at rates of almost 3 times and 2 times, respectively, their historical means (Table 4-6). Impingement rates for winter flounder have been steadily increasing since the late 1990s (Normandeau 2006b). There was a sharp drop in rainbow smelt impingement rates in 2000, but other than that, impingement rates have remained at relatively consistent levels since the 1990s. Impingement data for the Atlantic tomcod in 2005 were approximately six times greater than the historical mean and is the second highest impingement rate in the history of PNPS (Normandeau 2006b).

In 2005, there were 19 impingement events (greater than 20 fish impinged per hour). In the majority of these events, Atlantic menhaden and Atlantic silversides were the primary species impinged (Normandeau 2006b).

Generally, the smaller the amount of time an organism is impinged on a screen, the lower its probability of survival. In 2005, survival of impinged organisms was higher during the 60-minute samples than during the 30-minute samples. This trend is consistent with previous years (Normandeau 2006b). Survival of the Atlantic menhaden was low during both the 60-minute samples (27 percent) and the 30-minute samples (18 percent). The Atlantic silverside had a much greater difference in survival between the 60-minute samples and the 30-minute samples (62 percent versus 15 percent). Winter flounder survival averaged 96 percent when collected during the 60-minute samples, while survival was approximately 77 percent during the 30-minute samples. There was also a significant difference for the rainbow smelt, with 53 percent survival based on the 60-minute samples and no survival based on the 30-minute samples (Normandeau 2006b). Survival for the Atlantic tomcod ranges from 35 percent for the 30-minute samples to 63 percent for the 60-minute samples. It is likely that the difference in survival rates between the 30 and 60-minute samples is due to the duration of screen rotation prior to initiation of sampling activities, as described earlier in this section. Lower impingement survival rates would be expected in the 30-minute samples as organisms may be impinged on the screen for a longer time period prior to being washed into the sluiceway.

4.1.2.2 Assessment of Impingement Impact

To evaluate the impact of these impingement losses, the NRC staff conducted an independent analysis and evaluated the conclusions of the 316 demonstration report (ENSR 2000), the PNPS ER (Entergy 2006a), and recent monitoring reports developed by Entergy in fulfillment of NPDES permit requirements. The 316 demonstration report (ENSR 2000) evaluated

Table 4-6. Annual Extrapolated Totals for Typical Dominants Found on the PNPS Intake Screens, 1980-2005.

Species	1980	1981	1982	1983	1984[1]	1985	1986	1987[2]	1988	1989	1990	1991	1992
Atlantic silverside	191	90,449	2,626	1,586	245	4,417	702	1,298	940	2,838	4,761	2,955	2,381
Atlantic menhaden	226	0	171	522	11	1,491	953	0	177	2,020	3,135	1,117	32
Winter flounder	297	249	297	232	47	884	908	138	556	1,119	336	694	787
Blueback herring	46	230	251	754	34	791	63	7	222	207	1,194	298	110
Grubby	107	448	340	490	114	932	359	200	124	684	585	468	507
Rainbow smelt	814	236	634	1,224	29	189	1,909	1,070	370	886	387	372	317
Atlantic tomcod	63	76	221	276	157	389	174	57	1,578	433	291	159	104
Cunner	1,043	870	610	196	45	580	270	115	97	199	210	182	28
Atlantic Herring	83	53	156	22	0	35	3,009	6	51	138	408	24,238	51
Alewife	99	201	262	83	88	807	261	26	464	149	1,480	250	247
Hakes (Red and White)	93	101	125	0	8	34	27	53	23	55	0	55	14
Windowpane	68	96	107	173	56	146	87	0	0	171	171	103	41
Tautog	0	69	18	41	11	83	26	113	82	159	52	175	93
Lumpfish	38	0	160	103	75	125	46	72	674	30	78	51	122
Annual totals for dominants	3,168	93,078	5,978	5,702	920	10,903	8,794	3,155	5,358	9,088	13,088	31,117	4,834
Percent of total for dominants	79%	98%	71%	87%	83%	87%	95%	83%	80%	88%	82%	97%	90%
Total all fish	4,030	95,336	8,411	6,558	1,112	12,499	9,259	3,782	6,675	10,289	15,939	32,080	5,397
Collection Time (hrs.)	687	574.8	687	763	1,042	465	806	527	525	618	919.5	930.3	774
Impingement Rate (fish/hour)	0.66	10.02	0.93	0.57	0.13	1.14	1.26	0.28	0.27	0.8	1.70	3.38	0.63

Species	1993	1994[3]	1995[4]	1996	1997	1998	1999[5]	2000	2001[6]	2002	2003[7]	2004	Mean 1990-2004	2005[8]
Atlantic silverside	9,872	36,498	13,085	16,615	6,303	6,773	8,577	25,665	4,987	4,430	23,149	13,107	11,378	11,590
Atlantic menhaden	46	58	1,560	2,168	1,329	1,423	42,686	34,354	3,599	53,304	119,041	10,431	11,194	277,601
Winter flounder	1,181	1,018	1,628	857	608	2,069	1,021	1,358	1,729	1,466	1,435	2,021	917	2,688
Blueback herring	295	269	1,244	2,462	424	134	550	5,919	229	943	1,968	2,046	828	646
Grubby	640	1,094	648	1,347	405	335	628	1,105	517	1,087	237	2,257	626	501
Rainbow smelt	8,302	9,464	2,191	3,728	1,978	1,656	875	13	879	335	532	1,092	1,579	2,840
Atlantic tomcod	329	153	260	466	72	40	302	323	278	168	19	304	268	1,518
Cunner	93	77	346	332	41	101	153	348	140	59	172	240	262	716
Atlantic Herring	169	28	108	0	13	108	181	77	48	301	51	138	1,179	549
Alewife	1,021	123	39,884	216	317	158	610	2,443	1,618	334	438	145	2,069	265
Hakes (Red and White)	166	23	182	113	196	106	682	182	1,158	192	128	202	157	70
Windowpane	133	179	232	296	65	416	434	363	162	24	13	37	143	135
Tautog	275	50	73	488	172	129	119	157	92	289	46	14	113	39
Lumpfish	329	177	116	206	173	244	136	131	0	137	61	8	132	409
Annual totals for dominants	22,851	49,211	61,557	29,294	12,096	13,692	56,954	72,438	15,436	63,069	147,290	32,042	30,845	299,567
Percent of total for dominants	95%	98%	98%	97%	85%	96%	98%	70%	99%	98%	82%	95%	89%	99%
Total all fish	24,105	50,439	62,616	30,264	14,230	14,303	58,318	103,986	15,636	64,606	179,608	33,591	34,523	302,883
Collection Time (hrs.)	673.5	737.4	607.7	416	455	575	375.5	507	430.1	494.4	714.1	638.3	638	440.5
Impingement Rate (fish/hour)	2.78	5.97	5.87	3.11	1.43	1.30	7.21	9.25	1.78	4.93	25.58	2.85	3.75	18.87

1 No CWS pumps were in operation April to August 1984.
2 No CWS pumps were in operation August 1987.
3 No CWS pumps were in operation 9 October - 14 November 1994.
4 No CWS pumps were in operation 30 March - 15 May 1995.
5 No CWS pumps were in operation 10 May - 10 June 1999.
6 No CWS pumps were in operation 28 April - 9 May 2001.
7 No CWS pumps were in operation 21 April - 11 May 2003.
8 No CWS pumps were in operation 20 April - 8 May 2005.

Source: Normandeau 2006b.

impacts on representative important species and EFH. ENSR (2000) estimated that losses due to impingement from PNPS were less than 1 percent of the population for each of these species, with the exception of cunner and rainbow smelt.

The 316 demonstration report also concluded that impingement caused no adverse impacts to any representative important species population or to the integrity of the aquatic ecosystem of Cape Cod Bay (ENSR 2000). However, EPA Region 1, in discussions with NRC staff, indicated that there was some debate over the conclusions of the report.

The Atlantic menhaden and the Atlantic silverside have been the two most frequently impinged organisms at PNPS and have been consistently collected since PNPS went on line (Table 4-6). Atlantic menhaden were impinged in record numbers at PNPS in 2005, 25 times the long-term average. In 2005, Atlantic silversides were impinged at a rate equal to the long-term mean. Menhaden travel in dense schools, and juveniles and adults are frequently attracted to intake embayments and discharge canals. Other coastal New England power stations have observed several large year classes of Atlantic menhaden since 1999 (Normandeau 2006b). The Atlantic menhaden stock is considered to be healthy with stable stock size and high biomass. Information on the stock status for the Atlantic silverside is not available; however, it is a species with high levels of reproduction in near-coastal environments such as the area surrounding PNPS.

Atlantic menhaden is considered to be a single unit stock that undergoes extensive seasonal migrations north and south along the east coast of the United States. Schools of large menhaden have been scarce in the New England region since the early 1990s. Summer 2005 was noteworthy because it was the first time in 12 years that adult menhaden were abundant north of Long Island Sound. Several New England states recorded significant menhaden-for-bait landings for the first time in over a decade. In the spring of 2005, the purse-seine bait fishery in Massachusetts landed the highest quantity of menhaden since 1995 (ASMFC 2006b). The historical maximum menhaden impingement rate at PNPS in 2005 coincided with this notable increase in menhaden landings in Massachusetts, and both phenomena appear to result from the presence of abundant numbers of menhaden in Massachusetts coastal waters in 2005.

Subsequent analyses indicate that the various sources of menhaden mortality have not resulted in observable effects on menhaden abundance in Massachusetts waters. An evaluation of the current status of the stock by the ASMFC concluded that the estimated Atlantic menhaden fishing mortality rate and population fecundity have values typically considered to indicate a healthy stock (ASMFC 2006b). The Atlantic menhaden stock status was classified as healthy, not overfished, and rebuilt as of December 2006 (ASMFC 2006c). Also in 2006, the Population Dynamics Branch of the NMFS reported significant catches of large menhaden in fish traps in Massachusetts by mid May, and purse-seine catches for bait were reported off Massachusetts in late May (NMFS 2007). These observations were considered noteworthy by NMFS because (1) 2006 was the second consecutive year in which adult menhaden were reported to be abundant in nearshore waters of southern New England and (2) May was relatively early in the calendar year for adult menhaden to occur in New England waters, especially north of Cape Cod (NMFS 2007). These lines of evidence indicate that the elevated numbers of menhaden impinged at PNPS in 2005 were in proportion to the regional increase in numbers and that the incremental mortality associated with impingement at PNPS has not contributed to a significant reduction in menhaden numbers locally or within the larger east coast population.

The Atlantic tomcod is also a species that has been collected consistently at PNPS since the plant first went on line, although it is typically impinged at rates much less than those observed for the Atlantic silverside and Atlantic menhaden (Table 4-6). However, in 2005, the impingement rate for the Atlantic tomcod increased by approximately five times its long-term average (Table 4-6). Population data are not available to evaluate the potential effects of Atlantic tomcod impingement by PNPS; however, ENSR (2000) concluded that it is unlikely that PNPS is having a significant effect on the Atlantic tomcod.

In 2005, winter flounder were impinged at a rate approximately 2.5 times the long-term mean of 917 fish (Table 4-6). Over the last decade, the numbers of winter flounder impinged at PNPS have generally increased (Normandeau 2006b). With the exception of 2005, comparison of the number of impinged fish to the number of fish estimated by the area-swept surveys indicates a loss to the local population of less than 1 percent. However, such a loss of winter flounder juveniles and adults through impingement may be contributing to population declines.

For the cunner, impingement losses were estimated to be less than 3 percent; however, as shown by Lawton et al. (2000a), population numbers in the vicinity of PNPS are high.

For the rainbow smelt, ENSR (2000) estimated that there would be less than a 1 percent impact to the local population from PNPS impingement, based on the 1980 spawning run, the most recent estimate of spawning stock size in the Jones River. Taking into account state-wide declines in the stock and the lack of any recent information on the Jones River spawning run, ENSR (2000) estimated that impacts due to PNPS impingement could range up to 2.5 percent (ENSR 2000). However, the rainbow smelt impinged at PNPS also may have been spawned in rivers or streams other than the Jones River, which is the principal spawning run in the Plymouth area and the vicinity of PNPS. At least 12 rivers and streams between Boston Harbor and the Cape Cod Canal have been reported to potentially support rainbow smelt spawning runs (MDMF 2004). After the eggs hatch in the streams, the larvae drift downstream to estuaries. As larvae develop into juveniles and adults, the smelt move into waters of increasing salinity, spending most of their time in nearshore waters, including lower estuaries, harbors, and bays. Smelt move into slightly deeper and cooler waters during summer (MDMF 2006). Thus, populations from different spawning runs may mix in Cape Cod Bay, and the rainbow smelt present in the bay and impinged at PNPS may have been hatched in rivers or streams other than the Jones River. However, the proximity of PNPS to the Jones River makes this river the likely origin of a major proportion of the impinged rainbow smelt. The MDMF has recently initiated a sampling program to determine the population indices of rainbow smelt by monitoring runs in four rivers, including the Jones River. Data collected to date indicate that the Jones River population has a low degree of spawning activity. Recent data on population size are not available, as only the first year's data of a multi-year monitoring effort have been analyzed to date (Chase 2006). Thus, considerable uncertainty exists regarding the potential impacts to rainbow smelt populations in the area.

4.1.2.3 Summary of Impingement Impacts

Due to the lack of recent information describing the status of several local populations, it is difficult to quantify impingement impacts. Effects of impingement on rainbow smelt likely affect only the Jones River population. Based on the decline of that population, the uncertainty of the stock's status, impingement rates, and the low impingement survivability of rainbow smelt, the staff's conclusion is that continued operation of PNPS would have a MODERATE impact on the Jones River population of rainbow smelt due to impingement over the course of the license renewal term. However, the staff has concluded continued operation of PNPS during the renewal term would have SMALL to MODERATE impacts on other marine aquatic resources due to impingement.

Due to the uncertainty associated with local population abundance estimates and potential impingement impacts on the local populations, implementation of mitigation measures may further reduce impingement impacts. A discussion of potentially applicable mitigation measures is presented in Section 4.1.4. Additionally, EPA's evaluation of the PNPS NPDES permit renewal application would likely address any applicable site-specific mitigation measures that may reduce impingement impacts.

4.1.3 Heat Shock

For plants with once-through cooling systems, the effects of heat shock are listed as a Category 2 issue and require plant-specific evaluation for license renewal review. The NRC identified impacts on fish and shellfish resources resulting from heat shock as a Category 2 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 (NRC 1996). Information considered includes: (1) the type of cooling system (whether once-through or closed-cycle) and (2) evidence of a CWA Section 316(a) variance or equivalent State documentation. To perform this evaluation, the staff reviewed the ER, visited the PNPS site, reviewed the facility's 316 demonstration report (ENSR 2000), reviewed the applicant's NPDES permit, and considered public comments.

Section 316(a) of the CWA establishes a process by which a discharger can demonstrate that the established thermal discharge limitations are more stringent than necessary to protect balanced, indigenous populations of fish and wildlife and obtain facility-specific thermal discharge limits (33 USC 1326). The applicant has provided EPA with Section 316(a) demonstrations that address compliance with the thermal effluent limitations of the NPDES permit and environmental impacts of the thermal discharge. The NPDES permit (EPA 1994) states that "the thermal plumes from the station: (1) shall not deleteriously interfere with the natural movements, reproductive cycles, or migratory pathways of the indigenous populations within the water body segment; and (2) shall have minimal contact with the surrounding shorelines." In order to obtain information to assess compliance with these requirements, there has been an extensive program of monitoring of the coastal environmental near the PNPS site since the beginning of design/construction in the late 1960s (EG&G 1995).

A combined Section 316(a) and (b) demonstration report for PNPS was submitted to EPA Region 1 in 1975 and 1977 by the Boston Edison Company (Stone & Webster 1975, 1977), was accepted by EPA, and was used in determining facility-specific NPDES discharge temperature limits (Entergy 2006a). That initial Section 316 demonstration was based on engineering, hydrological, and ecological data from a 3-year pre-operational period (1969 to 1972) and a 5-year post-operational period (1972 to 1976). The report predicted that station operations would not result in long-term thermal impacts to the aquatic environment (ENSR 2000). Based on that report and ongoing ecological monitoring programs, EPA has issued and renewed the NPDES permit for PNPS for over 30 years and has determined that thermal discharges from PNPS are sufficiently protective of the aquatic community of Cape Cod Bay to satisfy alternative thermal effluent limitations under Section 316(a) of the CWA (ENSR 2000; Entergy 2006a).

In recent years, EPA Region 1 has required all NPDES permittees affected by Section 316 to submit new 316(a) and (b) demonstrations. A new 316 demonstration report for PNPS was prepared in 2000 (ENSR 2000), which updated the previous report based on approximately 25 years of additional engineering, hydrological, and biological data related to PNPS operations and conditions in the aquatic environment of western Cape Cod Bay. EPA Region 1 currently is reviewing an Entergy application for renewal of the NPDES permit for PNPS, including the newest combined 316 demonstration report (Entergy 2006a). In the interim, Entergy has continued biological monitoring. The Thermal Discharge Fish Surveillance Program involves periodic visual inspections of the discharge canal during times of fish migration in order to determine the presence of fish and their condition.

Previous investigations to characterize the extent of the thermal plume included studies that focused on collecting ambient temperature measurements and studies that used the measured temperature data to develop predictive models of temperature changes in the plume under a variety of operating and ambient conditions. These investigations have characterized the dimensions of the thermal plume and assessed biological impacts potentially associated with the plume. Two of the most detailed thermal investigations at PNPS were a 1974 study by the Massachusetts Institute of Technology, which focused on characterizing the plume based on surface water temperature measurements (ENSR 2000), and a 1994 study by EG&G (1995), which focused on bottom water temperature measurements to characterize the benthic thermal plume and validate mathematical models to predict bottom plume characteristics (ENSR 2000).

The 1974 study, which included one-day temperature surveys in July, August, and November 1973, found that the thermal plume is largest during high tide, and that during high tide the plume is detached from the bottom and is essentially confined to the surface layer. The depth of the plume was found to be relatively shallow, with depths ranging from 3 to 8 ft at high tide. The temperature difference (delta T) between ambient water and the thermal plume was found to cover a larger area when ambient temperatures were higher. For example, water with a delta T of 3°C (37.4°F) covered approximately 216 acres (ac) in August when the ambient temperature was 17.0°C (62.6°F), but only 14 ac in November when the ambient temperature was 8.5°C (47.3°F). The area of the plume also was found to decrease rapidly with increasing depth, as expected due to the buoyancy of the plume. Throughout the tidal cycle, the smallest surface areas with elevated temperatures occurred between low water slack tide and peak flood tide, and the largest areas occurred between high water slack tide and peak ebb tide (ENSR 2000).

The 1994 study (EG&G 1995) measured the bottom temperature patterns based on time series measurements at 59 locations in the immediate vicinity of the PNPS discharge. The results of this investigation were consistent with the 1974 study of the surface plume: the plume extended through the water column to the bottom during periods of low tide but was mainly confined to the surface layer during high tide. At the bottom, similar to the surface, the smallest temperature increment measured (1°C or 33.8°F) covered the largest area (up to 1.2 ac), and water with higher temperatures relative to ambient covered much smaller areas. For example, the highest delta T measured, 9°C (48.2°F), covered less than 0.13 ac of the bottom (ENSR 2000, EG&G 1995).

At low tide, the turbulent discharge plume is well mixed vertically as it leaves the canal, due in part to the significant downward momentum of the discharge as it spills from the mouth of the discharge canal. The plume remains in contact with the bottom at low tide for up to several hundred meters offshore. At the surface, the plume spreads by mixing with the ambient water, while at the bottom the core temperature of the plume drops and its width narrows with distance offshore. As a result, elevated temperatures are present at low tide over a limited area of the bottom near the discharge canal (EG&G 1995). At high tide, the discharge has a much lower velocity and no downward momentum. As a result, the thermal discharge plume separates from the bottom almost immediately upon leaving the discharge canal (EG&G 1995).

During the measurement period (26 to 29 August 1994) of the benthic thermal plume study, conditions were relatively calm, warm, and favorable for upwelling. Ambient bottom temperatures were relatively cold (16 to 17°C or 60.8 to 62.6°F), and the currents were weak and dominated by tidal fluctuations. Under these conditions, the areas of the sea floor in contact with elevated temperatures due to the heated discharge water were relatively small (EG&G 1995). The conclusions of the 1995 report (EG&G 1995) included the following:

- The discharge plume is in contact with the bottom of the bay for significant distances from shore only during the low tide half of the tidal cycle (i.e., when the tide is below mean sea level). Consequently, benthic organisms are exposed to alternating periods of ambient and elevated water temperatures.

- The maximum extent of the area of the bottom contacted by the plume and the highest temperatures occur at slack water around low tide.

- The plume begins to expand outward along the bottom about three hours before low tide, reaches 75 percent of its maximum area by about one hour before low tide, and declines rapidly to less than 50 percent of maximum area about one hour after low tide.

- The maximum offshore extent of the benthic thermal plume at low tide, based on the area of 1°C (34°F) temperature elevation, did not exceed 170 m (558 ft) from the mouth of the discharge canal, and its width did not exceed 40 m (131 ft) at a distance of 80 m (262 ft) offshore.

- The maximum bottom area covered by the 1°C (33.8°F) temperature elevation was about 1.2 ac, and higher temperatures were restricted to smaller areas. The smaller areas of higher temperatures approximately coincide with the areas with denuded or stunted benthic macroalgae (i.e., Irish moss).

- During high tide, there was no discernible temperature increase at any location, even within 50 m of the mouth of the discharge canal.

Because the benthic thermal plume study involved measurements taken over a short period of time and the temperatures and extent of the plume were strongly affected by ambient temperatures, the report (EG&G 1995) also considered the potential for more extreme thermal plume characteristics under worst case conditions. It concluded that extreme bottom temperatures and plume areas could result from a prolonged period of unusually warm weather, spring tide conditions in which the lowest water level can be nearly 1 m (3 ft) below mean water level (MLW), and conditions favorable for downwelling could be produced by warm winds from the north or northeast in summer. The combination of these conditions potentially could result in peak discharge temperatures in excess of 38°C (100.4°F). Given the uncertainty in the area measurements of the study, it was estimated that these conditions potentially could result in the thermal plume contacting the bottom over an area about four to seven times the area measured in the study (EG&G 1995).

An additional source of heated water discharge at PNPS is backwashing operations. Thermal backwashing is a commonly used method for control of biofouling in the condenser tubes and intake structures of power plants. Condenser tubes at PNPS are cleaned by backwashing on a 1- to 2-week interval, depending on the degree of biofouling. Because the plant electrical generation must be reduced during backwashing, the procedure usually is conducted during off-peak hours. The method involves reversing the flow of heated water so that organisms fouling the condenser tubes and intake structure are killed by the elevated temperatures. The process results in the flow of heated water out of the intake structure and into the intake embayment. The thermal backwashing process generally occurs for approximately 45 to 60 minutes and produces elevated water temperatures averaging approximately 37.8°C (100°F). A thermal survey to determine the effects of backwashing operations at PNPS found that the procedure caused a relatively thin thermal plume, averaging 3 to 5 ft in depth, that spread rapidly from the intake structure across the western end of the intake embayment and along the outer breakwater. The plume completely dissipated within a few hours (Normandeau 1977).

The biological impacts of the PNPS thermal discharge have been evaluated by several monitoring programs encompassing both pre-operational and post-operational periods. These programs have included fish, benthic invertebrates, and benthic microalgae monitoring. Fish monitoring programs have included methods such as bottom trawling to sample demersal fish populations inhabiting inshore bottom waters, haul seining to sample inshore fish populations, and gill netting to sample pelagic fish inhabiting the water column of the bay. In complex habitat areas unsuitable for survey with sampling equipment, visual transects were surveyed by divers in order to assess habitat-seeking fish species such as the tautog and cunner. Recreational creel surveys were used to assess the sport fishery in the vicinity of PNPS (ENSR 2000).

Heat shock to fish may occur when the water temperature meets or exceeds the thermal tolerance of fish species; duration of exposure to high water temperature is also a factor contributing to heat shock. Fish thermoregulate behaviorally by avoiding extreme temperatures and seeking optimal temperatures (Beyers and Rice 2002). Therefore, fish in the bay typically can avoid adverse effects from the thermal plume. The fish monitoring results indicate that the thermal plume excludes several fish species from a relatively small area of habitat near the discharge. However, fish mortality resulting from the thermal plume has been rare. Of the notable fish mortality incidents recorded since PNPS began operation, only two were considered to have been caused by thermal stress (heat shock) from exposure to high temperatures in the plume. Approximately 3000 Atlantic menhaden were killed in August 1975, and 2300 clupeids (schooling fish such as menhaden, sardines, and shad) died in August 1978. Such incidents have not been observed since 1978, confirming the rarity of fish mortality from heat shock at PNPS. In addition, finfish surveys conducted as part of the Thermal Discharge Fish Surveillance Program, provided no evidence of adverse impacts on populations resulting from the thermal plume. The area of the plume does not provide unique habitat, and adequate habitat exists in the vicinity in Cape Cod Bay for fish displaced from the area of the plume (ENSR 2000).

The benthic monitoring programs, which include several studies that have been performed in the vicinity of PNPS since 1973, have focused on invertebrates and macroalgae, particularly the Irish moss and the American lobster. Although benthic invertebrates and macroalgae are less mobile than fish and many are sessile, the relatively small bottom area in contact with the thermal plume at low tide minimizes the potential effects on populations. The episodes of high bottom temperatures during low tide are likely to be partially responsible for the observed effects on benthic organisms in the area near the discharge. The high velocity of the discharge at low tide, which is strong enough to scour the bottom in the area near the discharge, also is likely to affect the biota. At high tide, the plume has essentially no effect on benthic biota because the heated discharge water does not displace the denser, colder, ambient water that remains near the bottom (EG&G 1995). The results of the monitoring programs indicate that the thermal plume has had relatively insignificant impacts on benthic species in the vicinity of PNPS.

Visual observations of bottom transects conducted periodically from 1973 to 1998 to assess Irish moss abundance and density found that the plume does not impact Irish moss coverage, except in small areas (ENSR 2000). Scouring due to water currents has been hypothesized to cause greater stress to algal colonization than the elevated temperatures of the thermal plume. The observed denuded areas were attributed to scouring of the substrate, while areas where growth of Irish moss was stunted or sparse were attributed to elevated temperatures (ENSR 2000). A multi-year (1981 to 1998) benthic assessment confirmed that the impacts on Irish moss in the area of the thermal plume were minimal due to the relatively small area affected (ENSR 2000). Impacts on other submerged aquatic vegetation, such as eelgrass (*Zostera marina*), are expected to be smaller than those on Irish moss because there are no known areas in the immediate vicinity of PNPS covered by submerged aquatic vegetation other than Irish moss.

Lobster populations were surveyed using research and commercial trap catch data through 1993. The data did not indicate measurable impacts from the thermal plume or the current created by the effluent, and the program was discontinued. Based on the bottom temperature study results (EG&G 1995) and the thermal tolerance threshold (30.5°C or 86.9°F) of the American lobster, it has been estimated that the loss of bottom habitat for the lobster during periods of highest ambient water temperature (late summer to early fall) would be less than about 0.12 ac.

The staff has reviewed the available information, including that provided by the applicant, the staff's site visit, the Commonwealth, the 316(a) demonstration, public comments received, and other public sources. The staff evaluated the potential impacts to aquatic resources due to heat shock during continued operation during the renewal period. The staff concluded that the potential impacts to marine resources due to heat shock during the renewal term would be SMALL.

During the course of the SEIS preparation, the staff identified potential mitigation measures (as described in Section 4) for the continued operation of PNPS during the license renewal period. However, the NRC staff concluded that none of the mitigation measures considered would be beneficial enough to reduce the significance of heat shock impacts to northwestern Cape Cod Bay.

4.1.4 Potential Mitigation Measures

The staff has identified a variety of measures that could mitigate potential impacts resulting from continued operation of the PNPS cooling water system.(b) These could include:

- Automated chlorine monitoring
- Behavioral barriers
- Diversion devices
- Alternative intake systems
- Alternative intake screen systems
- Closed-cycle systems
- Variable-speed pumps
- Cooling water flow adjustments
- Scheduled outages
- Movement of fish return
- Habitat restoration
- Fish stocking

The NRC staff has not conducted an analysis of each of these measures relative to their applicability to PNPS. This discussion is meant to provide only a brief overview of these

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(b) It should be noted that the NRC cannot impose mitigation requirements on the applicant. The Atomic Safety and Licensing Appeal Board, in the “Yellow Creek” case determined that EPA has sole jurisdiction over the regulation of water quality with respect to the withdrawal and discharge of waters for nuclear power stations, and that the NRC is prohibited from placing any restrictions or requirements upon the licensees of those facilities with regards to water quality (Tennessee Valley Authority [Yellow Creek Nuclear Plant, Units 1 and 2], ALAB-515, 8 NRC 702, 712-13 [1978]).

technologies. ENSR (2000) conducted an analysis of several of these technologies in the 316(b) demonstration report as required by Section 316 of the Clean Water Act. It is expected that a more thorough analysis of the costs and benefits of these technologies would be included as part of the 316(b) CDS currently being conducted by PNPS in support of the NPDES permit renewal. Additionally, EPA's evaluation of the PNPS NPDES permit renewal application would likely address any applicable site-specific mitigation measures that may reduce entrainment and impingement impacts. It should be noted that EPA's Phase II Rule should be considered suspended and compliance with the rule is based on EPA's best professional judgment (EPA 2007).

An automated chlorine monitoring system would allow for continuous monitoring of chlorine levels in the service water and/or condenser cooling water systems. This system could also include a warning system to alert the PNPS operator whenever equipment malfunctions or when chlorine concentrations deviate from preset limits.

Behavioral barriers are designed to cause fish to actively avoid entry into an area. These may include sound, light, or air bubbles (Clay 1995). Sound barriers, which would be located at an intake structure, would include low-frequency, infra-wave sound; pneumatic or mechanically generated low-frequency sounds; or transducer-generated sound. Light barriers may emit either a constant or strobe-type beam of light. Air bubble curtains produce a continuous, dense chain of bubbles. These barrier types may deter some species of fish from entering the intake structure. ENSR (2000) determined that, of the behavioral barriers evaluated, light barriers would be the most effective. According to ENSR (2000), several studies have shown that some fish species are repelled by light while others are attracted to light and can be guided away from areas to be avoided. Therefore, additional analysis of the potential effectiveness of light barriers in altering the behavior of the fish species of principal concern at PNPS would be needed. In addition, this technology is still considered to be experimental in nature and would be effective only on species and/or life stages that can actively respond to a stimulus (i.e., not fish eggs, early larval life stages, or other planktonic organisms).

Diversion devices, the most commonly used barriers, are physical structures, such as louvers, barrier nets, or chains and cables, that are designed to guide fish away from a certain area, such as the intake (Clay 1995). Louvers consist of a series of evenly spaced vertical slats that create localized turbulence that fish can detect and actively avoid. Louvers typically have a smaller spacing between the slats or bars than a standard trash rack. Barrier nets are simply nets placed across an intake channel to prevent fish from access to an intake structure. The design of a barrier net system has to finely balance the mesh size with the intake requirements.(c) Chains or cables may be vertically hung in an intake structure to form a physical and visible barrier to fish. However, similar to barrier nets, they may alter hydraulic flow patterns in an intake (ENSR 2000). These types of structures also only affect those organisms that can actively respond and would not impact entrainment or impingement of fish eggs, larvae, or other planktonic organisms. Implementation of a biological surveillance program potentially could increase the effectiveness of barrier nets or other diversion devices. Such a program might identify the presence of large numbers of fish susceptible to being attracted to the thermal plume and discharge canal in time to allow the deployment of the most effective devices.

Another type of mitigation measure may be an alternative intake system. An alternate surface water intake system could include an offshore intake structure with a velocity cap. Vertical placement of the offshore intake within the water column would be a major factor in impingement and entrainment reduction. For example, ENSR (2000) conducted an evaluation of this type of structure and determined that it would result in lower fish impingement but an increased entrainment rate, especially for winter flounder as later stages of winter flounder larvae (stages 3 and 4) tend to settle on the bottom substrate. The Seabrook Nuclear Power Station utilizes a similar structure; however, the intake structure opening is at mid-depth. Based on analysis by Salia et al. (1997), the losses due to entrainment at this facility are less than the losses observed at other facilities. Groundwater could also be potentially used as a cooling water source. According to EPA Region 1, the Keyspan North Point Station is currently conducting a pilot study to evaluate the feasibility of using offshore groundwater extraction as a cooling water source (Earth Tech 2006a).

Alternative intake screen systems may include Ristroph traveling screens, wedgewire screens, and/or fine-mesh screens. Ristroph screens are traveling screens fitted with fish buckets that collect fish and lift them out of the water where they are gently sluiced away prior to debris removal with a high-pressure spray. They have been approved as the best technology available in several states (Siemens 2006). Recent studies have shown survival of species exceeding 95 percent when using the Ristroph screen (EPRI 2006). Wedgewire screens are constructed of wire of triangular cross sections so that the surface of the screen is smooth while the screen openings widen inwards (ENSR 2000). This type of screen has been widely used for hydropower diversion structures and has been shown to essentially eliminate impingement and reduce larval entrainment (ENSR 2000). Fine-mesh screens are simply wire screens with the mesh sized to minimize the ichthyoplankton entrainment. As reported in ENSR (2000), fine-

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(c) EPA has suggested the Gunderboom fabric barrier as a potential mitigation measure. However, NRC staff does not consider it as a viable option because it could present safety issues at intakes of nuclear power plants.

mesh screens have not been proven effective at reducing winter flounder larvae entrainment losses. However, as with any screen, smaller mesh could result in more clogging and fouling problems.

Closed-cycle systems recycling cooling water in a closed piping system and utilize evaporative cooling (such as is in a cooling tower or pond) as a means of dissipating the heat from the condensers. Cooling towers could include wet, hybrid, or dry towers. Wet and hybrid cooling towers would still require withdrawal of water from the bay to make up for water losses due to blowdown and evaporation. However, the water withdrawal rate would be significantly lower than the current once-through cooling system. A dry cooling tower utilizes ambient air to dissipate heat, essentially acting as an automobile radiator (ENSR 2000). No make-up water is required for this type of system as the steam is condensed in a closed cycle. However, this results in lower plant efficiency, thus requiring more fuel to produce the same amount of electricity (ENSR 2000).

Adjustments to the flow of cooling water through the plant is another type of mitigation strategy that may be applicable to PNPS. This could include the use of variable speed pumps, cooling water bypass flow, or rotating the existing screens more often or continuously. Variable-speed pumps would reduce the intake flow during periods of peak entrainment or impingement. These have been shown to be effective at reducing impingement and entrainment, but by reducing the amount of cooling water moving through the system, power generating efficiency may decrease, and the thermal plume may increase in size (ENSR 2000). Cooling water bypass flow would reduce the cooling water flow rate through the condensers and add a corresponding amount of bypass flow into the discharge canal (ENSR 2000). This alternative assumes that mortality in the discharge canal would be less than the condensers. It may reduce entrainment but not impingement (ENSR 2000).

A mitigation strategy related to the cooling system would be to rotate the existing screens more often or on a continual basis. This would increase the survival of impinged organisms and may reduce impingement rates for some species, but it would have little impact on the impingement rate or entrainment.

Another potential mitigation strategy may be to schedule outages for performing regular inspection, maintenance, and refueling during the peak spawning seasons of specific fish species such as the winter flounder, Atlantic menhaden, or rainbow smelt.

Movement of the fish-return sluiceway discharge point may also provide some mitigation benefits as impinged fish are currently returned to the intake embayment where potentially stunned, disoriented, or injured fish may not be able to actively avoid reentering the intake structure.

Habitat restoration and fish stocking are also potential mitigation strategies for some species. However, these are compensatory measures as opposed to preventive measures, which are the preferred mitigation strategies of Federal and State resource agencies. Several studies have been funded by the applicant over the last few years to evaluate these options. A monitoring program has been conducted by the applicant to assess the feasibility of improving the local winter flounder stock by releasing young-of-the-year flounder into the Plymouth area. No genetic studies have been conducted to determine if released hatchery fish breed with the wild stock. Up to 25,000 fish, ranging from 26 to 34 mm (1 to 1.3 in.) in length have been released into Plymouth Harbor on an annual basis since 2001. Post-release sampling has indicated that the released fish do survive and grow well when released earlier in the season (MRI 2006). The NRC staff has not found evidence indicating that this pilot program has substantially offset impacts from continued operation of PNPS to the local winter flounder population. If expanded, this stocking program may have a beneficial impact on the local winter flounder population.

The applicant also provided funding to the MDMF for a limited stocking of rainbow smelt eggs and habitat enhancement in the Jones River as a means to enhance production of rainbow smelt in this critical spawning ground (Lawton and Boardman 1999b). Stocking of young-of-the-year fish or eggs may be a proven mitigation strategy; however, both the EPA and MDMF have stated that re-stocking is not a preferred mitigation measure (Earth Tech 2006a).

4.2 Transmission Lines

The two transmission lines that connect PNPS with the transmission system share a single transmission line right-of-way (ROW) (Figure 2-6). For the purpose of this review, the transmission line ROW, which extends from the PNPS switchyard to the Snake Hill Road substation, has a length of approximately 7.2 mi and occupies approximately 260 ac. Ongoing surveillance and maintenance of PNPS transmission lines and ROW ensure continued conformance to transmission line design standards. NSTAR Gas and Electric Corporation's (NSTAR's) Vegetation Management Plan (NSTAR 2006) integrates the selective use of herbicides approved in Massachusetts for use in sensitive areas with the use of mechanical methods (i.e., selective removal of targeted vegetation by hand cutting or mowing) and biological methods (i.e., encouraging development of stable communities of low-growing plants) to restore and maintain habitat and control invasive species in the transmission line ROW. The transmission line ROW maintenance practices employed by NSTAR, which comply with all State and Federal regulations, encourage the development of stable communities of low-growing native plants that provide wildlife habitat and support biodiversity while controlling tall-growing trees and undesirable shrub species that would interfere with the operation of the transmission lines. In addition, NSTAR follows a program developed in coordination with and approved by the Natural Heritage and Endangered Species Program (NHESP) to protect rare species (i.e., turtles) and priority habitats that may be present in the transmission line ROW

(NSTAR 2006).

Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, that are applicable to transmission lines from PNPS are listed in Table 4-7. Entergy stated in its ER that it is not aware of any new and significant information associated with the renewal of the PNPS OL. The NRC staff has not identified any new and significant information during its independent review of the Entergy ER, the site visit, the scoping process, or evaluation of other available information. Therefore, the staff concludes that there would be no impacts related to these issues beyond those discussed in the GEIS. For all of those issues, the staff concluded in the GEIS that the impacts would be SMALL, and additional facility-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

Table 4-7. Category 1 Issues Applicable to the PNPS Transmission Lines During the Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections
TERRESTRIAL RESOURCES	
Power line right-of-way management (cutting and herbicide application)	4.5.6.1
Bird collisions with power lines	4.5.6.2
Impacts of electromagnetic fields on flora and fauna (plants, agricultural crops, honeybees, wildlife, livestock)	4.5.6.3
Floodplains and wetland on power line right-of-way	4.5.7
AIR QUALITY	
Air quality effects of transmission lines	4.5.2
LAND USE	
On-site land use	3.2
Power line right-of-way	4.5.3

A brief description of the staff's review and GEIS conclusions, as codified in Table B-1, for each of these issues follows:

- <u>Power line right-of-way management (cutting and herbicide application)</u>. Based on information in the GEIS, the Commission found that:

> The impacts of right-of-way maintenance on wildlife are expected to be of small significance at all sites.

The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, consultation with the U.S. Fish and Wildlife Service (FWS) and the Massachusetts Division of Fisheries and Wildlife (MDFW), evaluation of other information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of power line right-of-way maintenance on wildlife during the renewal term beyond those discussed in the GEIS.

- <u>Bird collisions with power lines</u>. Based on information in the GEIS, the Commission found that:

> Impacts are expected to be of small significance at all sites.

The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, consultation with the FWS and MDFW, evaluation of other information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of bird collisions with power lines during the renewal term beyond those discussed in the GEIS.

- <u>Impacts of electromagnetic fields on flora and fauna (plants, agricultural crops, honeybees, wildlife, livestock)</u>. Based on information in the GEIS, the Commission found that:

> No significant impacts of electromagnetic fields on terrestrial flora and fauna have been identified. Such effects are not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of electromagnetic fields on flora and fauna during the renewal term beyond those discussed in the GEIS.

- <u>Floodplains and wetlands on power line right of way</u>. Based on information in the GEIS, the Commission found that:

> Periodic vegetation control is necessary in forested wetlands underneath power lines and can be achieved with minimal damage to the wetland. No significant impact is expected at any nuclear power plant during the license renewal term.

The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, consultation with the FWS and MDFW, evaluation of other information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of power line ROW maintenance on floodplains and wetlands during the renewal term beyond those discussed in the GEIS.

- <u>Air quality effects of transmission lines</u>. Based on the information in the GEIS, the Commission found that:

> Production of ozone and oxides of nitrogen is insignificant and does not contribute measurably to ambient levels of these gases.

The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other information, or consideration of public comments. Therefore, the staff concludes that there would be no air quality impacts of transmission lines during the renewal term beyond those discussed in the GEIS.

- <u>On-site land use</u>. Based on the information in the GEIS, the Commission found that:

> Projected on-site land use changes required during … the renewal period would be a small fraction of any nuclear power plant site and would involve land that is controlled by the applicant.

The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other information, or consideration of public comments. Therefore, the staff concludes that there would be no on-site land use impacts during the renewal term beyond those discussed in the GEIS.

- <u>Power line right of way</u>. Based on information in the GEIS, the Commission found that:

> Ongoing use of power line ROWs would continue with no change in restrictions. The effects of these restrictions are of small significance.

The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of power line ROWs on land use during the renewal term beyond those discussed in the GEIS.

There is one Category 2 issue related to transmission lines. An additional issue related to transmission lines (chronic effects) was left uncategorized in the GEIS (NRC 1996) and is being treated as a Category 2 issue in this SEIS. These issues are listed in Table 4-8 and are discussed in Sections 4.2.1 and 4.2.2.

Table 4-8. Category 2 and Uncategorized Issues Applicable to the PNPS Transmission Lines During the Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections	10 CFR 51.53(c)(3)(ii) Subparagraph	SEIS Section
HUMAN HEALTH			
Electromagnetic fields, acute effects (electric shock)	4.5.4.1	H	4.2.1
Electromagnetic fields, chronic effects	4.5.4.2	NA	4.2.2

4.2.1 Electromagnetic Fields-Acute Effects

Based on the GEIS, the Commission 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.

In the GEIS (NRC 1996), the staff found that without a review of the conformance of each nuclear plant transmission line with National Electrical Safety Code (NESC 1997) criteria, it was not possible to determine the significance of the electric shock potential. 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 potential shock hazard 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 PNPS transmission lines were constructed to the NESC specifications and industry guidance in effect at the time the lines were constructed. PNPS transmission facilities and ROW, which are owned and operated by NSTAR, are maintained to ensure continued compliance with the standards and guidance in effect when they were constructed. In 1977, after the lines were constructed, a new criterion was added to the NESC that established minimum vertical clearances to the ground for power lines with voltages exceeding 98 kilovolts (kV). This criterion states that the clearance must limit the steady-state induced current to 5 milliamperes (mA) if the largest anticipated truck, vehicle, or equipment were short-circuited to the ground.

The PNPS is connected to the electric grid via two 345-kV lines. As part of their license renewal application, Entergy (2006a) reviewed these transmission lines for compliance with the 1977 NESC criterion. Because the two lines share the same towers, Entergy performed an analysis on a limiting case in which both lines operated together and, as a conservative assumption, were located at the minimum clearance distance (28 ft) allowed by the Commonwealth of Massachusetts for 345-kV lines. All spans on the lines exceed this minimum clearance distance, and NSTAR conducts surveillance and maintenance activities to ensure that the ground clearances do not change (Entergy 2006a).

The electric field strength beneath these lines was calculated by NSTAR using the Electric Power Research Institute (EPRI) code, ENVIRO (NSTAR 2001, in Entergy 2006a). Entergy used methods described in EPRI's Transmission Line Reference Book (EPRI 1982, in Entergy 2006a) to calculate the induced current based on the distribution of the electric field strength. The analysis assumed a vehicle of the maximum size allowed by the Commonwealth of Massachusetts, which is a tractor-trailer 60 ft long, 8 ft wide, and 13.5 ft high. This analysis determined that the combined effect of the two lines would result in a maximum induced current of 4.5 mA, below the NESC 5-mA criterion. Therefore, the transmission lines comply with the NESC provisions for preventing electric shock from induced current (Entergy 2006a).

The staff has reviewed the available information, including the applicant's evaluation and computational results, the site visit, the scoping process, and other public sources including public comments received. Based on this information, the staff evaluated the potential impacts of electric shock resulting from operation of PNPS and its associated transmission lines. It is the staff's conclusion that the potential impacts of electric shock during the renewal term would be SMALL, and no additional mitigation would be warranted.

4.2.2 Electromagnetic Fields-Chronic Effects

In the GEIS, the chronic effects of 60 hertz 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 for chronic effects from these fields continues to be studied and is not known at this time. The National Institute of Environmental Health Sciences (NIEHS) directs related research through the U.S. Department of Energy (DOE). The 1999 report of the NIEHS and DOE Working Group (Portier and Wolfe 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 a 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 staff to change its position with respect to the chronic effects of electromagnetic fields. The staff considers the GEIS finding of "not applicable" still appropriate and continues to follow developments on this issue.

4.3 Radiological Impacts of Normal Operations

Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, that are applicable to PNPS in regard to radiological impacts are listed in Table 4-9. Entergy stated in its ER (Entergy 2006a) that it has not identified any new and significant information concerning impacts related to these issues with respect to the renewal of the PNPS operating license. The staff did not identify any additional new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there are no impacts related to these issues beyond those discussed in the GEIS. For these issues, the staff concluded in the GEIS that the impacts are SMALL, and additional plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

Table 4-9. Category 1 Issues Applicable to Radiological Impacts of Normal Operations During the Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections
HUMAN HEALTH	
Radiation exposures to public (license renewal term)	4.6.2
Occupational radiation exposures (license renewal term)	4.6.3

A brief description of the staff's review and the GEIS conclusions, as codified in Table B-1, for each of these issues follows:

- Radiation exposures to public (license renewal term). Based on information in the GEIS, the Commission found that:

  > Radiation doses to the public will continue at current levels associated with normal operations.

  The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of radiation exposures to the public during the renewal term beyond those discussed in the GEIS. However, the staff did receive a number of comments on this issue during the scoping process. The staff's evaluation of this information is presented in Section 4.7.

- Occupational radiation exposures (license renewal term). Based on information in the GEIS, the Commission found that:

  > Projected maximum occupational doses during the license renewal term are within the range of doses experienced during normal operations and normal maintenance outages, and would be below regulatory limits.

  The staff has not identified any new and significant information during its independent review of the PNPS ER, the staff's site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of occupational radiation exposures during the renewal term beyond those discussed in the GEIS.

There are no Category 2 issues related to radiological impacts of routine operations.

4.4 Socioeconomic Impacts of Plant Operations During the

License Renewal Period

Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B-1 that are applicable to socioeconomic impacts during the renewal term are listed in Table 4-10. Entergy stated in its ER (Entergy 2006a) that it is not aware of any new and significant information associated with the renewal of the PNPS operating license. The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts related to these issues beyond those discussed in the GEIS (NRC 1996). For these issues, the staff concluded in the GEIS that the impacts are SMALL, and additional plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

Table 4-10. Category 1 Issues Applicable to Socioeconomics During the Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections
SOCIOECONOMICS	
Public services: public safety, social services, and tourism and recreation	4.7.3; 4.7.3.3; 4.7.3.4; 4.7.3.6
Public services: education (license renewal term)	4.7.3.1
Aesthetic impacts (license renewal term)	4.7.6
Aesthetic impacts of transmission lines (license renewal term)	4.5.8

A brief description of the staff's review and the GEIS conclusions, as codified in Table B-1, for each of these issues follows:

- <u>Public services: public safety, social services, and tourism and recreation</u>. Based on information in the GEIS, the Commission found that:

  > Impacts to public safety, social services, and tourism and recreation are expected to be of small significance at all sites.

  The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts on public safety, social services, and tourism and recreation during the renewal termbeyond those discussed in the GEIS.

- Public services: education (license renewal term). Based on information in the GEIS, the Commission found that:

  > Only impacts of small significance are expected.

  The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts on education during the renewal term beyond those discussed in the GEIS.

- Aesthetic impacts (license renewal term). Based on information in the GEIS, the Commission found that:

  > No significant impacts are expected during the license renewal term.

  The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no aesthetic impacts during the renewal term beyond those discussed in the GEIS.

- Aesthetic impacts of transmission lines (license renewal term). Based on information in the GEIS, the Commission found that:

  > No significant impacts are expected during the license renewal term.

  The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no aesthetic impacts of transmission lines during the renewal term beyond those discussed in the GEIS.

Table 4-11 lists the five Category 2 socioeconomic issues which require plant-specific analysis, as well as environmental justice, which was not addressed in the GEIS.

Table 4-11. Environmental Justice and GEIS Category 2 Issues Applicable to Socioeconomics During the Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections	10 CFR 51.53(c)(3)(ii) Subparagraph	SEIS Section
	SOCIOECONOMICS		
Housing impacts	4.7.1	I	4.4.1
Public services: public utilities	4.7.3.5	I	4.4.2
Off-site land use (license renewal term)	4.7.4	I	4.4.3
Public Services, transportation	4.7.3.2	J	4.4.4
Historic and archaeological resources	4.7.7	K	4.4.5
Environmental Justice	Not addressed[a]	Not addressed[a]	4.4.6

(a) Guidance related to environmental justice was not in place at the time the GEIS and the associated revision to 10 CFR Part 51 were prepared. Therefore, environmental justice must be addressed in the staff's supplemental environmental impact statement (NRC 2004b)

4.4.1 Housing Impacts During Operations

10 CFR Part 51, Subpart A, Appendix B, Table B-1 states that impacts on housing availability are expected to be of small significance at plants located in a high-population area where growth-control measures are not in effect. The PNPS site is located in a high-population area and Plymouth County is not subject to growth-control measures that would limit housing development. Based on the NRC criteria, Entergy expects housing impacts to be SMALL during continued operations (Entergy 2006a).

Small impacts result when no discernible change in housing availability occurs, changes in rental rates and housing values are similar to those occurring statewide, and no housing construction or conversion is required to meet new demand (NRC 1996). The GEIS assumes that an additional staff of 60 permanent per unit workers might be needed during the license renewal period to perform routine maintenance and other activities. Entergy plans no increase in employment during the license renewal term.

Section 2.2.8.1 discusses housing conditions in the region and notes the locations of residences for the approximately 700 employees of PNPS. Plymouth and Barnstable counties experienced substantial growth in housing units over the period of 1990 to 2000. Plymouth's number of occupied housing units increased by 12.6 percent and Barnstable by 22.2 percent over the decade. Section 2.2.8.5 stated the growth rate of Plymouth and Barnstable counties to be 8.6 percent and 19.0 percent, respectively, from 1990 to 2000. Both of these counties' growth rates are higher than Massachusetts' rate as a whole (5.5 percent). Projected population data indicates these rates will continue in these counties in the future.

The staff reviewed the available information relative to housing impacts and PNPS ER. Based on this review, the staff concludes that the impact on housing during the license renewal period would be SMALL, and additional mitigation is not warranted.

4.4.2 Public Services: Public Utility Impacts During Operations

Impacts on public utility services are considered SMALL if there is little or no change in the ability of the system to respond to the level of demand, and thus there is no need to add capital facilities. Impacts are considered MODERATE if overtaxing of service capabilities occurs during periods of peak demand. Impacts are considered LARGE if existing levels of service (e.g., water or sewer services) are substantially degraded and additional capacity is needed to meet ongoing demands for services. The GEIS indicates that, in the absence of new and significant information to the contrary, the only impacts on public utilities that could be significant are impacts on public water supplies (NRC 1996).

Analysis of impacts on the public water supply system considered both facility demand and facility-related population growth. PNPS purchases water from the Town of Plymouth Water Division. This water is used as potable water and reactor make-up water at the facility. As described in Section 2.2.2, PNPS estimated annual consumption of water obtained from the Town of Plymouth public water supply system to be 39.1 million gallons per year for a non-outage year. This usage represents approximately 2.3 percent of the town's total yearly consumption. No refurbishment or new construction activities are associated with the PNPS license renewal and PNPS water usage is not expected to change during the license renewal term. Therefore, the impact on the local water supply would not be expected to change. Entergy plans no increase in employment at PNPS during the license renewal term (Entergy 2006a). Therefore, facility-related population growth is not expected, and there would be no significant impact on the region's water supplies.

The Plymouth-Carver aquifer, which is the source of potable water for the Town of Plymouth public water supply system, has sufficient water for existing and projected demand. The town has measures in effect to limit development in order to prevent excess water withdrawal (Town of Plymouth 2006).

The staff has reviewed the available information, including actual water use records for PNPS and water use and water supply capacities for the major public water supply systems in the region. Based on this information, the staff concludes that the potential impacts of PNPS during the license renewal period on public water supplies are SMALL and that no additional mitigation measures are warranted.

4.4.3 Off-site Land Use During Operations

Off-site land use during the license renewal term is a Category 2 issue. Table B-1 of 10 CFR 51 Subpart A, Appendix B 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 follows:

> SMALL - Little new development and minimal changes to an area's land-use pattern.
>
> MODERATE - Considerable new development and some changes to the land-use pattern.
>
> LARGE - Large-scale new development and major changes in the land-use pattern.

The Town of Plymouth Conservation Commission has expressed concern that the breakwaters associated with the PNPS intake and discharge structures may have contributed to erosion of the shoreline in the Priscilla Beach community, located southeast of the facility along Cape Cod Bay, resulting in a cobble rather than sand beach(d). The Massachusetts Office of Coastal Zone Management's Shoreline Change Project provides data on changes in the location of the state's shoreline over time (MOCZM 2006). The Shoreline Change Project presents long and short-term shoreline change rates at 40 m (131 ft) intervals along the Massachusetts coast, classifying change in the location of the shoreline as either negative (erosion) or positive (accretion). The shoreline change data were derived from analyses of historical maps and aerial photographs spanning the time period from the mid-1800s to 1994. The staff examined shoreline change data from 32 transects covering the shoreline from the southern breakwater at PNPS southeast to the Priscilla Beach/White Horse Rocks area, for a total of 4200 ft. For the first time period studied, 1866 to 1951, most of this segment of shoreline experienced accretion (gain). The second time period, 1951 to 1978, saw erosion (loss) over many segments of this shoreline, with the greatest rate of erosion occurring in the portion farthest away from (southeast of) PNPS. Some segments experienced accretion. During the third time period studied, 1987 to 1994, more segments experienced erosion than accretion but not in any particular pattern or trend (i.e., some areas that experienced erosion in the second period experienced accretion during the third period and for others the opposite occurred). The segments with the greatest erosion rates during the second period (i.e., those farthest away from PNPS) experienced accretion or a slower rate of erosion during the third time period. Based on the review of this data, no detectable trend of erosion associated with the PNPS facility was observed.

(d) Interview with Town of Plymouth officials on May 2, 2006.

Tax revenue can affect land use because it enables local jurisdictions to be able 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 (1) the size of the plant's payments relative to the community's total revenues, (2) the nature of the community's existing land-use pattern, and (3) 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 adequate 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 jurisdictions revenue, the significance level would be small. If the plant's tax payments are projected to be medium to large relative to the community's total revenue, new tax-driven land-use changes would be moderate. If the plant’s tax payments are projected to be a dominant source 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.

PNPS pays annual property taxes to the Town of Plymouth. As discussed in Section 2.2.8.6, property taxes paid to the Town of Plymouth for PNPS have declined since 1998 when the Commonwealth of Massachusetts deregulated its utility industry, and in 1999 when Boston Edison Company sold PNPS to Entergy Corporation for significantly less than the assessed value. Subsequent to the State's deregulation law and Entergy's purchase of PNPS, the Town of Plymouth and Entergy agreed to payments in lieu of taxes of $1 million annually with the potential for payments to increase should Entergy make capital improvements or substantial additions to the facility. The agreement continues through 2012. It would be renegotiated in the event of license renewal (Entergy 2006a). However, in April 2007, the Town of Plymouth reached a new five-year PILOT agreement with Entergy that increases Entergy’s annual payment to an estimated $8.49 million in FY2008 (Town of Plymouth 2007). The payments decline thereafter, reaching an estimated $6.79 million in FY 2012. The agreement includes a reopener provision in the event that PNPS’ current license is renewed. In addition, the Massachusetts legislature has required the owners and operators of the transmission lines (NSTAR) to make payments to the Town of Plymouth until the end of the current PNPS license in 2012. NSTAR payments will decline from $12 million in 2006 to $1 million in 2007, and continue annually at that amount through 2012. Until 1999, PNPS property taxes provided approximately 22 percent of the Town of Plymouth's total property tax revenues or about 17 percent of the town’s total revenues. In FY2007, Entergy and NSTAR PILOT payments associated with PNPS represent only about 1.5 percent of the total property revenues received by the Town of Plymouth. In FY2008, under the new PILOT agreement with Entergy, the PNPS payments are expected to represent about 6 percent of the town’s total revenues.

No refurbishment or new construction activities are associated with the PNPS license renewal. Therefore, the Entergy FY2012 estimated PILOT payment of $6.79 million per year to the Town of Plymouth would not be expected to increase substantially (e.g., enough to raise it to 10 percent of the town's total revenues) as a result of the renegotiation that would occur at license renewal. Based on this analysis, tax payments for PNPS are expected to remain at less than 10 percent of the Town of Plymouth's total revenues over the license renewal term. Therefore, the staff concludes that the tax-related land use impacts would remain SMALL.

4.4.4 Public Services: Transportation Impacts During Operations

Table B-1, 10 CFR Part 51 states: "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." All applicants are required by 10 CFR 51.53(c)(3)(ii)(J) to assess the impacts of highway traffic generated by the proposed project on the level of service of local highways during the term of the renewed license.

Section 2.2.8.1 addressed existing transportation conditions in the vicinity of PNPS and found no serious substandard conditions in the highway network. The possible exception is Rocky Hill Road, which suffers from some safety issues associated with limited sight distances, tight curves, and no shoulders. The recent Old Colony Planning Council study of this highway makes specific recommendations for the town to improve safety on this local roadway (OCPC 2006). The study did not cite PNPS as contributing to these problems. Currently, PNPS truck traffic is directed to use Power House Road to access the plant. With no increase in personnel anticipated during the relicensing period, any changes in future transportation conditions in the area would not be attributable to PNPS.

The staff has reviewed the available information on traffic and transportation conditions and the potential effects of relicensing. Based on this information, the staff concludes that the potential impacts of relicensing on transportation are SMALL and no additional mitigation is needed.

4.4.5 Historic and Archaeological Resources

The National Historic Preservation Act (NHPA) requires that Federal agencies take into account the effects of their undertakings on historic properties. The historic preservation review process mandated by Section 106 of the NHPA is outlined in regulations issued by the Advisory Council on Historic Preservation at 36 CFR Part 800. Renewal of an operating license is an undertaking that could potentially affect historic properties. Therefore, according to the NHPA, the NRC is to make a reasonable effort to identify historic properties in the areas of potential effects. If no historic properties are present or affected, the NRC is required to notify the State

Historic Preservation Officer 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.

4.4.5.1 Site Specific Cultural Resources Information

A review of the Massachusetts Historical Commission (MHC) files shows that there are no National Register eligible or listed archaeological or historic above ground resources identified on the PNPS site. As noted in Section 2.2.9.2, an archaeological survey of a 517-ac portion of the PNPS site, including the area where the station and the transmission line were constructed, identified 25 archaeological sites (24 historic and one prehistoric), all of which were eventually determined to be ineligible for listing on the National Register (AEC 1972). This testing also concluded that there is no evidence of prehistoric occupation in the area around the station (AEC 1972).

There is potential for archaeological resources to be present on other portions of the PNPS site that have not been surveyed (i.e., in the former recreation area, the woodlands area, and within the transmission line corridor). One example reported by Entergy (2006a) is a possible cellar described by local informants as having been located and subsequently destroyed by construction of Power House Road. In addition, a small number of historic artifacts and two possible historic sites were observed by the NRC staff during the site visit (Section 2.2.9.2).

As noted in Section 2.2.9.2, 21 National Register and/or State Register listed historic resources have been identified within the Town of Plymouth. However, none are located within the boundaries of the PNPS site (Entergy 2006a).

4.4.5.2 Conclusions

A 1990 Environmental Assessment conducted by the NRC reported that operations at the PNPS site had not disturbed the integrity of local historic sites in the Town of Plymouth (NRC 1990). In a 2005 correspondence between the MHC and Entergy it was further determined that no National Register eligible historic or archaeological resources on the PNPS site would likely be impacted through continuing operations at the station (Entergy 2006a).

No new facilities, service roads or transmission lines are proposed for the PNPS site as part of this operating license renewal, nor are refurbishment activities proposed. Additionally, Entergy has an environmental review and evaluation procedure (EN-EV-115) in place to identify and assess the effects of its activities upon cultural resources (Entergy 2006d). Therefore, the potential for National Register eligible historic or archaeological resources to be impacted by renewal of this operating license is SMALL. Based on this conclusion, there would be no need to review mitigation measures.

4.4.6 Environmental Justice

Environmental justice refers to a Federal policy that requires Federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of its actions on minority(e) or low-income populations. The memorandum accompanying Executive Order 12898 (59 FR 7629) directs Federal executive agencies to consider environmental justice under the National Environmental Policy Act of 1969 (NEPA). The Council on Environmental Quality has provided guidance for addressing environmental justice (CEQ 1997a). Although the Executive Order is not mandatory for independent agencies, the NRC has voluntarily committed to undertake environmental justice reviews. Specific guidance is provided in the NRC Office of Nuclear Reactor Regulation Office Instruction LIC-203, *Procedural Guidance for Preparing Environmental Assessments and Considering Environmental Issues* Rev. 1 (NRC 2004a). In 2004, the Commission issued a final *Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions* (NRC 2004b).

The scope of the review, as defined in NRC guidance (NRC 2004a), includes identification of impacts on minority and low-income populations, the location and significance of any environmental impacts during operations on populations that are particularly sensitive, and information pertaining to mitigation. It also includes evaluation of whether these impacts are likely to be disproportionately high and adverse.

The staff identified minority and low-income populations within the 50-mi radius of the site. A minority population exists in a census block group if the percentage of each minority and aggregated minority category within the census block group exceeds the corresponding percentage of minorities in the state of which it is a part by 20 percentage points, or the corresponding percentage of minorities within the census block group is at least 50 percent. A low-income population exists if the percentage of low-income population within a census block group exceeds the corresponding percentage of low-income population in the state of which it is a part by 20 percentage points, or if the corresponding percentage of low-income population within a census block group is at least 50 percent.

(e) The Commission policy statement on environmental justice matters defines “minority” as American Indian or Alaskan Native; Asian; Native Hawaiian or other Pacific Islander; Black races; or Hispanic ethnicity. “Other” races and multi-racial individuals may be considered as separate minorities (NRC 2004b).

For the PNPS review, the staff examined the geographic distribution of minority and low-income populations within 50 mi of the site, employing the 2000 Census for low-income and minority populations (USCB 2000). The analysis was supplemented by field inquiries to the planning department and local officials in the towns in Plymouth County proximate to PNPS.

4.4.6.1 Minority Populations

The percent of each minority group and of minorities in aggregate was calculated for each of the 3863 block groups within 50 mi of PNPS and compared to the corresponding State's minority threshold percentages to determine whether environmental justice-defined minority populations exist.

Massachusetts, with approximately 83 percent of the block groups, accounts for 514 block groups defined as minority communities, with the remaining 17 percent of block groups in Rhode Island accounting for 137 block groups defined as minority communities (aggregating all minority racial groups and Hispanic populations). The location of these minority block groups is shown in Figure 2-11.

No minority communities were located within a 6-mi radius of PNPS. The nearest concentrations of minority groups to PNPS were in Brockton, approximately 25 mi to the northwest. Other minority communities were located in or near Boston, Massachusetts, and Providence, Rhode Island.

4.4.6.2 Low-Income Populations

NRC guidance defines "low-income" by using U.S. Census Bureau (USCB) statistical poverty thresholds (NRC 2004a). The same approach to defining low-income environmental justice thresholds is used for minorities (i.e., where the low-income population of the census block group exceeds 50 percent, or where the percentage of persons below the poverty level in a census block group is 20 percentage points or more than the state's percentage of low-income persons).

In Massachusetts, of the 3204 block groups within 50 mi of PNPS, low-income populations exist in 190 block groups, and in Rhode Island, 79 of the 659 block groups in the study area were defined as low-income.

No low-income populations were identified within the 6-mi radius of PNPS. The nearest low-income population occurring within the 50-mi radius was in northwest Plymouth County in Brockton. This population is approximately 25 mi northwest of the PNPS site. Other low-income populations within 50 mi of PNPS were clustered near Boston and in Bristol County, near the communities of Fall River and New Bedford, Massachusetts and in Providence County, Rhode Island. The location of these low-income block groups is shown in Figure 2-12.

With the locations of minority and low-income populations identified, the staff proceeded to evaluate whether any of the environmental impacts of the proposed action could affect these populations in a disproportionately high and adverse manner. The pathways through which the environmental impacts associated with the PNPS license renewal can affect human populations are discussed in each topical section. The staff evaluated whether minority and low-income populations could be disproportionately affected by these impacts. The staff found no unusual resource dependencies or practices, such as subsistence agriculture, hunting, or fishing that would be affected and, in turn, adversely affect minority and low-income populations. In addition, the staff did not identify any location-dependent disproportionately high and adverse impacts affecting these minority and low-income populations. The staff concludes that off-site impacts from PNPS on minority and low-income populations would be SMALL, and no special mitigation actions are warranted.

4.5 Ground-Water Use and Quality

Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, that are applicable to PNPS groundwater use and quality are listed in Table 4-12. Entergy stated in its ER that it is not aware of any new and significant information associated with the renewal of the PNPS OL (Entergy 2006a). The staff has not identified any new and significant information during its independent review of the PNPS ER, the staff's site visit, the scoping process, its evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts related to these issues beyond those discussed in the GEIS. For these issues, the GEIS concluded that the impacts would be SMALL, and additional plant specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

Table 4-12. Category 1 Issues Applicable to Groundwater Use and Quality During the Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections
GROUND-WATER USE AND QUALITY	
Ground-water use conflicts (potable and service water; plants that use <100 gpm)	4.8.1.1
Ground-water quality degradation (saltwater intrusion)	4.8.2.1

A brief description of the staff's review and the GEIS conclusions, as codified in Table B-1, 10 CFR 51, follows.

- Ground-water use conflicts (potable and service water; plants that use <100 gpm). Based on information in the GEIS, the Commission found that:

  > Plants using less than 100 gpm are not expected to cause any ground-water use conflicts.

  As discussed in Section 2.2.2, PNPS groundwater use is less than 100 gpm. The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no groundwater use conflicts during the renewal term beyond those discussed in the GEIS.

- Ground-water quality degradation (saltwater intrusion). Based on information in the GEIS, the Commission found that:

  > Nuclear power plants do not contribute significantly to saltwater intrusion.

  The staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no groundwater quality degradation impacts associated with saltwater intrusion during the renewal term beyond those discussed in the GEIS.

There are no Category 2 issues related to groundwater use and quality for PNPS.

4.6 Threatened or Endangered Species

Threatened or endangered species are listed as a Category 2 issue in 10 CFR Part 51, Subpart A, Appendix B, Table B-1. This issue is listed in Table 4-13.

Table 4-13. Category 2 Issue Applicable to Threatened or Endangered Species During the Renewal term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section	10 CFR 51.53(c)(3)(ii) Subparagraph	SEIS Section
THREATENED OR ENDANGERED SPECIES (FOR ALL PLANTS)			
Threatened or endangered species	4.1	E	4.6

This issue requires consultation with appropriate agencies to determine whether threatened or endangered species are present and whether they would be adversely affected by continued operation of the nuclear facility during the license renewal term. The presence of threatened or endangered species in the vicinity of the PNPS site is discussed in Sections 2.2.5.3.7 and 2.2.6.2. On April 25, 2006, the staff contacted the FWS and NMFS to request information on threatened and endangered species and the impacts of license renewal (NRC 2006b). In response, on May 23, 2006, the FWS provided additional information regarding Federally listed species that have been observed or may occur in the vicinity of PNPS and its associated transmission line ROW, as well as the concerns that the FWS have regarding those species (FWS 2006). The FWS implied in this letter that formal consultation is not required. NMFS responded on June 28, 2006, with a listing of marine species that were potentially affected by PNPS operations (NMFS 2006). The staff has prepared a biological assessment (BA) that documents its review, and the BA has been transmitted to NMFS for their concurrence. The BA is provided in Appendix E of this SEIS. The staff has not received a response from NMFS, upon publishing of this Final SEIS.

4.6.1 Marine Aquatic Species

As described in Section 2.2.5.3.6, there are ten Federally listed endangered or threatened marine aquatic species with some potential to occur in the vicinity of the PNPS. Four species of sea turtle Federally listed as endangered or threatened may occur in Cape Cod Bay. The loggerhead (*Caretta caretta*), Kemp's ridley (*Lepidochelys kempi*), leatherback (*Dermochelys coriacea*), and green (*Chelonia mydas*) turtles have all been observed within Cape Cod Bay, but none have been documented at the PNPS site. Throughout the operation of the plant, there have been no incidents of turtles being impinged on the screens, nor have any ever been observed in the intake embayment or discharge canal (Entergy 2006a).

Three Federally endangered great whale species are found seasonally in New England waters and have been documented in Cape Cod Bay: North Atlantic right whale (*Eubalaena glacialis*), humpback whale (*Megaptera novaeangliae*), and fin whale (*Balaenoptera physalus*). In addition, two other species, sei whale (*B. borealis*) and sperm whale (*Physter catadon*), are known to migrate in New England waters off of the coast of Massachusetts. Cape Cod Bay is designated as a critical habitat for the North Atlantic right whale. Although these species are documented in Cape Cod Bay and/or coastal Massachusetts waters, no whales have been observed in the shallow waters off PNPS or in the intake and discharge areas by applicant biologists since biological monitoring began at PNPS in the late 1960s (Entergy 2006a).

The range of the endangered shortnose sturgeon (*Acipenser brevirostrum*) includes the PNPS area; however, there are no known occurrences of the shortnose sturgeon in Plymouth or the surrounding area (NHESP 2006). Shortnose sturgeon have never been observed in Cape Cod

Bay near PNPS, or in the facility intake and discharge areas during the duration of the ecological monitoring studies since the plant first came on line (Entergy 2006a).

The staff concludes that continued operation of PNPS during the license renewal term is not likely to adversely affect any Federally listed marine aquatic species. Thus, the staff concludes that the impact on threatened or endangered marine aquatic species from an additional 20 years of operation would be SMALL, and no additional mitigation would be warranted. The staff's findings were documented in the BA (Appendix E) that has been forwarded to the NMFS for concurrence. The staff has not received a response from NMFS, upon publishing of this Final SEIS.

4.6.2 Terrestrial and Freshwater Aquatic Species

No Federally or State-listed threatened or endangered terrestrial species have been observed on the PNPS site or the transmission line ROW. Five species with a Federal listing status of endangered or threatened have been identified in the Town of Plymouth. The FWS (2006) identified four Federally listed species as potentially occurring in the PNPS vicinity or the transmission line ROW: the piping plover (*Charadrius melodus*), roseate tern (*Sterna dougallii*), bald eagle (*Haliaeetus leucocephalus*), and population 1 of the northern red-bellied cooter (*Pseudemys rubriventris*). The fifth Federally listed species, the dwarf wedgemussel (*Alasmidonta heterodon*), does not have habitat or the potential to occur in these area.

Although these three Federally listed birds occur in the vicinity of the facility, they are not dependent on habitats within the facility and are unlikely to be affected by facility operations. The piping plover is known to occur along Plymouth Beach just north of the PNPS (FWS 2006) and may move through the PNPS site while foraging along the shoreline and during migration (NHESP 1990). The piping plover has made a dramatic recovery in Massachusetts during the period that PNPS has been operating. The Massachusetts population increased from 139 breeding pairs in 1986 to over 500 breeding pairs in 1999, and now represents one-third of the entire Atlantic coast population (NHESP 1990). The roseate tern also is known to occur along Plymouth Beach just north of PNPS (FWS 2006), and it may pass over the PNPS site during migration (NHESP 1988). The roseate tern population in Massachusetts has been slowly increasing, from 1600 breeding pairs in 1978 to 1810 breeding pairs in 1999 (NHESP 2005).

Wintering bald eagles occasionally occur in the area of the PNPS (FWS 2006), and in 2005, juveniles and adults were observed at Plimoth Plantation, approximately 2 mi northwest of PNPS (Entergy 2006a). The bald eagle breeding population in Massachusetts has been recovering slowly, and in 2002 there were 12 breeding pairs producing approximately 15 chicks annually (NHESP 2005). Thus, there is no evidence that these species have been adversely affected by previous operation of the PNPS facility. Given that no expansion of existing facilities or disturbance of additional land is anticipated, these species are unlikely to be adversely affected during the renewal period (FWS 2006).

The northern red-bellied cooter is the only Federally listed species for which an area in the vicinity of PNPS and the transmission line ROW has been designated by FWS as critical habitat. Approximately 1400 ft of the transmission line ROW, near its southern end and adjacent to the boundary of Myles Standish State Forest, crosses the southeastern tip of an area containing numerous ponds that was designated as critical habitat (at 50 CFR 17.95) for the northern red-bellied cooter (FWS 1980) (Figure 2-6). The specific habitats used by the northern red-bellied cooter, which consist of ponds with abundant vegetation and areas of sandy soil on nearby land for nesting (NHESP 1995), do not occur within the transmission line ROW. The FWS concurred that the area of critical habitat crossed by the transmission line ROW does not provide the specific habitat needs of the northern red-bellied cooter (FWS 2006). The FWS noted that this area of the habitat was considered critical based on its value as a buffer against activities that may degrade water quality and quantity within ponds occupied by the turtle, and that the turtle potentially could traverse the ROW. The closest pond where the red-bellied cooter has been observed historically, Crooked Pond (50 CFR 17.95), is separated from the transmission line ROW by approximately 1500 ft of forested land. The second closest pond where the turtle has been observed, Island Pond (50 CFR 17.95), is separated from the ROW by approximately 1800 ft of forested land, residences, and roadway (Long Pond Road) (FWS 1980).

In addition to the Vegetation Management Plan, NSTAR follows a program, developed in coordination with and approved by the NHESP, to protect the northern red-bellied cooter and other turtles that may be present in the transmission line ROW during maintenance activities (NSTAR 2006). The northern red-bellied cooter has never been observed by NSTAR, Entergy, or Boston Edison biologists in this transmission line ROW, and no other Federally or State-listed endangered or threatened species is known or believed to occur in this transmission line ROW. Given that no expansion of existing facilities or disturbance of additional land associated with the transmission line ROW is anticipated, this species is unlikely to be adversely affected during the renewal period (FWS 2006).

Approximately 22 other rare species listed by the Commonwealth of Massachusetts may have the potential to occur on the PNPS site or transmission line ROW based on the possible presence of suitable habitat. However, because no expansion of existing facilities or disturbance of additional land associated with the transmission line ROW is anticipated, if these species were to occur in this area, it is unlikely that they would be adversely affected during the renewal period.

The staff reviewed information from the site audit, Entergy's ER, other reports, information from the FWS and NHESP, and public comments received. The staff concluded that the impacts on Federally or State-listed terrestrial endangered, threatened, proposed, or candidate species of an additional 20 years of operation and maintenance of PNPS and associated transmission lines and ROW would be SMALL, and no additional mitigation would be warranted. Because formal consultation is not required by the FWS, a BA was not developed to evaluate the potential impacts of continued operation of PNPS on Federally listed terrestrial and freshwater aquatic species (FWS 2006).

4.7 Evaluation of New and Potentially Significant Information on Impacts of Operations During the Renewal Term

The NRC staff reviewed the discussion of environmental impacts in the GEIS and conducted its own independent review (including public comments received) to identify new and significant information on environmental issues listed in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, related to PNPS during the renewal term. Processes for identification and evaluation of new and significant information are described in Section 1.2.2. Issues that were raised during scoping and public comment periods or through the staff's independent review of other available information are examined here to determine whether they represent new and significant information.

Of the 92 issues identified in the GEIS, the potential impact to aquatic habitat was not included. The consultation requirements of Section 305(b)of the Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996, provide that Federal agencies must consult with the Secretary of Commerce on all actions or proposed actions authorized, funded, or undertaken by the agency that may adversely affect EFH. Therefore, concurrent with issuance of the draft SEIS, the staff requested initiation of an EFH consultation with the NMFS. The EFH Assessment to support this consultation and NMFS's correspondence concluding consultation are presented in Appendix E of this SEIS.

A member of the public submitted a comment on the draft SEIS regarding the effects of continued operation of PNPS on aquatic habitat other than that designated as EFH. This comment, provided below, was determined to be a new and potentially significant issue.

> In the same way that there is concern for the EFH for fisheries determined by NOAA [National Oceanic and Atmospheric Administration] to require Management Plans pursu[ant] to the Magnuson-Stevens Act, so too should there be concern for the habitats essential to fish species that are experiencing precipitous population decline such as the Rainbow smelt, Alewife and Blueback herring, among others – the cumulative impact resulting from the plant impingement and entrainment on water quality, temperature and population abundance on these fish, and thus on long term survivability, was not adequately examined.

In response to the comment, the staff evaluated the potential impacts to aquatic habitat in this section of the SEIS. The aquatic habitat in the vicinity of PNPS is described in Section 2.2.5.1. The PNPS cooling water system is described in section 2.1.3.

Although the comment specifically expressed “concern for the habitats essential to fish species that are experiencing precipitous population decline,” the staff decided that the potential impacts on aquatic habitats throughout the entire local aquatic ecosystem should be addressed. Similar to the method used by the staff to assess EFH, the staff applied the use of four metrics (impingement, entrainment, discharge impacts, and food web impacts) in the assessment of impacts on aquatic habitat. Based on this analysis, the staff has determined that continued operation of the PNPS cooling water system would affect the aquatic habitat in the vicinity of PNPS. However, this impact would be of SMALL significance, and ample aquatic habitat is available in the immediate area and unaffected by PNPS operations.

As discussed in Section 4.3, radiation exposure issues for the license renewal term are Category 1 issues. During the scoping process and during the public comment period, members of the public (1) expressed concern about the possible impacts on human health (e.g., cancer) from exposure to radiation from Pilgrim's effluents and (2) cited a number of documents to support their concerns. The NRC reviewed these documents for potential new and significant information regarding the Category 1 radiation exposure issues.

Cancer is not rare; in fact, cancer is very common in the U.S. population. According to the American Cancer Society, more than a half million Americans die from cancer each year, an average of more than 1500 people a day (ACS 2005). There are many possible causes and risk factors for cancer, including radiation exposure.

Although radiation may cause cancers at high doses and high dose rates, currently there are no data that unequivocally establish the occurrence of cancer following exposure to doses below 10,000 millirem (mrem), received at low dose rates. However, radiation protection experts conservatively assume that any amount of radiation may pose some risk of causing cancer or a severe hereditary effect, and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold dose-response model is used to describe the relationship between radiation dose and risks such as cancer induction. Simply stated, any increase in dose, no matter how small, results in an incremental increase in health risks. This theory is accepted by the NRC as a conservative model for estimating health risks from radiation exposure, recognizing that the model probably overestimates those risks. According to the health risk estimates in International Commission on Radiological Protection Publication 60 (ICRP 1990), the risk of radiation exposure causing cancer is very low at doses below 10 mrem per year (mrem/yr).

Thousands of studies have been performed on the biological effects of radiation exposure. None of the scientifically valid studies show human health effects at acute doses less than 10,000 mrem. Based on a consensus of the conclusions of national and international experts such as the National Council on Radiation Protection and Measurements and the International Commission on Radiological Protection (ICRP), NRC and EPA have established conservative dose limits for the protection of human health. In 40 CFR Part 190, EPA set a limit of 25 mrem/yr to the whole body of a member of the public from the entire nuclear fuel cycle, including nuclear power plants. NRC established dose design objectives in 10 CFR Part 50, Appendix I, to implement the EPA standards for radiological effluents from nuclear power plants.

In spring 2006, the National Research Council of the National Academies published, "Health Risks from Exposure to Low Levels of Ionizing Radiation, BEIR VII Phase 2" (NAS 2006). A prepublication version of the report was made public in June 2005. A number of comments suggested that this report includes new and significant information that supports the concern about the possible impacts on human health from exposure to radiation from PNPS effluents.

The major conclusion of the BEIR VII report is that current scientific evidence is consistent with the hypothesis that there is a linear, no threshold dose response relationship between exposure to ionizing radiation and the development of cancer in humans. This conclusion is consistent with the radiological protection model that the NRC uses to develop its regulations. Therefore, the NRC's regulations continue to adequately protect public health and safety and the environment. None of the findings in the BEIR VII report warrant immediate changes to the NRC regulations (NRC 2005). The BEIR VII report does not say there is no safe level of exposure to radiation; it does not address "safe versus not safe." It does continue to support the conclusion that there is some amount of cancer risk associated with any amount of radiation exposure and that the risk increases with exposure and exposure rate. It does conclude that the risk of cancer induction at the dose levels in the NRC's and EPA's radiation standards is very small. Similar conclusions have been made in all of the associated BEIR reports since 1972 - BEIR I, III, and V (NAS 1972, NAS 1980, NAS 1990).

Since the BEIR VII findings are consistent with the prior BEIR studies, which were previously reviewed and found consistent with the bases of the current NRC regulations, the NRC staff concludes that the BEIR VII Phase 2 report does not constitute new and significant information.

With regard to the potential human health effect of PNPS effluents, as discussed in Sections 2.1.4 and 2.2.7 of this SEIS, Entergy monitors the amounts of radionuclides released in the effluents from Pilgrim to ensure compliance with these NRC regulations. Entergy also conducts an environmental radiological monitoring program to confirm the expected levels of radioactive materials in the area around PNPS. Based on recent effluent release reports (Entergy 2002, 2003, 2004, 2005, 2006c) the NRC staff expects the releases of radioactive material from Pilgrim to be well within regulations during the license renewal period and less than 10 mrem/yr to the maximally exposed member of the public. By comparison, the average dose of radiation in the United States from all sources including natural background and medical sources is approximately 360 mrem/yr (NRC 2007). Therefore, the additional dose to the maximally exposed member of the public from PNPS operations is less than 3 percent of the average annual background and medical dose to a member of the general public.

The NRC inspects Entergy's radiological effluent and environmental radiological monitoring programs at PNPS. In addition, Massachusetts Department of Public Health (MDPH) conducts environmental radiological monitoring around PNPS. As part of the Pilgrim site audit, the NRC staff met with officials of the MDPH to discuss the results of the MDPH radiological environmental monitoring program around Pilgrim. MDPH indicated that the results of the MDPH monitoring program have been consistent with the results from Entergy's monitoring program.(f)

With regard to the possibility of a causal relationship between PNPS effluents and human health, authors of various reports have suggested that statistical associations support a cause-and-effect relationship between cancer rates and reactor operations. While it is true that cancer rates vary among locations, it is very difficult to ascribe the cause of a cluster of cancers to some local environmental exposure, such as radiation from a nuclear power facility. Statistical association alone does not prove causation, and well-established scientific methods must be used to determine that for two things that appear to be associated over time, it can be concluded that one causes the other. For example, a person could say, "In the winter I wear boots, and in the winter I get colds." While there is a strong statistical association between wearing boots and getting colds, it would be inappropriate to say that wearing boots causes colds.

The scientific community adheres to several principles of good science that must be employed before a cause-and-effect claim can be made. These principles include: whether the study can be replicated; whether it has considered all the data or was selective (e.g., in the population or in the years studied); whether it evaluated all possible explanations for the observations; whether the data was valid and reliable; and whether its conclusions were subjected to independent peer review, evaluation, and confirmation.

A number of studies that conformed to these principles have been performed to examine the health effects around nuclear power facilities:

(f) Personal communication between Richard L. Emch, Jr., Senior Project Manager, Office of Nuclear Reactor Regulation, NRC; Charles R. Flynn, Senior Health Physicist, Earth Tech USA, (NRC Contractor); Susanne K. Condon, Director, Bureau of Environmental Health Assessment, Assistant Commissioner, MDPH; and Robert Walker, Director, Radiation Control Program, MDPH; May 3, 2006.

- National Cancer Institute – In 1990, at the request of Congress, the National Cancer Institute conducted a study of cancer mortality rates around 52 nuclear power plants and 10 other nuclear facilities. The study covered the period from 1950 to 1984 and evaluated the change in mortality rates before and during facility operations. The study concluded there was no evidence that nuclear facilities may be linked causally with excess deaths from leukemia or from other cancers in populations living nearby (NCI 1990 in NRC 2006a).

- University of Pittsburgh – Investigators from the University of Pittsburgh found no link between radiation released during the 1979 accident at the Three Mile Island nuclear station and cancer deaths among nearby residents. For 20 years, their study followed over 32,000 people who lived within 8 kilometers (5 mi) of the facility at the time of the accident (UOP 2000 in NRC 2006a).

- Connecticut Academy of Sciences and Engineering – In January 2001, the Connecticut Academy of Sciences and Engineering issued a report on a study around the Haddam Neck Nuclear Power Plant in Connecticut and concluded that radiation emissions were so low as to be negligible (CASE 2001 in NRC 2006a).

- American Cancer Society – In 2004, the American Cancer Society concluded that although reports about cancer clusters in some communities have raised public concern, studies show that clusters do not occur more often near nuclear plants than they do by chance elsewhere in the population. Likewise, there is no evidence that links the isotope strontium-90 with increases in breast cancer, prostate cancer, or childhood cancer rates. Radiation emissions from nuclear power plants are closely controlled and involve negligible levels of exposure for nearby communities (ACS 2001 in NRC 2006a).

- Florida Bureau of Environmental Epidemiology – In 2001, the Florida Bureau of Environmental Epidemiology reviewed claims that there are striking increases in cancer rates in southeastern Florida counties caused by increased radiation exposures from nuclear power plants. However, using the same data to reconstruct the calculations on which the claims were based, Florida officials were not able to identify unusually high rates of cancers in these counties compared with the rest of the state of Florida and the nation (FDOH 2001 in NRC 2006a).

- Illinois Public Health Department – In 2000, the Illinois Public Health Department compared childhood cancer statistics for counties with nuclear power plants to similar counties without nuclear plants and found no statistically significant difference (IPDH 2000, in NRC 2006a).

In summary, there are no studies to date that are widely accepted by the scientific community that show a correlation between radiation dose from nuclear power facilities and cancer to the general public. The amount of radioactive material released from nuclear power facilities is well measured, well monitored, and known to be very small. The doses of radiation that are received by members of the public as a result of exposure to nuclear power facilities are so low that resulting cancers have not been observed and would not be expected.

The scoping and public comments included citations that discussed the potential for impacts on human health from exposure to radiation from PNPS effluents. In these comments, a number of commenters expressed concern that operation of PNPS results in excess cancers in the population around the plant site. Commenters cited the following documents in support of these concerns:

- Clapp, R.W., Cobb, S., Chan, C.K., and B. Walker, 1987, Leukemia near Massachusetts nuclear power plant, Lancet (Dec 5): pgs. 1324-1325.
- Clapp, R.W., 1992, Statement before the Southeastern Massachusetts Health Study Review Committee.
- Clapp, R.W., 2006a, Analysis of 1974-1989 Massachusetts Cancer Registry for Leukemia and Thyroid Cancer, personal communication with Pilgrim Watch.
- Clapp, R.W., 2006b, Analysis of 1998-2002 Massachusetts Cancer Registry for Leukemia and Thyroid Cancer, personal communication with Pilgrim Watch.
- England, R.W., and E. Mitchell, 1987, Estimates of Environmental Accumulations of Radioactivity Resulting from Routine Operation of New England Nuclear Power Plants (1973-1984). A Report of the Nuclear Emission Research project, Whitemore School of Business and Economics, University of New Hampshire, Durham, New Hampshire.
- Knorr, R.S., and M.S. Morris, 1996, *The Southeastern Massachusetts Health Study* (published in the *Archives of Environmental Health*, Volume 51, pg.266, July through August 1996)
- Land, W.T., unknown date, Meteorological Analysis of Radiation Releases for the Coastal Areas of the State of Massachusetts for June 3rd to June 20th 1982.
- Morris, M.S., and R.S. Knorr, Southeastern Massachusetts Health Study. Final Report. Boston, MA: Bureau of Environmental Health Assessment, Massachusetts Department of Public Health; 1990.
- National Research Council of the National Academies, 2006, Health Risks from Exposure to Low Levels of Ionizing Radiation, BEIR VII, Phase 2, Committee to Assess Health Effects from Exposure to Low Levels of Ionizing Radiation, National Academies Press, Washington, DC, pg. 406.

- Russ, A., C. Burns, S. Tuler, and O. Taylor. 2006. Health Risks of Ionizing Radiation: An Overview of Epidemiological Studies. Community-Based Hazard Management, The George Perkins Marsh Institute. Clark University, Worcester, Massachusetts.

Many of these comments referred to the Southeastern Massachusetts Health Study (SMHS). The SMHS was conducted by investigators from the MDPH to determine if communities near PNPS in Plymouth, Massachusetts, had elevated leukemia incidence rates associated with radioactive plant discharges (Hoffman et al. 1992). The SMHS states that the "data support a finding of association between exposure potential to Pilgrim emissions and the risk of leukemia in adult cases diagnosed before 1984." The final report, released to the public in October 1990, found a two- to four-fold increase in the risk of leukemia among residents of certain towns within a 20-mi radius from the plant (Morris and Knorr 1990).

Six years after issuing the SMHS report, the authors published a paper in the Archives of Environmental Health about the SMHS (Knorr and Morris 1996). More recently, through the public comment process on PNPS's draft SEIS, the authors further clarified[(g)] their position stating that:

> "The MDPH report specifically states that it is not possible to reach definitive conclusions regarding cause and effect but that the results should be followed up to clarify their public health implications. This conclusion is consistent with that stated by the peer reviewers. While the findings of the study may not support a causal relationship, the NRC arguments in the Supplemental Impact Statement ignore the principal MDPH and peer review conclusions that the findings cannot be dismissed and that further attention to the possible risks associated with the power plant may be warranted".

The peer reviews (Sever et al. 1993; Hoffman et al. 1992; NRC NUREG/BR-0125 1992) focused on several issues that do not support a causal relationship. The first issue is temporality. There is a latency period of several years between radiation exposure and leukemia incidence, and the short duration of the increased incidence of leukemia reported in the study is inconsistent with the increase being radiation induced. The elevated incidence disappeared just when it would have been approaching a maximum if it had been caused by radiation exposure from PNPS. Second, the results of the study are inconsistent with the results of the large body of evidence from studies conducted before and after the SMHS that are widely accepted within the scientific community. Some of those studies, including the BEIR VII report are discussed above; none of them showed an increase in leukemia incidence from low radiation doses or proximity to nuclear power plants. Third, the level of radioactive material released from PNPS and the resulting estimated doses met NRC's rules and are well within

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(g) This comment can be found in the Agency (ADAMS) under Accession No. ML070660326. It can also be found in Appendix A of this document.

NRC's radiation standards. The SMHS did not actually estimate doses based on plant effluent reports, but inferred that the doses to members of the public were much higher near the plant than at distances in the range of 20 mi. This inference is not correct; there is almost no difference (i.e., the last 5 years of effluent release reports show that the dose to the maximally exposed person from PNPS operations is less than 3 percent of the average dose to the general public 20-mi away) (Entergy 2002, 2003, 2004, 2005, 2006c; NRC 2007). Finally, the SMHS concluded that two-thirds of the leukemia cases near the plants were caused by radiation. If this conclusion were true, the combined total of the radiation induced leukemia cases and the normally expected number of non-radiation induced leukemia cases would have been much higher than observed.

NRC has considered the relevant information in these citations and concludes that the SMHS does not demonstrate a causal relationship between the PNPS effluents and the potential effect of excess cancers in the areas around the site. With regard to the rest of these citations, NRC finds that they also fail to overturn the large body of evidence from widely accepted studies within the scientific community that find that the potential for this causality is not scientifically plausible.

In the GEIS, radiation exposure to the public during the license renewal term was considered a Category 1 issue (see Chapter 1 and Section 4.3 for a discussion of Category 1 issues and radiological impacts from normal operations). The GEIS concluded that the risk to the public from continued operation of a nuclear plant would not increase during the license renewal term. Doses to members of the public from PNPS emissions were specifically evaluated in Appendix E of the GEIS and were found to be well within the regulatory limits.

In summary, NRC's dose limits are conservative and supported by the EPA and international agencies such as: ICRP, United Nations Scientific Committee on the Effects of Atomic Radiation, and the European Commission on Radiation Protection. Review and evaluation of new studies and analyses of the health effects of radiation exposure is an ongoing process at the NRC. The scientifically defensible epidemiological studies on the biological effects of ionizing radiation provide solid evidence that the current regulatory standards are protective of human health. Entergy has demonstrated that releases from PNPS during the renewal period are expected to be below regulatory limits (Entergy 2002, 2003, 2004, 2005, 2006c).

The NRC staff has reviewed the information within the documents referenced by the commenters and finds that the information fails to demonstrate that the GEIS (as codified in 10 CFR Part 51, Subpart A, Appendix B, Table B-1) regarding the human health impact of radiation exposure resulting from the operation of PNPS is incorrect.

The staff concludes that the information provided during the scoping process was not new and significant with respect to the findings of the GEIS.

4.8 Cumulative Impacts

The staff considered the potential for cumulative impacts of operations of PNPS during the renewal term. For the purposes of this analysis, past actions are those related to the resources at and since the time of the plant licensing and construction, present actions are those related to the resources at the time of current operation of the power plant, and future actions are considered to be those that are reasonably foreseeable through the end of plant operation. Therefore, the analysis considers potential impacts through the end of the current license term as well as the 20-year renewal license term. The geographical area over which past, present, and future actions would occur is dependent on the resource evaluated and is described below for each resource.

The impacts of the proposed action, as described in previous sections of Chapter 4, are combined with other past, present, and reasonably foreseeable future actions at PNPS regardless of what agency (Federal or non-Federal) or person undertakes such other actions. These combined impacts are defined as “cumulative” in 40 CFR 1508.7 and include individually minor but collectively significant actions taking place over a period of time (CEQ 1997b). It is possible that an impact that may be SMALL by itself could result in a MODERATE or LARGE 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.

4.8.1 Cumulative Impacts on Marine Aquatic Resources

For the purposes of this analysis, the geographic area considered for impingement impacts on marine aquatic resources includes the Plymouth/Kingston/Duxbury areas and western Cape Cod Bay. As discussed in Section 4.1, the staff found no new and significant information that would indicate that the conclusions regarding any of the marine aquatic resources in the vicinity of PNPS are inconsistent with the conclusions in the GEIS (NRC 1996). The staff has determined that the combined effects of entrainment and impingement would likely have MODERATE cumulative impacts on the local winter flounder population and on the Jones River population of rainbow smelt. Entrainment and impingement combined would likely have SMALL to MODERATE cumulative impacts on other marine aquatic species and habitat.

There is a variety of natural and anthropogenic factors that may influence biota in the area surrounding PNPS, including fishing mortality, entrainment and impingement from PNPS and other water intakes, heat shock from PNPS and other thermal dischargers, contaminants, environmental changes associated with regional increases in water temperature, habitat modification and loss, protected areas, and predator-prey interactions. In addition, changes to water and sediment quality from runoff, urbanization, and industrial activities may act as stressors on the biological environment. To evaluate the impacts of these other stressors on biological communities in the area and in turn, be able to elucidate the cumulative impacts of PNPS's cooling system on the aquatic resources of Cape Cod Bay, the staff consulted with State and Federal resource agencies, reviewed the applicants ER and other environmental reports, conducted an independent search for other potential stressors in Cape Cod Bay, and considered public comments.

Other activities that may affect marine aquatic resources in Cape Cod Bay include periodic maintenance dredging, continued urbanization and development, and construction of new over-water or near-water structures, such as docks, and shoreline stabilization measures, such as sheet pile walls, rip-rap, or other hard structures. For instance, it is likely that the harbors and channels in the Plymouth/Kingston/Duxbury areas would require some dredging. However, based on discussions with plant personnel, there are no plans for dredging of the intake embayment or discharge canal at PNPS.

Cumulative impacts on the aquatic food web potentially could include reductions in the abundance of important phytoplankton and zooplankton species in the vicinity due to their entrainment in the cooling systems or from exposure to the heated discharges. This could potentially lead to effects on other species in the food web. However, based upon the review conducted by the NRC staff, there is no evidence that the operation of the PNPS cooling system has had an impact on phytoplankton or zooplankton communities, or any resultant effects on the aquatic food web, in Cape Cod Bay.

Impacts to fish and other macrobiota may include entrainment of small life stages, impingement of juvenile or adult forms, toxicity due to exposure to chemicals associated with the cooling water discharge, or physiological or behavioral changes associated with exposure to the discharge thermal plume. As discussed in Section 4.1, PNPS has a large degree of ichthyoplankton entrainment and impingement (based on absolute numbers); however, this impact was determined to be of moderate significance only for local populations of the winter flounder. Because entrainment would have a MODERATE impact on the local winter flounder population, cumulative impacts to the local winter flounder population would also be MODERATE. Regarding rainbow smelt, due to high impingement rates, very low impingement survivability, and declining population trends based on best available data for the Jones River population, NRC staff concluded that cumulative impacts on the Jones River population of rainbow smelt would be MODERATE.

Cumulative impacts on the marine aquatic food web also could potentially occur as a result of reductions in the prey base of higher-trophic-level predators. If major reductions in Cape Cod Bay populations of forage fish, such as rainbow smelt, alewife, herring, menhaden, and silverside, resulted from mortality due to entrainment and/or impingement at PNPS, then predatory fish, as well as some bird species, dependent on these prey populations might be adversely affected. Although populations of some forage species, such as the rainbow smelt, have declined relative to historical levels, stocks of most forage species are relatively healthy.

Predators typically are highly mobile, consume a variety of prey, and can adjust their prey selection based on availability. Thus, adverse effects on predator populations are unlikely in the absence of cumulative reductions in the populations of multiple forage species in the region. The review of fisheries impacts conducted by the NRC staff did not indicate that the operation of the PNPS cooling system has had a cumulative impact on the community of forage fish in Cape Cod Bay or the predatory species that depend upon them.

Other large-volume water intakes in Cape Cod Bay may also have a potentially significant impact on aquatic resources. There are no other large-volume water intakes in the immediate vicinity of PNPS; however, the Mirant Canal Station on Cape Cod Canal is another generating facility that withdraws water from and discharges water to Cape Cod Bay.

Other sources of potentially significant impacts to aquatic resources include fishing pressure (both commercial and recreational) and indirect impacts via loss of habitat (e.g., as a result of dredging, siltation, etc.). Cape Cod Bay and the Gulf of Maine support significant commercial and recreational fisheries for many of the fish and invertebrate species potentially affected by PNPS. Commercial and recreational fishing pressure may contribute to reduced stock sizes in Cape Cod Bay. Impingement and entrainment impacts from PNPS may also contribute to reduced stock sizes, in turn lowering the catch per unit effort for both commercial and recreational fishing. With the exception of winter flounder and rainbow smelt, most of the fish stocks potentially affected by PNPS are considered to be healthy or the levels of take by PNPS are very minimal.

However, fishery regulations and protected areas may have beneficial impacts on fish and shellfish populations due to reduced fishing pressure in local areas. In fact, the PNPS exclusion zone in Cape Cod Bay has likely reduced fishing pressure on the American lobster and possibly other species relative to the fishing pressure in the area adjacent to PNPS before implementation of that security measure. An additional contributor to beneficial impacts is NMFS's Ship Strike Reduction Strategy, which is designed to reduce vessel strikes of the endangered North Atlantic right whale; implementation of the Strategy's measures would have positive effects on the North Atlantic right whale population in Cape Cod Bay.

Potential future environmental impacts include the loss of sensitive habitats, including coastal marshes and submerged aquatic vegetation; continued non-point source impacts on the bay from stormwater runoff and contaminated groundwater; and fishing mortality.

As described in Chapter 2, operation of the PNPS cooling system has not had a detectable effect on water quality in Cape Cod Bay, and the staff determined that the impacts of continued operation of the cooling water system on water quality would be classified as SMALL. Given the large assimilative capacity of Cape Cod Bay and the fact that PNPS withdraws a relatively small percentage of the net volumetric flow of water - generally less than 0.1 percent

(ENSR and MRI 2005), the cumulative impact of continued operation of the PNPS cooling system on water quality would be SMALL. It is also expected that operation of the PNPS cooling system would not appreciably contribute to the cumulative impacts on the surface water supply.

Potential or proposed projects in the area that may impact aquatic habitat include: dredging for the Plymouth Harbor Federal Navigation Project by the U.S. Army Corps of Engineers; the filling of 26 ac within Plymouth Bay by the Town of Plymouth; the construction of a pile-supported, fixed pier and floating docks in the Federal anchorage in Plymouth Harbor; dredging to reestablish the entrance to Ellisville Harbor in Plymouth; and the ability to retain and maintain the Cordage Park Marina in Plymouth Bay (USACE 2006).

There is a potential for MODERATE cumulative impacts on local populations of winter flounder and rainbow smelt, but the cumulative impacts of continued operation of PNPS on other marine aquatic resources is expected to be SMALL to MODERATE.

4.8.2 Cumulative Impacts on Terrestrial and Freshwater Resources

This section analyzes past, present, and future actions that could result in adverse cumulative impacts to terrestrial resources such as wildlife populations, the size and distribution of habitat areas, and aquatic resources such as streams, wetlands and floodplains. For purposes of this cumulative effects analysis, the geographic area considered in the evaluation includes the Town of Plymouth, which contains the PNPS site and its associated transmission line ROW.
The transmission line ROW does not cross any State or Federal parks, wildlife refuges, or wildlife management areas (Entergy 2006a), nor does it cross any major lakes, ponds, or streams but does cross one small stream. NSTAR, the owner of the transmission lines, follows ROW management procedures that were found to be protective of sensitive ecological resources, including wildlife habitat, wetlands, and floodplains. The maintenance procedures minimize disturbance of wildlife and wetlands and prevent potential off-site effects, such as erosion, on surrounding areas with other land uses.

Maintenance and operation of the transmission system are not expected to destabilize or noticeably alter the existing terrestrial or freshwater aquatic environment. Likewise, operation of PNPS is not likely to have a detectable effect on terrestrial or freshwater aquatic species located in the vicinity of the PNPS site or the transmission line ROW. No other Federal or non-Federal activities have been identified that would have an adverse effect on terrestrial and freshwater aquatic species in the area. The staff concludes that the incremental contribution to cumulative impacts on terrestrial and freshwater aquatic resources resulting from continued operation of PNPS and its associated transmission line ROW would be SMALL, and that no additional mitigation would be warranted.

4.8.3 Cumulative Human Health Impacts

The EPA and NRC have developed radiological dose limits for protection of the public and workers to address the cumulative impact of acute and long-term exposure to radiation and radioactive material. These dose limits are codified in 40 CFR Part 190 and 10 CFR Part 20. For the purpose of this analysis, the area within a 50-mi radius of the PNPS site was included. As stated in Section 2.2.7, a radiological environmental monitoring program (REMP) has been conducted around the PNPS site since 1968 with the results presented annually in the PNPS REMP Report (Entergy 2002, 2003, 2004, 2005, 2006c). Although no other nuclear fuel cycle operations are located within the subject area, the REMP measures radiation and radioactive materials from all sources, including natural background. Monitoring results for the 5-year period from 2001 through 2005 were reviewed as part of the cumulative impacts assessment. Additionally, in Sections 2.2.7 and 4.3, the staff concluded that impacts of radiation exposure to the public and workers (occupational) from operation of PNPS during the renewal term would be SMALL. Therefore, the monitoring program and staff's conclusion considered cumulative impacts. The NRC and the Commonwealth of Massachusetts would regulate any future actions in the vicinity of the PNPS site that could contribute to cumulative radiological impacts. The staff determined that the electric field induced currents from the PNPS transmission lines are well below the National Electrical Safety Code (NESC) recommendations for preventing electric shock from induced currents. Therefore, the PNPS transmission lines do not detectably affect the overall potential for electric shock from induced currents within the analysis area. With respect to chronic effects of electromagnetic fields, although the NRC staff considers the GEIS finding of “not applicable” to be appropriate in regard to PNPS, the PNPS transmission lines are not likely to detectably contribute to regional exposure to extremely low frequency electromagnetic fields (ELF-EMFs). The PNPS transmission lines pass through a sparsely populated, rural area with very few residences or businesses close enough to the lines to have detectable ELF-EMFs.

Therefore, the staff concludes that cumulative radiological impacts of continued operations of PNPS would be SMALL, and that no further mitigation measures are warranted.

4.8.4 Cumulative Socioeconomic Impacts

The continued operation of PNPS is not likely to result in significant cumulative impacts for any of the socioeconomic impact measures assessed in Section 4.4 of this SEIS (public services, housing, and off-site land use). This is because operating expenditures, staffing levels, and local tax payments during renewal would be similar to those during the current license period. Similarly, the proposed action is not likely to result in significant cumulative impacts on historic and archaeological resources.

When combined with the impact of other potential activities likely to occur in the area surrounding the plant, socioeconomic impacts resulting from PNPS license renewal would not produce an incremental change in any of the impact measures used. The staff therefore determined that the impacts on employment, personal income, housing, local public services, utilities, and education occurring in the local socioeconomic environment as a result of license renewal activities, in addition to the impacts of other potential economic activity in the area, would be SMALL. The staff determined that the impact on off-site land use would be SMALL because no refurbishment activities are planned at PNPS, and no new incremental changes to plant-related tax payments are expected that could influence land use by fostering considerable growth. The impacts of license renewal on transportation and environmental justice would also be SMALL. There are no reasonably foreseeable scenarios that would alter these conclusions in regard to cumulative impacts.

There are no archeological or historic above ground resources eligible for listing on the National Register of Historic Places identified on the PNPS site. The staff has concluded that the impacts of license renewal on historic and archaeological resources would be SMALL. The continued operation and maintenance of the PNPS site and the transmission line corridor would not be expected to impact any properties beyond the site or transmission corridor boundaries. Therefore, the contribution to a cumulative impact on historic and archaeological resources would be negligible.

Based on this analysis, the staff concludes that the cumulative impact to socioeconomic resources resulting from continued operation of PNPS during the license renewal period would be SMALL, and no additional mitigation measures are warranted.

4.8.5 Cumulative Impacts on Groundwater Use and Quality

PNPS groundwater use is less than 100 gpm. The Town of Plymouth public water supply system, which provides water to PNPS for its potable and reactor make-up water needs, obtains its water from local groundwater. There are no operable groundwater production wells at PNPS. The applicant is not proposing an increase in demand of groundwater well usage during the renewal period. As demand for water supplies increases in the vicinity of PNPS, additional withdrawals of groundwater may be involved to satisfy the water needs of other water users in the region. However, Entergy does not anticipate a need for additional workers during the license renewal period. Renewal of the PNPS OL would not increase the population of the two-county area where most of the existing PNPS employees currently live and, therefore, would not increase the demand for groundwater.

On the basis of this analysis, the staff concludes that the cumulative impact to groundwater resources during the license renewal period would be SMALL and no additional mitigation measures would be warranted.

4.8.6 Cumulative Impacts on Threatened and Endangered Species

The geographic area considered in the analysis of potential cumulative impacts to threatened or endangered species includes the Town of Plymouth, which contains the PNPS site and its associated transmission line ROW, and the waters of Cape Cod Bay in the vicinity of the PNPS site. As discussed in Sections 2.2.5 and 2.2.6, a number of threatened or endangered species could occur within this area, including both terrestrial and aquatic species. The staff's findings, presented in the Biological Assessment [for marine aquatic species only (see Appendix E)] and in Section 4.6, are that continued operation of PNPS and maintenance of its associated transmission line ROW during the license renewal term would have no effect, or would not likely adversely affect, any Federally listed species or any designated critical habitat. No other Federal or non Federal activities have been identified that would have an adverse effect on any Federally threatened or endangered species in the area. However, NMFS's Ship Strike Reduction Strategy is designed to reduce vessel strikes of the endangered North Atlantic right whale; implementation of the Strategy's measures would have positive effects on the North Atlantic right whale in Cape Cod Bay. Therefore, the staff concludes that the contribution of PNPS operations to cumulative impacts on Federally protected species or designated critical habitat would be SMALL, and no additional mitigation would be warranted.

4.8.7 Conclusions Regarding Cumulative Impacts

The NRC staff considered the potential impacts resulting from the operation of PNPS and maintenance of the transmission line ROW since PNPS was constructed and went on line through the end of the license renewal term and resulting from other past, present, and future actions in the vicinity of PNPS. The staff's determination is that the cumulative impacts resulting from the incremental contribution of PNPS operation and maintenance of transmission line ROW would be SMALL for all resources with the exception of marine aquatic species, which would experience SMALL to MODERATE cumulative impacts.

4.9 Summary of Impacts of Operations During the Renewal Term

Neither Entergy nor the NRC staff is aware of information that is both new and significant related to any of the applicable Category 1 issues associated with the PNPS operation during the renewal term. Consequently, the staff concludes that the environmental impacts associated with these issues are bounded by the impacts described in the GEIS. For each of these issues, the GEIS concluded that the impacts would be SMALL and that additional plant-specific mitigation measures are not likely to be sufficiently beneficial to warrant implementation. Plant-specific environmental evaluations were conducted for 11 Category 2 issues applicable to PNPS operation during the renewal term and for environmental justice and chronic effects of electromagnetic fields. For 8 issues and environmental justice, the staff concluded that the potential environmental impact of renewal term operations of PNPS would be of SMALL significance in the context of the standards set forth in the GEIS and that additional mitigation would not be warranted. For impacts on the local winter flounder population due to entrainment, the staff's conclusion is that the impacts would be MODERATE. Also, impacts on the Jones

River population of rainbow smelt due to impingement would be MODERATE. Impacts due to entrainment and impingement on other marine fish and shellfish resources would be SMALL to MODERATE. Impacts on marine mammals and aquatic habitat would be SMALL. Potential mitigation measures are discussed in Section 4.1.4. In addition, the staff determined that a consensus has not been reached by appropriate Federal health agencies regarding chronic adverse effects from electromagnetic fields. Therefore, the staff did not conduct an evaluation of this issue.

Cumulative impacts of past, present, and reasonably foreseeable future actions were considered, regardless of what agency (Federal or non-Federal) or person undertakes such other actions. The staff concluded that cumulative impacts of PNPS license renewal would be SMALL for all potentially affected resources, with the exceptions of the local winter flounder population and rainbow smelt population, for which impacts would be MODERATE, and other marine aquatic species, for which impacts would be SMALL to MODERATE.

4.10 References

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

10 CFR Part 50. Code of Federal Regulations, Title 10, *Energy*, Part 20, "Domestic Licensing of Production and Utilization Facilities."

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

36 CFR Part 800. Code of Federal Regulations, Title 36, *Parks, Forests, and Public Property*, Part 800, “Protection of Historic Properties.”

40 CFR Part 190. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 190, “Environmental Radiation Protection Standards for Nuclear Power Operation.”

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5.0 Environmental Impacts of Postulated Accidents

Environmental issues associated with postulated accidents are discussed in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437, Volumes 1 and 2 (NRC 1996, 1999).(a) The GEIS includes a determination of whether the analysis of the environmental issue could be applied to all plants and whether additional mitigation measures would be warranted. Issues are 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:

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

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

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

For issues that meet the three Category 1 criteria, no additional plant-specific analysis is required 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.

This chapter describes the environmental impacts from postulated accidents that might occur during the license renewal term.

5.1 Postulated Plant Accidents

Two classes of accidents are evaluated in the GEIS. These are design-basis accidents and severe accidents, as discussed below.

(a) 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 Addendum 1.

5.1.1 Design-Basis Accidents

In order to receive U.S. Nuclear Regulatory Commission (NRC) approval to operate a nuclear power facility, an applicant for an initial operating license (OL) 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 are provided to prevent and mitigate accidents. The NRC staff reviews the application to determine whether the plant design meets the Commission's regulations and requirements and includes, in part, the nuclear plant design and its anticipated response to an accident.

Design-basis accidents (DBAs) are those accidents that both the licensee 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. A number 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 preventive and mitigative safety systems of the facility. The acceptance criteria for DBAs are described in Title 10 of the Code of Federal Regulations Part 50 and Part 100 (10 CFR Part 50 and 10 CFR Part 100).

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 OL. The results of these evaluations are found in license documentation such as the applicant's Final Safety Analysis Report (FSAR), the NRC staff's Safety Evaluation Report (SER), the Final Environmental Statement (FES), and Section 5.1 of this Supplemental Environmental Impact Statement (SEIS). A licensee 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 maximally exposed individual; as such, changes in the plant environment will not affect these evaluations. 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, and the environmental impacts of those accidents were not examined further in the GEIS.

The Commission 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 of the plant; the current licensing basis of the plant is to be maintained by the licensee under its current license and, therefore, under the provisions of 10 CFR 54.30, is not subject to review under license renewal. This issue, applicable to Pilgrim Nuclear Power Station (PNPS), is listed in Table 5-1.

Table 5-1. Category 1 Issue Applicable to Postulated Accidents During the Renewal Term

ISSUE–10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections
POSTULATED ACCIDENTS	
Design-basis accidents	5.3.2; 5.5.1

Based on information in the GEIS, the Commission found that:

> The NRC staff has concluded that the environmental impacts of design-basis accidents are of small significance for all plants.

Entergy Nuclear Operations, Inc. (Entergy) stated in its Environmental Report (ER) (Entergy 2006a) that it is not aware of any new and significant information associated with the renewal of the PNPS OL. The NRC staff has not identified any new and significant information during its independent review of the PNPS ER, the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the NRC staff concludes that there are no impacts related to DBAs beyond those discussed in the GEIS.

5.1.2 Severe Accidents

Severe nuclear accidents are those that are more severe than DBAs because they could result in substantial damage to the reactor core, regardless of off-site consequences. In the GEIS, the NRC staff assessed the impacts of severe accidents using the results of existing analyses and site-specific information to conservatively predict the environmental impacts of severe accidents for each plant during the renewal period.

Severe accidents initiated by external phenomena, such as tornadoes, floods, earthquakes, fires, and sabotage, traditionally have not been discussed in quantitative terms in FESs and were not specifically considered for the PNPS site in the GEIS. However, in the GEIS, the NRC staff did evaluate existing impact assessments performed by the NRC and by the industry at 44 nuclear plants in the United States and concluded that the risk from beyond-design-basis earthquakes at existing nuclear power plants is SMALL. The GEIS for license renewal performed a discretionary analysis of terrorist acts in connection with license renewal, and concluded that the core damage and radiological release from such acts would be no worse than the damage and release expected from internally initiated events. In the GEIS, the Commission concludes that the risk from sabotage and beyond design-basis earthquakes at existing nuclear power plants is small and, additionally, that the risks from other external events are adequately addressed by a generic consideration of internally initiated sever accidents (GEIS, Vol. 1, p-5-18) .

Based on information in the GEIS, the Commission found that:

> The probability weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to groundwater, and societal and economic impacts from severe accidents are small for all plants. However, alternatives to mitigate severe accidents must be considered for all plants that have not considered such alternatives.

Therefore, the Commission has designated mitigation of severe accidents as a Category 2 issue in 10 CFR Part 51, Subpart A, Appendix B, Table B-1. This issue, applicable to PNPS, is listed in Table 5-2.

Table 5-2. Category 2 Issue Applicable to Postulated Accidents During the Renewal Term

ISSUE–10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections	10 CFR 51.53(c)(3)(ii) Subparagraph	SEIS Section
POSTULATED ACCIDENTS			
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	L	5.2

The NRC staff has not identified any new and significant information with regard to the consequences from severe accidents during its independent review of the PNPS ER (Entergy 2006a), the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the NRC staff concludes that there are no impacts of severe accidents beyond those discussed in the GEIS. However, in accordance with 10 CFR 51.53(c)(3)(ii)(L), the NRC staff has reviewed severe accident mitigation alternatives (SAMAs) for PNPS. The results of its review are discussed in Section 5.2.

5.2 Severe Accident Mitigation Alternatives

Section 51.53(c)(3)(ii)(L) of 10 CFR requires that license renewal applicants consider alternatives to mitigate severe accidents if the 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 of this consideration is to ensure that 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 for PNPS; therefore, the remainder of Chapter 5 addresses those alternatives.

5.2.1 Introduction

This section presents a summary of the SAMA evaluation for PNPS conducted by Entergy and described in the ER, and the NRC's review of this evaluation. The details of the review are described in the NRC staff evaluation that was prepared with contract assistance from Information Systems Laboratories, Inc. The entire SAMA evaluation for PNPS is presented in Appendix G.

The SAMA evaluation for PNPS was conducted with a four-step approach. In the first step Entergy quantified the level of risk associated with potential reactor accidents using the plant-specific probabilistic safety assessment (PSA) and other risk models. In the second step Entergy examined the major risk contributors and identified possible ways (i.e., SAMAs) of reducing that risk. Common ways of reducing risk are changes to components, systems, procedures, and training. Entergy initially identified 281 potential SAMAs for PNPS. Entergy screened out 222 SAMAs from further consideration because they are not applicable at PNPS due to design differences, have already been implemented at PNPS, or are addressed by a similar SAMA. The remaining 59 SAMAs were subjected to further evaluation. In the third step Entergy estimated the benefits and the costs associated with each of the remaining SAMAs. Estimates were made of how much each SAMA could reduce risk. Those estimates were developed in terms of dollars in accordance with NRC guidance for performing regulatory analyses (NRC 1997). The cost of implementing the proposed SAMAs was also estimated.

Finally, in the fourth step, the costs and benefits of each of the remaining SAMAs were compared to determine whether the SAMA was cost-beneficial, meaning the benefits of the SAMA were greater than the cost (a positive cost-benefit). Entergy found five SAMAs to be potentially cost-beneficial (Entergy 2006a). However, in response to NRC staff inquiries regarding estimated benefits for certain SAMAs and lower cost alternatives, Entergy identified two additional potentially cost-beneficial SAMAs (Entergy 2006b and 2006c). The potentially cost-beneficial SAMAs do not relate to adequately managing the effects of aging during the period of extended operation; therefore, they need not be implemented as part of license renewal pursuant to 10 CFR Part 54. Entergy's SAMA analyses and the NRC's review are discussed in more detail below.

5.2.2 Estimate of Risk

Entergy submitted an assessment of SAMAs for PNPS as part of the ER (Entergy 2006a). This assessment was based on the most recent PNPS PSA available at that time, a plant-specific off-site consequence analysis performed using the MELCOR Accident Consequence Code System 2 (MACCS2) computer program, and insights from the PNPS Individual Plant Examination (IPE) (BEC 1992) and Individual Plant Examination of External Events (IPEEE) (BEC 1994).

The baseline core damage frequency (CDF) for the purpose of the SAMA evaluation is approximately 6.4×10^{-6} per year. This CDF is based on the risk assessment for internally-initiated events. Entergy did not include the contribution to risk from external events within the PNPS risk estimates; however, it did account for the potential risk reduction benefits associated with external events by increasing the estimated benefits for internal events by a factor of five. The breakdown of CDF by initiating event is provided in Table 5-3.

Table 5-3. PNPS Core Damage Frequency

Initiating Event	CDF (Per Year)	Percent Contribution to CDF
Loss of direct current (DC) power buses	3.1×10^{-6}	48
Loss of off-site power	1.3×10^{-6}	20
Loss of alternating current (AC) power buses	8.8×10^{-7}	14
Loss of salt service water	3.9×10^{-7}	6
Transients	3.6×10^{-7}	6
Loss of coolant accidents	1.8×10^{-7}	3
Station blackout	1.5×10^{-7}	2
Anticipated transient without scram	5.3×10^{-8}	1
Interfacing system loss-of-coolant accident (LOCA)	3.6×10^{-8}	<1
Internal flooding	1.3×10^{-8}	<1
Total CDF (from internal events)	**6.4×10^{-6}**	**100**

As shown in Table 5-3, events initiated by loss of DC buses and loss of off-site power are the dominant contributors to CDF. Station blackout (SBO) sequences contribute 1.5 x 10^{-7} per year (about 2 percent of the total internal events CDF), while anticipated transient without scram (ATWS) sequences are insignificant contributors to CDF (5.3 x 10^{-8} per year).

In the ER, Entergy estimated the dose to the population within 50 miles of the PNPS site to be approximately 0.136 person-sievert (Sv) (13.6 person-roentgen equivalents, man [person-rem]) per year. The breakdown of the total population dose by containment release mode is summarized in Table 5-4. Containment failures within the late time frame (greater than 7.5 hours following event initiation) dominate the population dose risk at PNPS.

The NRC staff has reviewed Entergy's data and evaluation methods and concludes that the quality of the risk analyses is adequate to support an assessment of the risk reduction potential for candidate SAMAs. Accordingly, the staff based its assessment of off-site risk on the CDFs and off-site doses reported by Entergy.

5.2.3 Potential Plant Improvements

Once the dominant contributors to plant risk were identified, Entergy searched for ways to reduce that risk. In identifying and evaluating potential SAMAs, Entergy considered insights from the plant-specific PSA, and SAMA analyses performed for other operating plants that have submitted license renewal applications. Entergy identified 281 potential risk-reducing improvements (SAMAs) to plant components, systems, procedures and training.
Entergy removed 222 SAMAs from further consideration because they are not applicable at PNPS due to design differences, have already been implemented at PNPS, or are addressed by a similar SAMA. A detailed cost-benefit analysis was performed for each of the 59 remaining SAMAs.

The staff concludes that Entergy used a systematic and comprehensive process for identifying potential plant improvements for PNPS, and that the set of potential plant improvements identified by Entergy is reasonably comprehensive and, therefore, acceptable.

Table 5-4. Breakdown of Population Dose by Containment Release Mode

Containment Release Mode	Population Dose (Person-Rem[1] Per Year)	Percent Contribution
Late Containment Failure	12.7	93
Early Containment Failure	0.7	5
Containment Bypass	0.2	2
Intact Containment	negligible	negligible
Total	**13.6**	**100**

[1] One person-rem = 0.01 person-Sv

5.2.4 Evaluation of Risk Reduction and Costs of Improvements

Entergy evaluated the risk-reduction potential of the remaining 59 SAMAs. The majority of the SAMA evaluations were performed in a bounding fashion in that the SAMA was assumed to completely eliminate the risk associated with the proposed enhancement.

Entergy estimated the costs of implementing the 59 candidate SAMAs through the application of engineering judgement, and use of other licensees' estimates for similar improvements. The cost estimates conservatively did not include the cost of replacement power during extended outages required to implement the modifications, nor did they include contingency costs associated with unforeseen implementation obstacles.

The staff reviewed Entergy's bases for calculating the risk reduction for the various plant improvements and concludes that the rationale and assumptions for estimating risk reduction are reasonable and somewhat conservative (i.e., the estimated risk reduction is similar to or somewhat higher than what would actually be realized). Accordingly, the staff based its estimates of averted risk for the various SAMAs on Entergy's risk reduction estimates.
The staff reviewed the bases for the applicant's cost estimates. For certain improvements, the staff also compared the cost estimates to estimates developed elsewhere for similar improvements, including estimates developed as part of other licensees' analyses of SAMAs for operating reactors and advanced light-water reactors. The staff found the cost estimates to be consistent with estimates provided in support of other plants' analyses.

The staff concludes that the risk reduction and the cost estimates provided by Entergy are sufficient and appropriate for use in the SAMA evaluation.

5.2.5 Cost-Benefit Comparison

The cost-benefit analysis performed by Entergy was based primarily on NUREG/BR-0184 (NRC 1997) and was executed consistent with this guidance. NUREG/BR-0058 has recently been revised to reflect the agency's revised policy on discount rates. Revision 4 of NUREG/BR-0058 states that two sets of estimates should be developed – one at three percent and one at seven percent (NRC 2004). Entergy provided both sets of estimates (Entergy 2006a).

Entergy identified five potentially cost-beneficial SAMAs in the baseline analysis contained in the ER (using a seven percent discount rate, and considering the combined impact of both external events and uncertainties). The potentially cost-beneficial SAMAs are:

- SAMA 30 – install key-locked control switches to enable AC bus cross-ties and modify procedures to enhance the reliability of the AC power system.

- SAMA 34 – modify plant procedures to use DC bus cross-ties to enhance the reliability of the DC power system.

- SAMA 56 – install additional fuses in panel C7 to enable the direct torus vent (DTV) valve function during loss of containment heat removal accident sequences.

- SAMA 57 – modify plant procedures to allow use of the diesel fire pump hydro turbine in the event that emergency diesel generator (EDG) A fails or fuel oil transfer pump P-141A is unavailable.

- SAMA 58 – modify plant procedures to allow alternately feeding B1 loads via B3 when A3 is available, and alternately feeding B2 loads via B4 when A4 is available.

In response to a request for additional information, Entergy provided a revised assessment based on a modified multiplier for external events and a separate accounting of uncertainties (Entergy 2006b). The revised assessment resulted in identification of the same potentially cost-beneficial SAMAs. No additional SAMAs were identified when the benefits were evaluated using a three percent discount rate, or when the benefits were increased by a factor of 1.6 to account for uncertainties. However, in response to additional NRC staff inquiries regarding estimated benefits for certain SAMAs and lower cost alternatives, Entergy identified two additional potentially cost-beneficial SAMAs (Entergy 2006b and 2006c):

- Control containment venting with a narrow pressure band (SAMA 53), and
- Use the security diesel generator to extend the life of the 125 volt DC batteries (a new SAMA).

The staff concludes that, with the exception of the potentially cost-beneficial SAMAs discussed above, the costs of the SAMAs evaluated would be higher than the associated benefits.

5.2.6 Conclusions

The staff reviewed Entergy's analysis and concluded that the methods used and the implementation of those methods were sound. The treatment of SAMA benefits and costs support the general conclusion that the SAMA evaluations performed by Entergy are reasonable and sufficient for the license renewal submittal. Although the treatment of SAMAs for external events was somewhat limited by the unavailability of an external event PSA, the likelihood of there being cost-beneficial enhancements in this area was minimized by improvements that have been realized as a result of the IPEEE process, and increasing the estimated SAMA benefits for internal events by a factor of five to account for potential benefits in external events.

Based on its review of the SAMA analysis, the staff concurs with Entergy's identification of areas in which risk can be further reduced in a cost-beneficial manner through the implementation of all or a subset of potentially cost-beneficial SAMAs. Given the potential for cost-beneficial risk reduction, the staff considers that further evaluation of these SAMAs by Entergy is warranted. However, none of the potentially cost-beneficial SAMAs relate to adequately managing the effects of aging during the period of extended operation. Therefore, they need not be implemented as part of the license renewal pursuant to 10 CFR Part 54.

5.3 References

10 CFR Part 50. Code of Federal Regulations, Title 10, *Energy*, Part 50, Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operations to Meet the Criterion 'As Low As Reasonably Achievable' for Radiological Material in Light-Water-Cooled Nuclear Power Reactor Effluents."

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

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

10 CFR Part 73. Code of Federal Regulations, Title 10, *Energy*, Part 73, "Physical Protection of Plants and Materials."

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

Boston Edison Company (BEC). 1992. Letter from E. T. Boulette, BEC to U.S. Nuclear Regulatory Commission Document Control Desk. Subject: Response to Generic Letter 88-20, Individual Plant Examination for Severe Accident Vulnerabilities. September 30, 1992.

Boston Edison Company (BEC). 1994. Letter from E. T. Boulette, BEC to U.S. Nuclear Regulatory Commission Document Control Desk. Subject: Response to Generic Letter 88-20, Supplement 4 Individual Plant Examination of External Events for Severe Accident Vulnerabilities. June 30, 1994.

Entergy Nuclear Operations, Inc. 2006a. *Applicant's Environmental Report–Operating License Renewal Stage, Pilgrim Nuclear Power Station*, Docket Number 50-293, Plymouth, Massachusetts.

Entergy Nuclear Operations, Inc. 2006b. Letter from Stephen J. Bethay, Entergy to NRC Document Control Desk. Subject: License Renewal Application Amendment 4: Response to Request for Additional Information Regarding Severe Accident Mitigation Alternatives for Pilgrim Nuclear Power Station (TAC No. MC9676), July 5, 2006.

Entergy Nuclear Operations, Inc. 2006c. Letter from Stephen J. Bethay, Entergy to NRC Document Control Desk. Subject: License Renewal Application Amendment 7, August 30, 2006.

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

Nuclear Regulatory Commission (NRC). 1997. *Regulatory Analysis Technical Evaluation Handbook*. NUREG/BR-0184, Washington, DC.

Nuclear Regulatory Commission (NRC). 1999. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants Main Report*. "Section 6.3 – Transportation, Table 9.1, Summary of findings on NEPA issues for license renewal of nuclear power plants," Final Report. NUREG-1437, Volume 1, Addendum 1, Washington DC.

Nuclear Regulatory Commission (NRC). 2004. *Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission*. NUREG/BR-0058, Revision 4, Washington, DC.

6.0 Environmental Impacts of the Uranium Fuel Cycle and Solid Waste Management

Environmental issues associated with the uranium fuel cycle and solid waste management are discussed in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437, Volumes 1 and 2 (NRC 1996; 1999.)[a] The GEIS includes a determination of whether the analysis of the environmental issue could be applied to all plants and whether additional mitigation measures would be warranted. Issues are 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:

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

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

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

For issues that meet the three Category 1 criteria, no additional plant-specific analysis is required 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.

This chapter addresses the issues that are related to the uranium fuel cycle and solid waste management during the license renewal term that are listed in Table B-1 of Title 10 of the Code of Federal Regulations (CFR) Part 51, Subpart A, Appendix B, and are applicable to Pilgrim Nuclear Power Station (PNPS). 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 GEIS based, in part, on the generic impacts provided in 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

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[a] 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.

to and from One Light-Water-Cooled Nuclear Power Reactor." The U.S. Nuclear Regulatory Commission (NRC) staff also addresses the impacts from radon-222 and technetium-99 in the GEIS.

6.1 The Uranium Fuel Cycle

Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B-1 that are applicable to PNPS from the uranium fuel cycle and solid waste management are listed in Table 6-1.

Table 6-1. Category 1 Issues Applicable to the Uranium Fuel Cycle and Solid Waste Management During the Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section
URANIUM FUEL CYCLE AND WASTE MANAGEMENT	
Off-site radiological impacts (individual effects from other than the disposal of spent fuel and high level waste)	6.2.1; 6.2.2.1; 6.2.2.3; 6.2.3; 6.2.4
Off-site radiological impacts (collective effects)	6.2.2.1; 6.2.3; 6.2.4
Off-site radiological impacts (spent fuel and high level waste disposal)	6.2.2.1; 6.2.2.2; 6.2.3; 6.2.4
Nonradiological impacts of the uranium fuel cycle	6.2.2.6; 6.2.2.7; 6.2.9.8; 6.2.2.9; 6.2.3; 6.2.4
Low-level waste storage and disposal	6.2.2.2; 6.4.2; 6.4.3
Mixed waste storage and disposal	6.4.5
On-site spent fuel	6.4.6
Nonradiological waste	6.5
Transportation	6.3; Addendum 1

Entergy stated in its Environmental Report (ER) (Entergy 2006) that it is not aware of any new and significant information associated with the renewal of the PNPS operating license. The staff has not identified any new and significant information during its independent review of the PNPS ER (Entergy 2006), the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there are no impacts related to these issues beyond those discussed in the GEIS. For these issues, the staff concluded in the GEIS that the impacts are SMALL except for the collective off-site radiological impacts from the fuel cycle and from HLW and spent fuel disposal, as discussed below, and that additional plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

A brief description of the staff review and the GEIS conclusions, as codified in Table B-1, 10 CFR Part 51, for each of these issues follows:

- Off-site radiological impacts (individual effects from other than the disposal of spent fuel and high level waste). Based on information in the GEIS, the Commission found that:

  > Off-site impacts of the uranium fuel cycle have been considered by the Commission in Table S-3 of this part (10 CFR 51.51[b]). Based on information in the GEIS, impacts on individuals from radioactive gaseous and liquid releases including radon-222 and technetium-99 are small.

  The staff has not identified any new and significant information during its independent review of the PNPS ER (Entergy 2006), the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no off-site radiological impacts of the uranium fuel cycle during the renewal term beyond those discussed in the GEIS.

- Off-site radiological impacts (collective effects). Based on information in the GEIS, the Commission found that:

  > The 100 year environmental dose commitment to the U.S. population from the fuel cycle, high level waste and spent fuel disposal excepted, is calculated to be about 14,800 person rem, or 12 cancer fatalities, for each additional 20-year power reactor operating term. Much of this, especially the contribution of radon releases from mines and tailing piles, consists of tiny doses summed over large populations. This same dose calculation can theoretically be extended to include many tiny doses over additional thousands of years as well as doses outside the U.S. The result of such a calculation would be thousands of cancer fatalities from the fuel cycle, but this result assumes that even tiny doses have some statistical adverse health effect which will not ever be mitigated (for example no cancer cure in the next one thousand years), and that these doses projected over thousands of years are meaningful. However, these assumptions are questionable. In particular, science cannot rule out the possibility that there will be no cancer fatalities from these tiny doses. For perspective, the doses are very small fractions of regulatory limits and even smaller fractions of natural background exposure to the same populations.
  >
  > Nevertheless, despite all of the uncertainty, some judgement as to the regulatory NEPA (National Environmental Policy Act of 1969, as amended) implications of these matters should be made and it makes no sense to repeat the same judgement in every case. Even taking the uncertainties into account, the Commission concludes that these impacts are acceptable in that these impacts

> would not be sufficiently large to require the NEPA conclusion, for any plant, that the option of extended operation under 10 CFR Part 54 should be eliminated. Accordingly, while the Commission has not assigned a single level of significance for the collective effects of the fuel cycle, this issue is considered Category 1.

The staff has not identified any new and significant information during its independent review of the PNPS ER (Entergy 2006), the staffs site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no off-site radiological impacts (collective effects) from the uranium fuel cycle during the renewal term beyond those discussed in the GEIS.

- Off-site radiological impacts (spent fuel and high level waste disposal). Based on information in the GEIS, the Commission found that:

> For the high level waste and spent fuel disposal component of the fuel cycle, there are no current regulatory limits for off-site releases of radionuclides for the current candidate repository site. However, if we assume that limits are developed along the lines of the 1995 National Academy of Sciences (NAS) report, “Technical Bases for Yucca Mountain Standards” (NAS 1995), and that in accordance with the Commission’s Waste Confidence Decision, 10 CFR 51.23, a repository can and likely will be developed at some site which will comply with such limits, peak doses to virtually all individuals will be 100 millirem per year or less. However, while the Commission has reasonable confidence that these assumptions will prove correct, there is considerable uncertainty since the limits are yet to be developed, no repository application has been completed or reviewed, and uncertainty is inherent in the models used to evaluate possible pathways to the human environment. The NAS report indicated that 100 millirem per year should be considered as a starting point for limits for individual doses, but notes that some measure of consensus exists among national and international bodies that the limits should be a fraction of the 100 millirem per year. The lifetime individual risk from 100 millirem annual dose limit is about 3 × 10^{-3}.
>
> Estimating cumulative doses to populations over thousands of years is more problematic. The likelihood and consequences of events that could seriously compromise the integrity of a deep geologic repository were evaluated by the Department of Energy in the “Final Environmental Impact Statement: Management of Commercially Generated Radioactive Waste,” October 1980 (DOE 1980). The evaluation estimated the 70-year whole-body dose commitment to the maximum individual and to the regional population resulting from several modes of breaching a reference repository in the year of closure,

> after 1,000 years, after 100,000 years, and after 100,000,000 years. Subsequently, the NRC and other federal agencies have expended considerable effort to develop models for the design and for the licensing of a high level waste repository, especially for the candidate repository at Yucca Mountain. More meaningful estimates of doses to population may be possible in the future as more is understood about the performance of the proposed Yucca Mountain repository. Such estimates would involve very great uncertainty, especially with respect to cumulative population doses over thousands of years. The standard proposed by the NAS is a limit on maximum individual dose. The relationship of potential new regulatory requirements, based on the NAS report, and cumulative population impacts has not been determined, although the report articulates the view that protection of individuals will adequately protect the population for a repository at Yucca Mountain. However, EPA's (U.S. Environmental Protection Agency's) generic repository standards in 40 CFR Part 191 generally provide an indication of the order of magnitude of cumulative risk to population that could result from the licensing of a Yucca Mountain repository, assuming the ultimate standards will be within the range of standards now under consideration. The standards in 40 CFR Part 191 protect the population by imposing "containment requirements" that limit the cumulative amount of radioactive material released over 10,000 years. Reporting performance standards that will be required by EPA are expected to result in releases and associated health consequences in the range between 10 and 100 premature cancer deaths with an upper limit of 1,000 premature cancer deaths world-wide for a 100,000 metric tonne repository.
>
> Nevertheless, despite all of the uncertainty, some judgement as to the regulatory NEPA implications of these matters should be made and it makes no sense to repeat the same judgement in every case. Even taking the uncertainties into account, the Commission concludes that these impacts are acceptable in that these impacts would not be sufficiently large to require the NEPA conclusion, for any plant, that the option of extended operation under 10 CFR Part 54 should be eliminated. Accordingly, while the Commission has not assigned a single level of significance for the impacts of spent fuel and high level waste disposal, this issue is considered Category 1.

On February 15, 2002, based on a recommendation by the Secretary of the Department of Energy, the President recommended the Yucca Mountain site for the development of a repository for the geologic disposal of spent nuclear fuel and HLW. The U.S. Congress approved this recommendation on July 9, 2002, in Joint Resolution 87, which designated Yucca Mountain as the repository for spent nuclear waste. On July 23, 2002, the President signed Joint Resolution 87 into law; Public Law 107-200, 116 Stat. 735 (2002) designates Yucca Mountain as the repository for spent nuclear waste. This development does not represent new and significant information with respect to the off-site radiological impacts from license renewal related to disposal of spent nuclear fuel and HLW.

The EPA developed Yucca Mountain-specific repository standards, which were subsequently adopted by the NRC in 10 CFR Part 63. In an opinion, issued July 9, 2004, the U.S. Court of Appeals for the District of Columbia Circuit (the Court) vacated EPA's radiation protection standards for the candidate repository, which required compliance with certain dose limits over a 10,000 year period. The Court's decision also vacated the compliance period in NRC's licensing criteria for the candidate repository in 10 CFR Part 63.

Therefore, for the HLW and spent fuel disposal component of the fuel cycle, there is some uncertainty with respect to regulatory limits for off-site releases of radioactive nuclides for the current candidate repository site. However, prior to promulgation of the affected provisions of the Commission's regulations, it was assumed that limits would be developed in line with the 1995 NAS report, *Technical Bases for Yucca Mountain Standards* (NAS 1995), and that in accordance with the Commission's Waste Confidence Decision, 10 CFR 51.23, a repository that would comply with such limits could and likely would be developed at some site. Peak doses to virtually all individuals would be 100 mrem per year or less.

Despite the current uncertainty with respect to these rules, some judgment as to the 1969 NEPA implications of off-site radiological impacts of spent fuel and HLW disposal should be made. The staff concludes that these impacts are acceptable in that the impacts would not be sufficiently large to require the NEPA conclusion that the option of extended operation under 10 CFR Part 54 should be eliminated.

The staff has not identified any new and significant information during its independent review of the PNPS ER (Entergy 2006), the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no off-site radiological impacts related to spent fuel and HLW disposal during the renewal term beyond those discussed in the GEIS.

- Nonradiological impacts of the uranium fuel cycle. Based on information in the GEIS, the Commission found that:

> The nonradiological impacts of the uranium fuel cycle resulting from the renewal of an operating license for any plant are found to be small.

The staff has not identified any new and significant information during its independent review of the PNPS ER (Entergy 2006), the staffs site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no nonradiological impacts of the uranium fuel cycle during the renewal term beyond those discussed in the GEIS.

- Low-level waste storage and disposal. Based on information in the GEIS, the Commission found that:

  > The comprehensive regulatory controls that are in place and the low public doses being achieved at reactors ensure that the radiological impacts to the environment will remain small during the term of a renewed license. The maximum additional on-site land that may be required for low-level waste storage during the term of a renewed license and associated impacts will be small. Nonradiological impacts on air and water will be negligible. The radiological and nonradiological environmental impacts of long-term disposal of low-level waste from any individual plant at licensed sites are small. In addition, the Commission concludes that there is reasonable assurance that sufficient low-level waste disposal capacity will be made available when needed for facilities to be decommissioned consistent with NRC decommissioning requirements.

  The staff has not identified any new and significant information during its independent review of the PNPS ER (Entergy 2006), the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of low-level waste storage and disposal associated with the renewal term beyond those discussed in the GEIS.

- Mixed waste storage and disposal. Based on information in the GEIS, the Commission found that:

  > The comprehensive regulatory controls and the facilities and procedures that are in place ensure proper handling and storage, as well as negligible doses and exposure to toxic materials for the public and the environment at all plants. License renewal will not increase the small, continuing risk to human health and the environment posed by mixed waste at all plants. The radiological and nonradiological environmental impacts of long-term disposal of mixed waste from any individual plant at licensed sites are small. In addition, the Commission concludes that there is reasonable assurance that sufficient mixed waste disposal capacity will be made available when needed for facilities to be decommissioned consistent with NRC decommissioning requirements.

The staff has not identified any new and significant information during its independent review of the PNPS ER (Entergy 2006), the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of mixed waste storage and disposal associated with the renewal term beyond those discussed in the GEIS.

- On-site spent fuel. Based on information in the GEIS, the Commission found that:

  > The expected increase in the volume of spent fuel from an additional 20 years of operation can be safely accommodated on-site with small environmental effects through dry or pool storage at all plants if a permanent repository or monitored retrievable storage is not available.

  The staff has not identified any new and significant information during its independent review of the PNPS ER (Entergy 2006), the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of on-site spent fuel associated with license renewal beyond those discussed in the GEIS.

- Nonradiological waste. Based on information in the GEIS, the Commission found that:

  > No changes to generating systems are anticipated for license renewal. Facilities and procedures are in place to ensure continued proper handling and disposal at all plants.

  The staff has not identified any new and significant information during its independent review of the PNPS ER (Entergy 2006), the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no nonradiological waste impacts during the renewal term beyond those discussed in the GEIS.

- Transportation. Based on information contained in the GEIS, the Commission found that:

  > The impacts of transporting spent fuel enriched up to 5 percent uranium-235 with average burnup for the peak rod to current levels approved by NRC up to 62,000 MWd/MTU (megawatt-days per metric ton of uranium) and the cumulative impacts of transporting high-level waste to a single repository, such as Yucca Mountain, Nevada are found to be consistent with the impact values contained in 10 CFR 51.52(c), Summary Table S-4 – Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor. If fuel enrichment or burnup conditions are not met, the applicant must submit an assessment of the implications for the environmental impact values reported in § 51.52.

PNPS meets the fuel-enrichment and burnup conditions set forth in Addendum 1 to the GEIS. The staff has not identified any new and significant information during its independent review of the PNPS ER (Entergy 2006), the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts of transportation associated with license renewal beyond those discussed in the GEIS.

There are no Category 2 issues for the uranium fuel cycle and solid waste management.

6.2 References

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

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

10 CFR Part 63. Code of Federal Regulations, Title 10, *Energy,* Part 63, "Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada."

40 CFR Part 191. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Waste."

Department of Energy (DOE). 1980. *Final Environmental Impact Statement: Management of Commercially Generated Radioactive Waste*. DOE/EIS-0046F, Washington, DC.

Entergy Nuclear Operations, Inc. (Entergy). 2006. *Applicant's Environmental Report – Operating License Renewal Stage Pilgrim Nuclear Power Station*. Docket Number 50-293, Plymouth, Massachusetts.

Joint Resolution 87, 2002. Public Law 107-200, 116 Stat 735.

National Academy of Sciences (NAS). 1995. *Technical Bases for Yucca Mountain Standards*. Washington, DC.

National Environmental Policy Act of 1969, as amended (NEPA) 42 USC 4321, et seq.

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

Nuclear Regulatory Commission (NRC). 1999. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Main Report*, “Section 6.3 – Transportation, Table 9.1, Summary of findings on NEPA issues for license renewal of nuclear power plants,” Final Report. NUREG-1437, Volume 1, Addendum 1, Washington, DC.

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 staff's evaluation of the environmental impacts of decommissioning presented in NUREG-0586, Supplement 1 identifies a range of impacts for each environmental issue.

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)[a]. 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 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:

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

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

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

For issues that meet the three Category 1 criteria, no additional plant-specific analysis is required 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.

(a) 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.

7.1 Decommissioning

Category 1 issues in Table B-1 of Title 10 of the Code of Federal Regulations (CFR) Part 51, Subpart A, Appendix B that are applicable to Pilgrim Nuclear Power Station (PNPS) decommissioning following the renewal term are listed in Table 7-1. Entergy Nuclear Operations, Inc. (Entergy) stated in its Environmental Report (ER) (Entergy 2006) that it is aware of no new and significant information regarding the environmental impacts of PNPS license renewal. The staff has not identified any new and significant information during its independent review of the PNPS ER (Entergy 2006), the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there are no impacts related to these issues beyond those discussed in the GEIS. For all of these issues, the staff concluded in the GEIS that the impacts are SMALL, and additional plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

Table 7-1. Category 1 Issues Applicable to the Decommissioning of PNPS Following the Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section
DECOMMISSIONING	
Radiation doses	7.3.1
Waste management	7.3.2
Air quality	7.3.3
Water quality	7.3.4
Ecological resources	7.3.5
Socioeconomic impacts	7.3.7

A brief description of the staff's review and the GEIS conclusions, as codified in Table B-1, 10 CFR Part 51, for each of the issues follows:

- Radiation doses. Based on information in the GEIS, the Commission found that:

> Doses 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 man-rem caused by buildup of long-lived radionuclides during the license renewal term.

The staff has not identified any new and significant information during its independent review of the PNPS ER (Entergy 2006), the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no radiation dose impacts associated with decommissioning following the license renewal term beyond those discussed in the GEIS.

- Waste management. Based on information in the GEIS, the Commission found that:

> Decommissioning 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.

The staff has not identified any new and significant information during its independent review of the PNPS ER (Entergy 2006), the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts from solid waste associated with decommissioning following the license renewal term beyond those discussed in the GEIS.

- Air quality. Based on information in the GEIS, the Commission found that:

> Air 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.

The staff has not identified any new and significant information during its independent review of the PNPS ER (Entergy 2006), the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts on air quality associated with decommissioning following the license renewal term beyond those discussed in the GEIS.

- Water quality. Based on information in the GEIS, the Commission found that:

> The 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.

The staff has not identified any new and significant information during its independent review of the PNPS ER (Entergy 2006), the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts on water quality associated with decommissioning following the license renewal term beyond those discussed in the GEIS.

- Ecological resources. Based on information in the GEIS, the Commission found that:

> Decommissioning after either the initial operating period or after a 20-year license renewal period is not expected to have any direct ecological impacts.

The staff has not identified any new and significant information during its independent review of the PNPS ER (Entergy 2006), the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no impacts on ecological resources associated with decommissioning following the license renewal term beyond those discussed in the GEIS.

- Socioeconomic Impacts. Based on information in the GEIS, the Commission found that:

> Decommissioning 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.

The staff has not identified any new and significant information during its independent review of the PNPS ER (Entergy 2006), the site visit, the scoping process, evaluation of other available information, or consideration of public comments. Therefore, the staff concludes that there would be no socioeconomic impacts associated with decommissioning following the license renewal term beyond those discussed in the GEIS.

7.2 References

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

Entergy Nuclear Generation Company (Entergy). 2006. *Applicant's Environmental Report – Operating License Renewal Stage Pilgrim Nuclear Power Station*. Docket Number 50-293, Plymouth, Massachusetts.

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

Nuclear Regulatory Commission (NRC). 1999. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Main Report*, "Section 6.3 – Transportation, Table 9.1, Summary of findings on NEPA issues for license renewal of nuclear power plants," Final Report. NUREG-1437, Volume 1, Addendum 1, Washington, DC.

Nuclear Regulatory Commission (NRC). 2002. *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities: Supplement 1, Regarding the Decommissioning of Nuclear Power Reactors.* NUREG-0586, Supplement 1, Volumes 1 and 2, Washington, DC.

8.0 Environmental Impacts of Alternatives to License Renewal

This chapter examines the potential environmental impacts associated with denying the renewal of an operating license (OL) (i.e., the no-action alternative); the potential environmental impacts from electric generating sources other than Pilgrim Nuclear Power Station (PNPS); the possibility of purchasing electric power from other sources to replace power generated by PNPS and the associated environmental impacts; the potential environmental impacts from a combination of generating and conservation measures; and other generation alternatives that were deemed unsuitable for replacement of power generated by PNPS. The environmental impacts are evaluated using the U.S. Nuclear Regulatory Commission's (NRC's) three-level standard of significance—SMALL, MODERATE, or LARGE—developed using the Council on Environmental Quality guidelines and set forth in the footnotes to Table B-1 of Title 10 of the Code of Federal Regulations (CFR) Part 51, Subpart A, Appendix B:

> 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 impact categories evaluated in this chapter are the same as those used in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS*), NUREG-1437, Volumes 1 and 2 (NRC 1996, 1999)(a), with the additional impact categories of environmental justice and transportation.

8.1 No-action Alternative

The NRC's regulations implementing the National Environmental Policy Act of 1969, as amended (NEPA) specify that the no-action alternative be discussed in an NRC environmental impact statement (EIS) [see 10 CFR Part 51, Subpart A, Appendix A(4)]. For license renewal, the no-action alternative refers to a scenario in which the NRC would not renew the OL for PNPS and Entergy Nuclear Operations, Inc. (Entergy) would then cease plant operations by the end of the current license and initiate decommissioning of the plant.

(a) 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.

Entergy will be required to shut down PNPS and comply with NRC decommissioning requirements in 10 CFR 50.82 whether or not the OL is renewed. If the PNPS OL is renewed, shutdown of the facility and decommissioning activities will not be avoided, but will be postponed for up to an additional 20 years.

The environmental impacts associated with decommissioning, following a license renewal period of up to 20 years or following the no-action alternative, would be bounded by the discussion of impacts in Chapter 7 of the GEIS, Chapter 7 of this supplemental EIS (SEIS), and the *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities*, NUREG 0586, Supplement 1 (NRC 2002). The impacts of decommissioning after 60 years of operation are not expected to be significantly different from those occurring after 40 years of operation.

Impacts from the decision to permanently cease operations are not considered in NUREG-0586, Supplement 1(b). Therefore, immediate impacts that occur between plant shutdown and the beginning of decommissioning are considered here. These impacts will occur when the unit shuts down regardless of whether the license is renewed or not and are discussed below, with the results presented in Table 8-1, which is presented at the end of this section (Section 8.1). Plant shutdown will result in a net reduction in power production capacity. The power not generated by PNPS during the license renewal term would likely be replaced by (1) power supplied by other independent producers using generating technologies that will differ from that employed at PNPS, (2) demand-side management (DSM) and energy conservation, or (3) some combination of these options. The environmental impacts of these options are discussed in Section 8.2.

8.1.1 Land Use

In Chapter 4, the staff concluded that the impacts of continued plant operation on land use would be SMALL. On-site land use will not be affected immediately by the cessation of operations. Plant structures and other facilities are likely to remain in place until decommissioning. In the near term the transmission line associated with PNPS will likely be retained until final disposition of the dormant facility and site are ascertained. In the long term, it is possible that the transmission lines that extend from the on-site switch yard to interconnections at Jordan and Snake Hill Roads will be removed at which point maintenance of the right-of-way (ROW) will discontinue and the ROW will revert to the conditions found in

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(b) Appendix J of NUREG-0586 Supplement 1 discusses the socioeconomic impacts of plant closure, but the results of the analysis in Appendix J are not incorporated in the analysis presented in the main body of the NUREG.

adjacent areas. Also, as a result of plant shutdown, there would be a reduction in uranium mining activity positively impacting approximately 715 acres (ac). Therefore, the staff concludes that the impacts on land use from plant shutdown would be SMALL.

8.1.2 Ecology

In Chapter 4 of this SEIS, the NRC staff concluded that the ecological impacts of continued plant operation ranged from SMALL to MODERATE. Cessation of operations will be accompanied by elimination of the cooling water intake flow and the facility's thermal plume. The environmental impacts to aquatic species, including threatened and endangered species, associated with these changes are generally positive. The impacts of plant closure on the terrestrial ecosystem range between negative and positive depending on final disposition of the Entergy Woodlands area across which the PNPS transmission lines run. Currently, there is an active management program on that property that preserves habitat and controls invasive species. Cessation of that program would produce negative impact. Therefore, the staff concludes that overall ecological impacts from shutdown of the plant would be SMALL.

8.1.3 Water Use and Quality–Surface Water

In Chapter 4 of this SEIS, the NRC staff concluded that impacts of continued plant operation on surface water use and quality were SMALL. When the plant stops operating there will be an immediate reduction in the consumptive use of water because of the elimination of the cooling water intake and in the amount of heat discharged to Cape Cod Bay. Therefore, the staff concludes that the impacts on surface water use and quality from plant shutdown would be SMALL.

8.1.4 Water Use and Quality–Groundwater

In Chapter 4, the staff determined that the facility does not utilize on-site groundwater resources. In addition, impacts of continued subsurface discharge of treated sanitary wastes by the facility were determined to be SMALL. When the plant stops operating, there will be an immediate reduction in discharge of treated sanitary waste. Therefore, the staff concludes that groundwater quality impacts from shutdown of the plant would be SMALL.

8.1.5 Air Quality

In Chapter 4, the staff found the impacts of continued plant operation on air quality to be SMALL. When the plant stops operating, there will be a reduction in emissions from activities related to plant operation such as use of diesel generators and workers transportation. Therefore, the staff concludes that the impact on air quality from shutdown of the plant would be SMALL.

8.1.6 Waste

The impacts of waste generated by continued plant operation are discussed in Chapter 6. The impacts of low-level and mixed waste from plant operation are characterized as SMALL. When the plant stops operating, the plant will stop generating high-level waste and generation of low-level and mixed waste associated with plant operation and maintenance will be reduced. Therefore, the staff concludes that the impact of waste generated after shutdown of the plant would be SMALL.

8.1.7 Human Health

In Chapter 4 of this SEIS, the NRC staff concluded that the impacts of continued plant operation on human health were SMALL. After the cessation of operations, the amount of radioactive material released to the environment in gaseous and liquid forms will be reduced. Therefore, the staff concludes that the impact of shutdown of the plant on human health would be SMALL. In addition, the variety of potential accidents at the plant will be reduced to a limited set associated with shutdown events and fuel handling. In Chapter 5 of this SEIS, the NRC staff concluded that the impacts of accidents during operation were SMALL. Therefore, the staff concludes that the impacts of potential accidents following shutdown of the plant would be SMALL.

8.1.8 Socioeconomics

In Chapter 4, the NRC staff concluded that the socioeconomic impacts of continued plant operation would be SMALL. But, should the plant shutdown, there would be immediate socioeconomic impacts due to the loss of jobs (approximately 700) and there may also be an immediate reduction in property tax revenues for Plymouth Township. These impacts may, however, be offset as a result of the projected regional economic growth. The NRC staff concludes that the socioeconomic impacts of plant shutdown would be MODERATE. See Appendix J to NUREG-0586, Supplement 1 (NRC 2002), for additional discussion of the potential impacts of plant shutdown.

8.1.9 Socioeconomics (Transportation)

In Chapter 4, the staff concluded that the impacts of continued plant operation on transportation would be SMALL. Cessation of operations will be accompanied by reduced traffic in the vicinity of the plant. Most of the reduction will be associated with a reduction in plant workforce, but there will also be a reduction in shipment of maintenance materials to and from the plant. Therefore, the staff concludes that the impacts of plant closure on transportation would be SMALL.

8.1.10 Aesthetics

In Chapter 4, the staff concluded that the aesthetic impacts of continued plant operation would be SMALL. Plant structures and other facilities are likely to remain in place until decommissioning. Upon decommissioning the number of on-site structures would be reduced. Therefore, the staff concludes that the aesthetic impacts of plant closure would be SMALL.

8.1.11 Historic and Archaeological Resources

In Chapter 4, the staff concluded that the impacts of continued plant operation on historic and archaeological resources would be SMALL. On-site land use will not be affected immediately by the cessation of operations. Plant structures and other facilities are likely to remain in place until decommissioning. The transmission lines associated with the project may ultimately be removed once the facility stops operating and, should this occur, maintenance of the transmission line ROW will cease. Therefore, the staff concludes that the impacts on historic and archaeological resources from plant shutdown would be SMALL.

8.1.12 Environmental Justice

In Chapter 4, the staff concluded that the environmental justice impact of continued operation of the plant would be SMALL because continued operation of the plant would not have a disproportionately high and adverse impact on minority and low-income populations. Shutdown of the plant likewise is not expected to disproportionately impact minority and low-income populations. The staff concludes that the environmental justice impacts of plant shutdown would be SMALL. See Appendix J to NUREG-0586, Supplement 1 (NRC 2002), for additional discussion of these impacts.

Table 8-1. Summary of Environmental Impacts of the No-action Alternative

Impact Category	Impact	Comment
Land Use	SMALL	Impacts are expected to be SMALL because plant shutdown is expected to result in few changes to off-site and on-site land use, and transition to alternate uses is expected over an extended timeframe.
Ecology	SMALL	Small negative impacts to terrestrial ecology of conservation management of transmission corridor ceases. Moderate positive impacts to local winter flounder populations.
Water Use and Quality-Surface Water	SMALL	Impacts are expected to be SMALL because surface water intake and discharges will decrease.
Water Use and Quality-Groundwater	SMALL	Impacts are expected to be SMALL because groundwater discharges will decrease.
Air Quality	SMALL	Impacts are expected to be SMALL because discharges related to plant operation and worker transportation will decrease.
Waste	SMALL	Impacts are expected to be SMALL because generation of high-level waste will stop, and generation of low-level and mixed waste will decrease.
Human Health	SMALL	Impacts are expected to be SMALL because radiological doses to workers and members of the public, which are within regulatory limits, will be reduced.
Socioeconomics	MODERATE	Impacts are expected to be MODERATE because of a decrease in employment and tax revenues.
Socioeconomics (Transportation)	SMALL	Impacts are expected to be SMALL because the decrease in employment would reduce traffic.
Aesthetics	SMALL	Impacts are expected to SMALL because plant structures will remain for an extended period.
Historic and Archaeological Resources	SMALL	Impacts are expected to be SMALL because shutdown of the plant will not change land use.
Environmental Justice	SMALL	Impacts are expected to be SMALL because there are no disproportionate impacts to minority or low income populations.

8.2 Alternative Energy Sources

This section discusses the environmental impacts associated with developing alternative sources of electric power to replace power generated by PNPS under the assumption that the OL for PNPS is not renewed. The order of alternative energy sources presented in this section does not imply which alternative would be most likely to occur or which is expected to have the least environmental impacts.

The following central generating station alternatives are considered in detail:

- coal-fired generation at an alternate greenfield(c) site (Section 8.2.1),
- natural gas-fired generation at either the PNPS site or an alternate greenfield site (Section 8.2.2), and
- nuclear generation at an alternate greenfield site (Section 8.2.3).

The alternative of importing power to replace power generated at PNPS is discussed in Section 8.2.4. Other power generation alternatives and conservation alternatives considered by the staff are discussed in Section 8.2.5. Section 8.2.6 discusses the environmental impacts of a combination of generation and conservation alternatives.

Each year the Energy Information Administration (EIA), a component of the U.S. Department of Energy (DOE), issues an Annual Energy Outlook. In its *Annual Energy Outlook* 2006 *with Projections to* 2030, EIA projects that natural gas-fired plants will account for approximately 40 percent of new electric generating capacity between the years 2004 and 2030 (DOE/EIA2006a). This technology is designed primarily to supply peak and intermediate electric generating capacity, but combined-cycle gas-fired systems can also be used to meet baseload(d) requirements. Coal-fired plants are projected by EIA to account for approximately 50 percent of new capacity additions during this period. Coal-fired plants are generally used to meet baseload requirements. Renewable energy sources, primarily wind, biomass gasification, and municipal solid waste units, are projected by EIA to account for 8 percent of capacity additions.

EIA's projections of technologies are based on the assumption that providers of new generating capacity will seek to minimize cost while meeting applicable environmental requirements.

(c) A greenfield site is assumed to be an undeveloped site with no previous construction.

(d) A baseload plant normally operates to supply all or part of the minimum continuous load of a system and consequently produces electricity at an essentially constant rate. Nuclear power plants are commonly used for baseload generation; and generally run near full load.

According to EIA, advanced coal-fired and advanced combined-cycle generating facilities are expected to be approximately competitive with each other in 2015, on a total evaluated cost of production basis, while advanced coal-burning facilities are expected to gain a competitive edge by 2030 (DOE/EIA 2006a). EIA projects that oil-fired plants will account for little or none of the new generating capacity additions in the United States (U.S.) during the 2004 to 2030 time frame because of high fuel costs (DOE/EIA 2006a). EIA also projects that about 6 gigawatts of new nuclear power generating capacity will be constructed prior to 2020 when the Energy Policy Act of 2005 tax credits expire (DOE/EIA 2006a). NRC established a reactor licensing program organization to manage reactor and site licensing applications (NRC 2001). Several site licensing applications are currently under review by the NRC and nuclear operating companies have announced their intention to submit reactor license applications beginning in late 2007. NRC has announced plans to reorganize the agency to further prepare for the industry's announced interest in licensing and building new nuclear plants (NRC 2006). Thus, a new nuclear plant alternative for replacing power generated by PNPS is considered in this SEIS and resulting impacts are presented in Section 8.2.3.

Since PNPS has a gross electric output of 715 megawatts electric [MW(e)], the staff evaluated coal, natural gas, and new nuclear alternatives having comparable capabilities. As discussed further below, siting a 715 MW(e) alternative technology depends, in part, on the land area available at PNPS. If the available land at PNPS is inadequate to support a particular technology, the analysis addresses impacts under the assumption that the new generating capacity is built at a hypothetical greenfield site. For technologies that can be constructed at PNPS, the analysis considers impacts at both PNPS and at a greenfield site. The location of the hypothetical greenfield site is not specified herein.

Since PNPS began operating in 1972, the era of regulated utilities generating power for distribution within their service territories has largely passed. Today New England in general, and Massachusetts in particular, obtain most electric power from independent power producers that operate generating facilities throughout and beyond the region. Thus, both appropriate market conditions as well as siting opportunities would have to be present for one of the alternative technologies evaluated in Section 8.2 to actually be developed.

While the greenfield site considered here need not be situated within the New England region, the availability of transmission line capacity to deliver the output of an alternative technology to current PNPS customers could significantly constrain siting choices. Based on a recent DOE Report (DOE/EIA 2006b) it appears that transmission line constraints currently occur within both New England and adjoining New York State. According to the DOE, new projects are expected to ease transmission line congestion in New England, though continued growth in demand and the retirement of older facilities will result in a need to consider investments in both new generating and transmission line capacity (DOE/EIA 2006b). Finally, the feasibility of finding a greenfield site and obtaining approvals to construct either a coal-fired or nuclear facility there by 2012, when the PNPS OL expires, is questionable. This difficulty is not addressed in Section 8.2, but rather it is assumed that power would be obtained from various sources in the interim while one of the alternate technologies is constructed and comes on-line. In contrast, it may be possible for a gas-fired facility to be operational by 2012 at either the PNPS site or at a greenfield location.

8.2.1 Coal-Fired Generation

The assumptions and numerical values used in Section 8.2.1 are based on the staff's independent assessment and on information provided by Entergy in the PNPS Environmental Report (ER) (Entergy 2006). Where information from the PNPS ER was used, it was independently reviewed by the staff and compared to environmental impact information in the GEIS. Impacts of a coal-fired alternative evaluated by the staff assume that the new plant would have a gross electrical capacity of 715 MW(e); this differs somewhat from the assumption made in the ER. Furthermore, while the PNPS OL renewal period is only 20 years, the impact of operating a coal-fired alternative for a full 40 years is considered, since 40 years is the expected operating life of a new coal-fired plant.

There is insufficient land area at PNPS to support operations of a 715 gross MW(e) coal-fired alternative. Therefore, the coal-fired alternative is analyzed only for a greenfield site. Based on Table 8-1 of the GEIS, a pulverized coal-fired facility requires approximately 1.7 ac of land per MW(e). To replace PNPS with a coal-fired facility a 1215 ac parcel would be needed while only 140 ac are available at PNPS. It is unrealistic to think that a pulverized coal-fired facility with associated coal yard, waste disposal area, and transportation systems could be accommodated at PNPS. It should be noted that several of the newer coal utilization technologies (e.g., Integrated Gasification Combined Cycle [IGCC]) could be accommodated on smaller sites than estimated here. However, these alternate technologies would still involve transportation of fuel to the power plant and that facet of coal combustion which involves construction of either a new rail line or coal pier, is not compatible with conditions of the PNPS site.

The coal-fired plant would consume approximately 2.18 million tons per year of pulverized bituminous coal with an ash content of approximately 8.2 percent. Entergy assumes a heat rate(e) of 10,200 BTU/kWh and a capacity factor(f) of 0.85 in the ER (Entergy 2006). After combustion, 99.9 percent of the ash would be collected and disposed of at the plant site. In

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(e) Heat rate is a measure of generating station thermal efficiency. In English units, it is generally expressed in British thermal units (BTUs) per net kilowatt-hour (kWh). It is computed by dividing the total BTU content of the fuel burned for electric generation by the resulting kWh generation.

(f) The capacity factor is the ratio of electricity generated, for the period of time considered, to the energy that could have been generated at continuous full-power operation during the same period.

addition, approximately 77,700 tons of scrubber sludge would also be disposed on-site based on annual lime usage of approximately 26,300 tons. Lime is used in the scrubbing process for control of sulfur dioxide (SO_2) emissions.

Coal and lime would be delivered to the generating station site by either rail or barge. If deliveries were by rail, then a rail spur would be constructed to bring coal onto the site from a main rail line. Should waterborne delivery prove feasible, a receiving dock would be constructed for berthing either barges or colliers alongside the facility. Development of a coal-fired facility at an alternate site would also necessitate the construction of a transmission line to connect the new plant to the regional transmission system.

8.2.1.1 Closed-Cycle Cooling System

For purposes of this section, the staff assumed that a coal-fired plant located at an alternate site would use a closed-cycle cooling system.

The overall impacts of the coal-fired generating system are discussed in the following sections and summarized in Table 8-2, at the end of this section (Section 8.2.1.1). The implications of constructing a new coal-fired plant at an alternate greenfield site will depend on the actual location of that site; however, as presented below, a general evaluation of impacts is possible.

- **Land Use**

  Construction of a 715 gross MW(e) pulverized coal-fired alternative at a greenfield site could impact up to 1215 ac of land (NRC 1996). Additional land would be needed to bring a rail spur onto the greenfield site and, as well, for a transmission line to deliver the plant's output to the nearest transmission inter-tie. Depending on the length of transmission line and rail line routing, this alternative would result in MODERATE to LARGE land-use impacts at and in the vicinity of the greenfield site.

  Additionally, land use changes would occur at an undetermined coal mining area where approximately 24 square miles (mi^2) would be affected for mining coal and disposing of mining wastes to support a 715 MW(e) coal-fired power plant [the GEIS estimates that approximately 34 mi^2 would be disturbed for a 1000 MW(e) coal-fired plant (NRC 1996)]

- **Ecology**

  Siting a coal-fired plant at a greenfield site would introduce construction and operating impacts. Ecological resources would be altered due to the need to convert roughly 1215 ac of land to industrial use (generating facilities, coal storage, ash and scrubber sludge disposal). Even if some of the site had been previously disturbed, it is expected that impacts of developing a 1215 ac area would include wildlife habitat loss, reduced productivity, habitat fragmentation, and reduction in on-site biological diversity.

Use of a nearby surface water resource to provide cooling tower make-up would have some impact on local aquatic resources. Construction and maintenance of a transmission line and rail spur would incrementally add to the terrestrial ecological impacts. Overall, the staff concludes that ecological impacts at an alternate site would be MODERATE to LARGE.

- **Water Use and Quality**

Surface Water

For the coal-fired alternative at a greenfield site, impacts to surface waters would result from withdrawal of water for various operating needs of the facility. These operating needs would include cooling tower make-up and possibly auxiliary cooling for equipment and potable water requirements.

Discharges to surface water could result from cooling tower blowdown, coal pile runoff, and runoff from coal ash and scrubber byproduct disposal areas. Both the use of surface waters and runoff to surface waters would be regulated by the State [or U.S. Environmental Protection Agency (EPA) in the case of a facility built in Massachusetts] within which the facility is located. Consequently, it can be expected that a coal-fired facility at a greenfield site would comply with requirements of a discharge permit and would legally be obligated to meet water quality standards. Overall, the staff concludes that the potential impacts to surface water resources and water quality would be SMALL to MODERATE. The impact level would importantly depend on the discharge volume and characteristics of the receiving water body.

Groundwater

Groundwater use at an alternate site for potable water purposes could potentially occur. It is also possible that other plant requirements could be met with groundwater depending on site-specific hydrogeologic conditions. Potential impacts to groundwater quality may occur as a result of on-site coal storage and on-site disposal of ash and scrubber sludge. In all cases, it is expected that a coal-fired facility would be obligated to comply with a groundwater use and discharge permit issued by the State within which the facility is located. Therefore, the staff concludes that the potential impacts to groundwater resources would be SMALL to MODERATE.

- **Air Quality**

The air quality impacts of a pulverized coal-fired facility vary considerably from those of a comparable nuclear plant, due to emissions of sulfur oxides (SO_x), nitrogen oxides (NO_x), particulates, carbon monoxide (CO), hazardous air pollutants (e.g., mercury) and naturally occurring radioactive materials.

PNPS is located in Plymouth County, Massachusetts which has been designated an attainment area (i.e., meets the National Ambient Air Quality Standards promulgated by EPA and found in 40 CFR Part 50 for CO, NO_2, lead, and SO_2). In addition, Plymouth County is in attainment of the Federal standards for particulate air pollution [less than 10 (PM_{10}) and less than 2.5 ($PM_{2.5}$) microns (μm)]. However, Plymouth County, as part of the Boston-Lawrence-Worcester ozone non-attainment area, does not meet the Federal 8-hour standard for ozone.

The EPA has various regulatory requirements for visibility protection in 40 CFR Part 51, Subpart P, including a specific requirement for review of any major stationary source in an area designated as attainment or unclassified under the Clean Air Act (CAA). These requirements could apply to the coal-fired alternative depending on the attainment status of the region within which the alternative is located. As noted above, the Plymouth County vicinity is in attainment of all Federal criteria pollutants except ozone.

A new coal-fired generating plant located in Massachusetts would need a prevention of significant deterioration permit issued under Title 1, Part C, of the CAA. The project would also need an operating permit under Title V of the CAA. The plant would be required to comply with the new source performance standards for such plants as set forth in 40 CFR Part 60 Subpart D(a). The standards establish limits for particulate matter and opacity (40 CFR 60.42a), SO_2 (40 CFR 60.43a), and NO_X (40 CFR 60.44a).

Section 169A of the CAA (42 USC 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. EPA issued a regional haze rule on July 1, 1999 [64 FR 35714 (EPA 1999)]. The rule specifies that for each mandatory Class I federal area located within a state, the State must establish goals that provide for reasonable progress towards achieving natural visibility conditions. The reasonable progress goals must provide for an improvement in visibility for the most impaired days over the period of the implementation plan and ensure no degradation in visibility for the least impaired days over the same period (40 CFR 51.308[d][1]). If a coal-fired plant were located close to a mandatory Class I area (there are none in Massachusetts), additional air pollution control requirements could be imposed.

In 1998, the EPA issued a rule requiring 22 eastern states, including Massachusetts, to revise their state implementation plans to reduce NO_x emissions. NO_x emissions contribute to violations of the national ambient air quality standard for ozone. The total amount of NO_x which can be emitted by each of the 22 states in the year 2007 ozone season (May 1 to September 30) is set out at 40 CFR 51.121(e). For Massachusetts, the amount is 85,296 tons.

EPA issued the Clean Air Interstate Rule (CAIR) in May 2005 [70 FR 25162 (EPA 2005)]. CAIR provides a Federal framework requiring certain states to reduce emissions of SO_2 and No_x. EPA anticipates that states will achieve this reduction primarily by limiting emissions from the power generation sector. CAIR covers 28 eastern states and any new fossil-fired power plant sited in Massachusetts would be subject to the CAIR limitations.

Air quality impacts for various pollutants are as follows:

<u>Sulfur oxides emissions</u>. Entergy indicates in its ER that a coal-fired plant would use a hydrated lime-wet scrubbing system for flue gas desulfurization (Entergy 2006). A new coal-fired power plant would be subject to the requirements in Title IV of the CAA. Title IV was enacted to reduce emissions of SO_x and NO_x, the two principal precursors of acid rain, by restricting emissions of these pollutants from power plants. Title IV caps aggregate annual power plant SO_x emissions and imposes controls on SO_x emissions through a system of marketable allowances. EPA issues one allowance for each ton of SO_x that a unit is allowed to emit.

New units do not receive allowances, but are required to have allowances to cover their SO_x emissions. Owners of new units must, therefore, acquire allowances from owners of other power plants or reduce SO_x emissions at other power plants they own. Allowances can be banked for use in future years. Thus, a new coal-fired power plant would not add to net regional SO_x emissions, although it might contribute to the local SO_x burden.

Regardless, SO_x emissions would be greater for the coal alternative than the OL renewal alternative. The staff estimates that with using the hydrated lime-wet scrubbing system to control SO_x emissions, the stack emissions of this constituent from a new 715 MW(e) coal-fired facility would be approximately 1428 tons per year.

<u>Nitrogen oxides emissions</u>. Section 407 of the CAA establishes technology-based emission limitations for NO_x emissions. The market-based allowance system used for SO_x emissions is not used for NO_x emissions. A new coal-fired power plant would be subject to the new source performance standards for such plants at 40 CFR 60.44a(d)(1).

This regulation, issued September 16, 1998 [63 FR 49453 (EPA 1998)], limits the discharge of any gases that contain nitrogen oxides (expressed as NO_2) in excess of 200 nanograms per joule of gross energy output (1.6 pound/MWh), based on a 30-day rolling average.

The staff estimates that using the technology referenced in Entergy's ER [NO_x burners with overfire air and selective catalytic reduction (SCR)] the total annual NO_x emissions for a new coal-fired power plant would be approximately 522 tons. This level of NO_x emissions would be greater than for the OL renewal alternative since a nuclear power plant releases almost no NO_x during normal operations.

Particulate emissions. The staff estimates that the total annual stack emissions would include 89 tons of filterable total suspended particulates and 21 tons of particulate matter having an aerodynamic diameter less than or equal to 10 μm (PM_{10}) (40 CFR 50.6). As indicated in the PNPS ER, fabric filters or electrostatic precipitators would be used for particulate control. In addition to flue emissions, coal-handling equipment would introduce fugitive particulate emissions from coal piles, reclamation equipment, conveyors, and other sources. Particulate emissions would be greater under the coal alternative than the OL renewal alternative. Fugitive dust would also be generated during the construction of a coal-fired plant and construction vehicles and motorized equipment would further contribute to construction phase air emissions.

Carbon monoxide emissions. The staff estimates that the total CO emissions from coal combustion would be approximately 544 tons per year. This level of emission is greater than would occur under the OL renewal alternative.

Hazardous air pollutants including mercury. In December 2000, the EPA issued regulatory findings on emissions of hazardous air pollutants from electric utility steam-generating units (EPA 2000b). EPA determined that coal- and oil-fired electric utility steam-generating units are significant emitters of hazardous air pollutants. Coal-fired power plants were found by EPA to emit arsenic, beryllium, cadmium, chromium, dioxins, hydrogen chloride, hydrogen fluoride, lead, manganese, and mercury (EPA 2000b). EPA concluded that mercury is the hazardous air pollutant of greatest concern. EPA found that (1) there is a link between coal consumption and mercury emissions; (2) electric utility steam-generating units are the largest domestic source of mercury emissions; and (3) certain segments of the U.S. population (e.g., the developing fetus and subsistence fish-eating populations) are believed to be at potential risk of adverse health effects due to mercury exposures resulting from consumption of contaminated fish (EPA 2000b). Accordingly, EPA added coal- and oil-fired electric utility steam-generating units to the list of source categories under Section 112(c) of the CAA for which emission standards for hazardous air pollutants will be issued (EPA 2000b).

Uranium and thorium. Coal contains uranium and thorium. Uranium concentrations are generally in the range of 1 to 10 parts per million (ppm). Thorium concentrations are generally about 2.5 times greater than uranium concentrations (Gabbard 1993). One estimate is that a typical coal-fired plant released roughly 5.2 tons of uranium and 12.8 tons of thorium in 1982 (Gabbard 1993). The population dose equivalent from the uranium and thorium releases and daughter products produced by the decay of these isotopes has been calculated to be significantly higher than that from nuclear power plants (Gabbard 1993).

Carbon dioxide. A coal-fired plant would also have unregulated carbon dioxide (CO_2) emissions that could contribute to global warming. The level of emissions from a coal-fired plant would be greater than the OL renewal alternative.

Summary. The GEIS analysis did not quantify emissions from coal-fired power plants, but implied that air impacts would be substantial. The GEIS also mentioned global warming from unregulated carbon dioxide emissions and acid rain from SO_x and NO_x emissions as potential impacts (NRC 1996). Adverse human health effects such as cancer and emphysema have been associated with the products of coal combustion. The appropriate characterization of air impacts from coal-fired generation would be MODERATE. The impacts would be clearly noticeable, but would not destabilize air quality.

- **Waste**

Coal combustion generates waste in the form of ash and scrubber sludge. A 715 gross MW(e) coal-fired plant would generate approximately 222,000 tons of such waste annually for 40 years. The waste would be disposed on-site, accounting for approximately 142 ac of land area over the 40-year plant life. Impacts of on-site waste disposal to groundwater and surface water could extend beyond the operating life of the plant if leachate and runoff from the waste storage area occurs. Waste disposal could noticeably affect land use and groundwater quality, but with appropriate management and monitoring, it would not destabilize any resources. After waste site closure and revegetation, the land could be available for other uses.

In May 2000, the EPA issued a “Notice of Regulatory Determination on Wastes From the Combustion of Fossil Fuels [65 FR 32214 (EPA 2000a)]. EPA concluded that some form of national regulation is warranted to address coal combustion waste products because: (a) the composition of these wastes could present danger to human health and the environment under certain conditions; (b) EPA has identified 11 documented cases of proven damages to human health and the environment by improper management of these wastes in landfills and surface impoundments; (c) present disposal practices are such that, in 1995, these wastes were being managed in 40 percent to 70 percent of landfills and surface impoundments without reasonable controls in place, particularly in the area of groundwater monitoring; and (d) EPA identified gaps in state oversight of coal combustion wastes. Accordingly, EPA announced its intention to issue regulations for disposal of coal combustion waste under subtitle D of the Resource Conservation and Recovery Act (RCRA). In addition to the waste streams generated during plant operations, considerable debris would be generated during construction of a coal fired facility.

For all of the preceding reasons, the appropriate characterization of impacts from the waste generated by a coal-fired facility (construction and operating phases) is MODERATE; the impacts would be clearly noticeable, but would not destabilize any important resource.

- **Human Health**

Coal-fired power generation introduces risks to workers from fuel and limestone mining, from fuel and lime/limestone transportation, and from disposal of coal combustion waste. In addition, there are public health risks from inhalation of stack emissions that can be widespread and difficult to quantify. The coal alternative also introduces the risk of coal-pile fires and attendant inhalation risks.

In the GEIS, the staff stated that there could be human health impacts (cancer and emphysema) from inhalation of toxins and particulates, but it did not identify the significance of these impacts (NRC 1996). In addition, the discharges of uranium and thorium from coal-fired plants can potentially produce radiological doses in excess of those arising from nuclear power plant operations (Gabbard 1993).

Regulatory agencies, including EPA and State agencies, set air emission standards and requirements based on human health impacts. These agencies also impose site-specific emission limits as needed to protect human health. As discussed previously, EPA has recently concluded that certain segments of the U.S. population (e.g., the developing fetus and subsistence fish-eating populations) are believed to be at potential risk of adverse health effects due to mercury exposures from sources such as coal-fired power plants. However, in the absence of more quantitative data, human health impacts from radiological doses and inhaling toxins and particulates generated by burning coal are characterized as SMALL.

- **Socioeconomics**

Construction of a coal-fired facility at an alternative greenfield site would take approximately four years. The work force would be expected to vary between 800 and 2000 workers during the 4-year construction period (NRC 1996). During construction, the surrounding communities would experience demands on housing and public services that could have MODERATE impacts unless some of the work force is composed of local residents. After construction, the host community would be impacted by the loss of the construction jobs.

However, this loss would be offset by the approximately 200 permanent jobs associated with the new facility. Socioeconomic impacts would be greater if the facility were constructed at a rural location than if it were constructed in a more developed area. The staff considers the most appropriate characterization of non-transportation socioeconomic impacts of developing a new greenfield site to be MODERATE to LARGE.

During the 4-year construction period of the coal-fired unit, up to 2000 construction workers would be working at the site. The addition of these workers would increase traffic on highways and local roads that lead to the construction site. The impact of this additional traffic could have a MODERATE impact on nearby roadways, particularly if the greenfield site is an a rural area.

Impacts associated with plant operating personnel commuting to work are considered SMALL. The number of plant operating personnel at a new coal-fired facility would be approximately 200. For rail transportation of coal and lime to the greenfield site, impacts are likely to range from MODERATE to LARGE. On average, approximately one 70-car train load per day would deliver coal to the new generating station and one 10-car train load per week would deliver lime to the facility. Should deliveries of coal be accomplished via barge, approximately two barges per week would deliver fuel to the facility. Overall, transportation impacts of coal and lime delivery would be MODERATE to LARGE.

- **Aesthetics**

The boiler house and associated air pollution control equipment at a new coal-fired facility could be up to 200 feet (ft) in height and a typical exhaust stack would be somewhere in the range of 400 to 600 ft high. Cooling tower(s) could be either of the mechanical (approximately 75 ft tall) or natural draft type (approximately 400 ft tall). The new generating facility and the plume generated by its cooling towers(s) would be visible from a considerable distance. Additionally, the facility would be noticeable at night due to its 24-hour operating schedule and the need for on-site safety lighting.

Beyond near site aesthetic impacts, development of a new coal-fired facility at a greenfield site would entail construction of a new transmission line and a new rail spur to bring coal and lime to the plant. The rail spur and transmission line could extend a considerable distance off-site to tie-in points with existing rail and transmission systems. The visual intrusion of these two linear elements, particularly the transmission line, could be significant. Consequently, the overall aesthetic impacts of a new coal-fired facility at a greenfield site are expected to be MODERATE to LARGE.

Coal-fired generation would introduce mechanical sources of noise that would be audible off-site. Sources contributing to total noise produced by plant operation are classified as continuous or intermittent. Continuous sources include the mechanical equipment associated with normal plant operations. Intermittent sources include the equipment related to coal handling, solid-waste disposal, on-site activities related to coal and lime delivery, use of outside loudspeakers, and the commuting of plant employees. The incremental noise impacts of a coal-fired plant at a greenfield site are considered to be MODERATE.

Noise impacts associated with rail delivery of coal and lime to a greenfield site would be most significant for residents living along the new rail spur leading to the plant. Since this is a new generating station site, these residents would not have experienced previous rail noise. Although noise from passing trains significantly raises noise levels near the rail corridor, the short duration of the noise reduces impact. Nevertheless, the impact of noise on residents in the vicinity of the facility and the rail line is considered MODERATE.

- **Historic and Archaeological Resources**

  Before construction at an alternate greenfield site, studies would likely be needed to identify, evaluate, and address mitigation of the potential impacts of new plant construction on cultural resources. The studies would likely be needed for all areas of potential disturbance at the proposed plant site and along associated corridors where new construction would occur (e.g., roads, transmission corridors, rail lines, or other ROWs). Historic and archaeological resource impacts can generally be effectively managed and, therefore, are considered SMALL.

- **Environmental Justice**

  Impacts of constructing a coal-fired facility at an alternate greenfield site would depend upon the site chosen and the nearby population distribution. It is expected that these impacts are likely to be SMALL to MODERATE.

Table 8-2. Summary of Environmental Impacts of Coal-Fired Generation at an Alternate Greenfield Site Using Closed-Cycle Cooling

	Alternate Greenfield Site	
Impact Category	**Impact**	**Comments**
Land Use	MODERATE to LARGE	Uses approximately 1215 ac, for plant, offices, parking, transmission line, and rail spur; additional land impacts for coal and limestone mining.
Ecology	MODERATE to LARGE	Impact depends on location and ecology of the site, surface water body used for cooling tower make-up and discharge, and transmission line route, potential habitat loss and fragmentation, reduced productivity and biological diversity.
Water Use and Quality-Surface Water	SMALL to MODERATE	Impact will depend on the volume of water withdrawn and discharged and the characteristics of the surface water body.
Water Use and Quality-Groundwater	SMALL to MODERATE	Impact will depend on the volume of water withdrawn and discharged and the characteristics of the aquifers.
Air Quality	MODERATE	• Sulfur oxides (Estimated 1428 tons/yr) • Nitrogen oxides (Estimated 522 tons/yr) • Particulates (Estimated 89 tons/yr of total suspended particulates) (Estimated 21 tons/yr of PM_{10}) • Carbon Monoxide (Estimated 544 tons/yr) Small amounts of mercury and other hazardous air pollutants and naturally occurring radioactive materials - mainly uranium and thorium.

Table 8-2. (contd)

	Alternate Greenfield Site	
Impact Category	**Impact**	**Comments**
Waste	MODERATE	Total volume of approximately 220,000 tons/yr requiring approximately 142 ac for disposal over 40-year life of plant.
Human Health	SMALL	Impacts are uncertain but considered SMALL in the absence of more quantitative data.
Socioeconomics	MODERATE to LARGE	Construction impacts depend on location, but could be LARGE if plant is located in a rural area.
Socioeconomics (Transportation)	MODERATE to LARGE	Transportation impacts associated with construction workers and coal and lime shipments. For rail transportation of coal and lime, the impact is considered MODERATE to LARGE. For barge transportation, the impact is considered MODERATE.
Aesthetics	MODERATE to LARGE	Impacts from boiler house, cooling tower, and new transmission line.
Historic and Archeological Resources	SMALL	Alternate location would necessitate cultural resource studies.
Environmental Justice	SMALL to MODERATE	Impacts will vary depending on population distribution and makeup at the site.

8.2.1.2 Once-Through Cooling System

This section discusses the environmental impacts of constructing a coal-fired generating station at a greenfield site using once-through cooling. The impacts (SMALL, MODERATE, or LARGE) of this option are approximately the same as the impacts for a coal-fired plant using the closed-cycle system, with the exception of land use, aesthetics, ecology, and water use. For land use and aesthetics, the impacts would be less, while for ecology and water use the impacts would be greater. Table 8-3 summarizes the incremental differences.

Table 8-3. Summary of Environmental Impacts of Coal-Fired Generation at the PNPS Site with Once-Through Cooling System

Impact Category	Change in Impacts from Closed-Cycle Cooling System
Land Use	Impacts may be less (e.g., through elimination of cooling towers) or greater (e.g., if a reservoir is required).
Ecology	Impact would depend on ecology at the site. Possible impacts associated with entrainment of fish and shellfish in early life stages, impingement of fish and shellfish, and heat shock.
Water Use and Quality-Surface Water	Increased water withdrawal leading to possible water-use conflicts; thermal load higher than with closed-cycle cooling.
Water Use and Quality-Groundwater	No change.
Air Quality	No change.
Waste	No change.
Human Health	No change.
Socioeconomics	No change.
Socioeconomics (Transportation)	No change.
Aesthetics	Elimination of cooling towers and plume.
Historic and Archaeological Resources	No change.
Environmental Justice	No change.

8.2.2 Natural Gas-Fired Generation

The environmental impacts of constructing a natural gas-fired alternative are examined in this section for both the PNPS site and an alternate greenfield site. The staff assumed that a gas-fired plant at the PNPS site could have either a closed or open-cycle cooling system.

The assumptions and numerical values used in Section 8.2.2 are based on the staff's independent assessment and on information provided by Entergy in the PNPS ER (Entergy 2006). Where information from the PNPS ER was used, it was independently reviewed by the staff and compared to environmental impact information in the GEIS. Impacts of a gas-fired alternative evaluated by the staff assume that the new plant would have a gross electrical capacity of 715 MW(e); this differs from the assumption made in the ER.

Entergy assumed that a replacement natural gas-fired plant would use combined-cycle technology (Entergy 2006). Furthermore, Entergy, uses a standard-sized gas-fired combined-cycle plant with a net capacity of 585 MW(e) in their analysis. The staff considers the combined-cycle technology to be a reasonable choice for the gas-fired replacement system but that the capacity selected by Entergy underestimates impacts of this technology. Consequently, the staff has evaluated impacts of a hypothetical 715 gross MW(e) gas-fired combined-cycle facility which would essentially fully replace the capacity lost if the PNPS OL is denied. While this approach may be hypothetical, air emissions calculated for a 715 MW(e) gas-fired facility better represent, in the staff's opinion, the implications of denying the PNPS OL.

The staff has assumed that approximately 50 ac would be needed to construct a new gas-fired plant at either the PNPS site or at an alternate greenfield site. This would include land for the power block and associated infrastructure. Since the PNPS site is not served by a natural gas supply and the nearest significant gas supply line is approximately 5 to 6 mi from the site, it will be necessary to construct a tie-in to that line from the PNPS site. Proximity to a natural gas supply will also be a factor in the selection of a greenfield location for the gas-fired alternative.

Some of the existing infrastructure at PNPS can be used to serve operations of the gas-fired alternative. Most significantly this would include the transmission lines that currently carry electric power from the plant to the regional distribution system. At an alternate greenfield site, new transmission lines would need to be constructed.

In performing the impact analysis in Section 8.2.2 the staff reviewed information provided by Entergy, environmental information in the GEIS, and data available in the technical literature. Although the OL renewal period is only 20 years, the impact of operating the natural gas-fired alternative for 40 years is considered (as a reasonable projection of a natural gas-fired plant's operating life).

8.2.2.1 Closed-Cycle Cooling System

The overall impacts of the natural gas-fired system using closed-cycle cooling are discussed below and summarized in Table 8-4, at the end of this section (Section 8.2.2.1). The extent of impacts at an alternate greenfield site will depend on the actual location of the selected site.

- **Land Use**

  For siting at PNPS, existing facilities and infrastructure would be used to the extent practicable, limiting the amount of new construction that would be required. Specifically, the staff assumed that the natural gas-fired replacement plant would use the switchyard, offices, and transmission line ROW. Much of the land that would be used has been previously disturbed. At PNPS, the staff assumed that approximately 50 ac would be needed for the plant and associated infrastructure including cooling tower. There would be an additional temporary impact of up to approximately 10 ac for construction of a gas pipeline from the Plymouth tie-in to the PNPS site.

  For construction at an alternate site, the staff assumed that 50 ac would also be needed for the plant and associated infrastructure (NRC 1996). In addition, land would be needed for construction of a transmission line and for a new gas line to supply fuel to the facility.

  Regardless of where the plant is built, additional land would be required for natural gas wells and collection stations. In the GEIS, the staff estimated that 3600 ac would be needed for gas wells and collection stations to support a 1000 MW(e) plant or about 2600 ac for a 715 MW(e) facility (NRC 1996). Overall, land-use impacts of the gas-fired alternative would be MODERATE at the PNPS site and MODERATE to LARGE at a greenfield site.

- **Ecology**

  The use of cooling towers would be expected to reduce aquatic ecological impacts below those currently being experienced at PNPS. With regard to terrestrial ecological impacts of building a gas-fired alternative, though the site is well built-out for the existing nuclear plant, additional land clearing would be necessary. This could entail some loss of natural habitat with a corresponding impact to terrestrial species. Also, bringing a natural gas pipeline onto the PNPS site may result in some further disturbance to undeveloped areas but it is expected that most of the pipeline construction would be in roadway ROW and, therefore, would not be expected to impact terrestrial species. Overall, given that closed-cycle cooling would be implemented for this alternative, the ecological impacts of developing a gas-fired facility at the PNPS site are considered SMALL.

  Ecological impacts at an alternate site would depend on the nature of the land converted to energy generation and the possible need for a new gas pipeline and/or electric transmission line. Construction of a transmission line and a gas pipeline would be expected to have temporary ecological impacts. Ecological impacts at the plant site and along utility easements could include impacts to threatened or endangered species, wildlife habitat loss and reduced productivity, habitat fragmentation, and a local reduction in biological diversity.

Some aquatic ecological impacts would also be expected due to withdrawal of surface water for cooling tower makeup. Overall, the ecological impacts of developing a gas-fired facility at a greenfield site are considered MODERATE.

- **Water Use and Quality**

  Surface Water

  The natural gas-fired facility described by Entergy in the ER would include a heat-recovery boiler, using waste heat from gas turbines to generate steam. The steam would then turn a turbine-generator. The net result would be an overall reduction in the amount of waste heat that would need to be discharged to the environment in comparison to an equivalent capacity nuclear plant. In addition, since a closed-cycle cooling system would be employed under this alternative, the rate at which water would be withdrawn from Cape Cod Bay, for cooling purposes, would be significantly reduced.

  Plant discharges would consist mostly of cooling tower blowdown, with the discharge having a higher temperature and increased concentration of dissolved solids relative to Cape Cod Bay; there would also be intermittent low concentrations of biocides (e.g., chlorine) in the discharge stream. In addition to the cooling tower blowdown, process waste streams could be discharged as well. However, all discharges would be regulated through a Federally issued National Pollutant Discharge Elimination System (NPDES) permit. Finally, some erosion and sedimentation would probably occur during construction (NRC 1996). Overall, the water quality impacts of implementing the natural gas-fired alternative at the PNPS site are considered SMALL due to the relatively low water withdrawal from Cape Cod Bay.

  A natural gas-fired plant at an alternate greenfield site is also assumed to use a closed-cycle cooling system. The staff assumed that surface water would be used for cooling tower make-up and that the withdrawal rate of make-up water would be small compared to an open-cycle system. The impact on surface waters would depend on the volume of water needed for make-up and the characteristics of the receiving water body. Intake from, and discharge to, any surface body of water would be regulated by a Federal or State issued discharge permit. The impacts would be SMALL. Water-quality impacts from sedimentation during construction have been characterized in the GEIS as SMALL.

  Groundwater

  At the PNPS site, groundwater supplied by the Town of Plymouth would continue to be used for potable water purposes and for certain plant operations requiring fresh water. However, the quantity of groundwater required will be reduced under the gas-fired alternative since the level of staffing would be less than that for current operations. Also, sanitary wastes would continue to be discharged to groundwater, as is currently the case at PNPS, but at a reduced rate. At an alternate site, groundwater could be used for general plant operations and for potable water purposes as well. Any groundwater withdrawal would require a permit from the local permitting authority and impacts on groundwater would depend on the volume required and characteristics of the water source. Overall impacts to groundwater of a gas-fired alternative at either the PNPS site or an alternate greenfield site would be SMALL.

- **Air Quality**

Natural gas is a relatively clean-burning fuel. A new gas-fired generating plant located in New England would likely need a prevention of significant deterioration permit and an operating permit under the CAA. A new combined-cycle natural gas power plant would also be subject to the new source performance standards for such units at 40 CFR Part 60, Subparts Da and GG. These regulations establish emission limits for particulates, opacity, SO_x, and NO_x.

In 1998, EPA issued a rule requiring 22 eastern states, including Massachusetts, to revise their state implementation plans to reduce NO_x emissions. NO_x emissions contribute to violations of the National Ambient Air Quality Standard (40 CFR 50.9) for ozone. The total amount of nitrogen oxides which can be emitted by each of the 22 states in the year 2007 ozone season (May 1 - September 30) is set out in 40 CFR 51.121(e). For Massachusetts, the amount is 85,296 tons.

EPA has various regulatory requirements for visibility protection in 40 CFR 51, Subpart P, including a specific requirement for review of any new major stationary source in an area designated attainment or unclassified under the CAA. Plymouth County has a non-attainment status for ozone but attains the National Ambient Air Quality Standards for other air pollutants. The air quality status of an alternate greenfield site would depend on where that site is located.

Section 169A of the CAA 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. EPA issued a new regional haze rule on July 1, 1999 (64 FR 35714 [EPA 1999]). The rule specifies that for each mandatory Class I Federal area located within a state, the State must establish goals that provide for reasonable progress towards achieving natural visibility conditions. The reasonable progress goals must provide for an improvement in visibility for the most impaired days over the period of the implementation plan and ensure no degradation in visibility for the least-impaired days over the same period [40 CFR 51.308(d)(1)].

If a natural gas-fired plant were located close to a mandatory Class I area, additional air pollution control requirements could be imposed. There are no designated Class I areas in Massachusetts. However, EPA's regional haze rule could apply to an alternate greenfield site, depending on where that site is located.

EPA issued the Clean Air Interstate Rule (CAIR) in May 2005 [70 FR 25162 (EPA 2005)]. CAIR provides a Federal framework requiring certain states to reduce emissions of SO_2 and No_x. EPA anticipates that states will achieve this reduction primarily by limiting emissions from the power generation sector. CAIR covers 28 eastern states and any new fossil-fired power plant sited in Massachusetts would be subject to the CAIR limitations.

The staff projects the following emissions for the natural gas-fired alternative:

SO_x - 56 tons/yr
No_x - 180 tons/yr
CO - 38 tons/yr
PM_{10} - 31 tons/yr

A natural gas-fired plant would also have unregulated CO_2 emissions that could contribute to global warming. In December 2000, EPA issued regulatory findings on emissions of hazardous air pollutants from electric utility steam-generating units (EPA 2000b). Natural gas-fired power plants were found by EPA to emit arsenic, formaldehyde, and nickel (EPA 2000b). Unlike coal and oil-fired plants, EPA did not determine that emissions of hazardous air pollutants from natural gas-fired power plants should be regulated under Section 112 of the CAA.

The projected emissions would likely be the same whether the gas-fired facility were operated at PNPS or at an alternate greenfield site. Impacts from the above emissions would be clearly noticeable, but would not be sufficient to destabilize air resources overall.

Construction activities either at PNPS or an alternate greenfield site would result in temporary fugitive dust emissions. Fugitive dust emissions would also occur along the construction route for new gas lines (at either site) or along the route of a new transmission line (greenfield site only). Exhaust emissions would also come from vehicles and motorized equipment used during the construction process.

The overall air quality impact of a new natural gas-fired plant sited at PNPS or at an alternate greenfield site is considered MODERATE.

- **Waste**

There will be spent SCR catalyst from NO_x emissions control and small amounts of solid-waste products (i.e., ash) from burning natural gas fuel. In the GEIS, the staff concluded that waste generation from gas-fired technology would be minimal (NRC 1996). Gas firing results in very few combustion by-products because of the clean nature of the fuel. Waste-generation impacts would be so minor that they would not noticeably alter any important resource attribute. Construction-related debris would be generated during construction activities.

In the winter, it may become necessary for a replacement baseload natural-gas fired plant to operate on fuel oil due to lack of gas supply. Oil combustion generates waste in the form of ash, and equipment for controlling air pollution generates additional ash and scrubber sludge. The amount of ash and sludge generated would depend on the type and quantity of fuel oil combusted (e.g. use of Number 2 fuel oil does not produce appreciable ash).

Overall, the waste impacts would be SMALL for a natural gas-fired plant sited at PNPS or at an alternate greenfield site.

- **Human Health**

In Table 8-2 of the GEIS, the staff identifies cancer and emphysema as potential health risks from gas-fired plants (NRC 1996). The risk may be attributable to NO_x emissions that contribute to ozone formation, which in turn contribute to health risks. NO_x emissions from any gas-fired plant would be regulated. For a plant sited in Massachusetts, NO_x emissions would be regulated by the Massachusetts Department of Environmental Protection. Human health effects from gas-fired operations are not expected to be detectable and, therefore, the impacts on human health of the natural gas-fired alternative sited at either PNPS or an alternate greenfield site are considered SMALL.

- **Socioeconomics**

Construction of a natural gas-fired plant would take approximately 3 years. Peak employment would be approximately 600 workers (NRC 1996). The staff assumed that construction would take place while PNPS continues operation and would be completed by the time it permanently ceases operations. During construction, the communities surrounding the PNPS site would experience demands on housing and public services that could have MODERATE impacts. After construction, nearby communities could be impacted by the loss of jobs. The current PNPS work force (700 workers) would decline through a decommissioning period to a minimal maintenance size.

The gas-fired plant would introduce a replacement tax base at PNPS or a new tax based on an alternate greenfield site and approximately 150 new permanent jobs.

In the GEIS (NRC 1996), the staff concluded that socioeconomic impacts from constructing a natural gas-fired plant would not be very noticeable and that the small operational work force would have the lowest socioeconomic impacts of any nonrenewable technology. Compared to the coal-fired and nuclear alternatives, the smaller size of the construction work force, the shorter construction time frame, and the relatively small operations work force would mitigate socioeconomic impacts. For these reasons, socioeconomic impacts associated with construction and operation of a natural gas-fired power plant would be SMALL to MODERATE for siting at PNPS or at an alternate greenfield site.

Transportation impacts associated with construction and operating personnel commuting to the plant site would depend on the population density and transportation infrastructure in the vicinity of the site. The impacts can be classified as SMALL to MODERATE for siting at PNPS and MODERATE at an alternate greenfield site, particularly if the greenfield site is in a rural area.

- **Aesthetics**

If the gas-fired facility was built at the PNPS site, the turbine buildings (approximately 100 ft tall) and exhaust stacks (approximately 125 ft tall) would be visible during daylight hours from the immediately adjacent properties. The cooling tower plume can be expected to be visible from the surrounding vicinity including, at times, the Town of Plymouth. Noise and light from the plant would be detectable in the immediate area. Overall, the aesthetic impacts associated with the gas-fired facility at PNPS are categorized as MODERATE.

At an alternate greenfield site, the buildings, cooling towers, cooling tower plumes, and the associated transmission line and gas pipeline would be visible off-site. The visual impact of a new transmission line could be especially significant at a greenfield site. Aesthetic impacts would be mitigated if the plant were located in an industrial area adjacent to other power plants. Overall, aesthetic impacts associated with an alternate greenfield site are categorized as MODERATE to LARGE. The most significant contributor to the aesthetic impacts is the new transmission line.

- **Historic and Archaeological Resources**

Before construction at PNPS or an alternate greenfield site, studies would likely be needed to identify, evaluate, and address mitigation of the potential impacts of new plant construction on cultural resources. The studies would likely be needed for all areas of potential disturbance at the proposed plant site and along associated corridors where new construction would occur (e.g., roads, transmission and pipeline corridors, or other ROWs). Impacts to cultural resources can be effectively managed under current laws and regulations and are likely to be SMALL.

- **Environmental Justice**

  No environmental pathways or locations have been identified that would result in disproportionately high and adverse environmental impacts on minority and low-income populations if a replacement natural gas-fired plant were built at the PNPS site. Some impacts on housing availability and prices during construction might occur, but it is not expected this would disproportionately affect minority and low-income populations. Closure of PNPS would result in a decrease in employment of approximately 550 operating employees (700 existing jobs versus 150 replacement jobs). This loss could possibly be offset by general economic growth in the eastern Massachusetts area and the loss is not expected to disproportionately impact low income or minority populations. Overall, impacts of terminating PNPS operations and replacing its output with a gas-fired facility at the same site are expected to be SMALL. Impacts at an alternate greenfield site would depend upon the site chosen and the nearby population distribution, but are likely to also be SMALL.

Table 8-4. Summary of Environmental Impacts of Natural Gas-Fired Generation at the PNPS Site and an Alternate Greenfield Site Using Closed-Cycle Cooling

	PNPS Site		Alternate Greenfield Site	
Impact Category	**Impact**	**Comments**	**Impact**	**Comments**
Land Use	MODERATE	50 ac for power block, cooling tower(s), offices, roads, parking areas. Additional temporary impact of approximately 10 ac for construction of underground gas pipeline.	MODERATE to LARGE	50 ac for power block, cooling towers, offices, roads, and parking areas. Additional area for electric and gas transmission lines.
Ecology	SMALL	Reduces water withdrawal from Bay but uses some undeveloped area at current PNPS.	MODERATE	Impact depends on location and ecology of the site, surface water body used for make-up and transmission and pipeline routes.

Table 8-4. (contd)

Impact Category	PNPS Site		Alternate Greenfield Site	
	Impact	**Comments**	**Impact**	**Comments**
Water Use and Quality-Surface Water	SMALL	Uses a closed-cycle cooling system with natural gas-fired combined-cycle units. This would result in relatively low water withdrawals.	SMALL	Impact depends on volume of water, withdrawal and discharge, and characteristics of surface water body.
Water Use and Quality-Groundwater	SMALL	Uses little groundwater beyond current potable water needs.	SMALL	Impact depends on volume of water withdrawal.
Air Quality	MODERATE	• Sulfur oxides (56 tons/yr) • Nitrogen oxides (180 tons/yr) • Carbon monoxide (38 tons/yr) • PM_{10} particulates (31 tons/yr) Some hazardous air pollutants.	MODERATE	Same emissions as PNPS site.
Waste	SMALL	Small amount of ash produced.	SMALL	Same waste produced as at the PNPS site.
Human Health	SMALL	Impacts considered to be minor.	SMALL	Impacts considered to be minor.
Socioeconomics	SMALL to MODERATE	During construction, impacts would be MODERATE. Up to 600 additional workers during the peak of the 3-year construction period, followed by reduction from current PNPS work force of 700 to 150; tax base preserved. Impacts during operation would be SMALL.	SMALL to MODERATE	During construction, impacts would be SMALL to MODERATE. Up to 600 additional workers during the peak of the 3-year construction period.

Table 8-4. (contd)

Impact Category	PNPS Site		Alternate Greenfield Site	
	Impact	Comments	Impact	Comments
Socioeconomics (Transportation)	SMALL to MODERATE	Transportation impacts associated with construction workers.	MODERATE	Transportation impacts associated with construction workers.
Aesthetics	MODERATE	Aesthetic impact due to impact of new plant and cooling towers.	MODERATE to LARGE	Potential impacts would be from the new plant, cooling towers, and new transmission line.
Historic and Archeological Resources	SMALL	Potential impacts can likely be effectively managed.	SMALL	Potential impacts can likely be effectively managed.
Environmental Justice	SMALL	Impacts on minority and low-income communities should be similar to those experienced by the population as a whole.	SMALL	Approximately same as for PNPS site.

8.2.2.2 Once-Through Cooling System

This section discusses the environmental impacts of constructing a natural gas-fired facility at the PNPS site using once-through cooling. The impacts of this option are generally the same as the impacts for a natural gas-fired plant using the closed-cycle system with some exceptions. The principal exceptions are that ecological and water quality impacts of once-through cooling would be greater than for closed-cycle cooling. Also, the aesthetic impacts of the cooling tower plume would be eliminated for the once-through cooling scenario. Table 8-5 summarizes the differences.

8.2.3 Nuclear Power Generation

Since 1997, the NRC has certified four new standard designs for nuclear power plants under 10 CFR Part 52, Subpart B. These designs are the 1300 MW(e) U.S. Advanced Boiling Water Reactor (10 CFR 52, Appendix A), the 1300 MW(e) System 80+ Design (10 CFR 52, Appendix B), the 600 MW(e) AP600 Design (10 CFR 52, Appendix C) and the 1000 MW(e) AP1000 Design (10 CFR Part 52, Appendix D). All of these plants are light-water reactors. Although no applications for a construction permit or a combined license based on these certified designs have been submitted to NRC, the submission of the design certification applications indicates continuing interest in the possibility of licensing new nuclear power plants. In addition, recent escalation in prices of natural gas and oil have made new nuclear power plant construction more attractive from a cost standpoint.

Table 8-5. Summary of Environmental Impacts of Natural Gas-Fired Generation at the PNPS Site with Once-Through Cooling

Impact Category	Change in Impacts from Closed-Cycle Cooling System
Land Use	Impacts may be less through elimination of cooling towers.
Ecology	Potentially greater impacts associated with entrainment of fish and shellfish in early life stages, impingement of fish and shellfish, and heat shock.
Water Use and Quality-Surface Water	Increased water withdrawal leading to higher thermal load than with closed-cycle cooling.
Water Use and Quality-Groundwater	No change.
Air Quality	No change.
Waste	No change.
Human Health	No change.
Socioeconomics	No change.
Socioeconomics (Transportation)	No change.
Aesthetics	Elimination of cooling towers reduces visual impacts.
Historic and Archaeological Resources	No change.
Environmental Justice	No change.

As a result of the increased interest in new nuclear facilities, construction of a nuclear power plant at a greenfield site is considered in this section. The staff assumed that the new nuclear plant would have a 40-year lifetime. Consideration of a new nuclear generating plant at the PNPS site is not addressed in this section due to the lack of sufficient on-site area to support construction of a new generating station, with associated cooling towers, while maintaining operation of the existing plant.

NRC has summarized environmental data associated with the uranium fuel cycle in Table S-3 of 10 CFR 51.51. The impacts shown in Table S-3 are representative of the impacts that would be associated with a replacement nuclear power plant built to one of the certified designs, sited at a greenfield site. The impacts shown in Table S-3 are for a 1000 MW(e) reactor and would need to be adjusted to reflect impacts of a new 715 MW(e) nuclear facility. The environmental impacts associated with transporting fuel and waste to and from a light-water cooled nuclear power reactor are summarized in Table S-4 of 10 CFR 51.52. The summary of NRC's findings on NEPA issues for license renewal of nuclear power plants in Table B-1 of 10 CFR 51 Subpart A, Appendix B, is also relevant, although not directly applicable, for consideration of environmental impacts associated with the operation of a replacement nuclear power plant. Additional environmental impact information for a replacement nuclear power plant using closed-cycle cooling is presented in Section 8.2.3.1 and in Section 8.2.3.2 for the once-through cooling scenario.

8.2.3.1 Closed-Cycle Cooling System

The impacts of constructing a nuclear generating station at a greenfield site using closed-cycle cooling are discussed in this section and summarized in Table 8-6, at the end of this section (Section 8.2.3.1). It should be noted, however, that the scale of impacts at the greenfield site will depend largely on characteristics of the site actually selected for the project.

- **Land Use**

  Land-use impacts at a greenfield site would be significant since the new nuclear plant, with its associated closed-cycle cooling system, would entail development on approximately 350 ac of land area. In addition, property would be needed to construct a transmission line from the greenfield site to the nearest tie-in with the regional transmission system. Also, it may be necessary to construct a rail spur or pier at the alternate site to bring in equipment during construction. Depending particularly on transmission line routing, siting a new nuclear plant at an alternate greenfield site could result in MODERATE to LARGE land-use impacts.

- **Ecology**

  Ecological impacts at an alternate site would result from both construction and operation of the replacement nuclear facility. Even assuming siting at a previously disturbed location, the terrestrial ecological impacts could include wildlife habitat loss, reduced productivity, habitat fragmentation, and a local reduction in biological diversity. Construction of a transmission line would further exacerbate terrestrial impacts but would be highly dependent on the length of line and the specific habitat conditions in that particular locale.

Drawing on a local surface water body for cooling tower make-up could have adverse aquatic resource impacts. Additional impacts could occur from the discharge of cooling tower blow-down to the surface water body. Overall, ecological impacts at an alternate site are expected to range from MODERATE to LARGE with the principal issue likely to be the loss of habitat resulting from on-site and off-site construction.

- **Water Use and Quality**

Surface Water

Construction and operation of a nuclear facility on a greenfield site could potentially impact water use and quality in several ways. Construction of the plant would entail significant disruption to the greenfield site resulting in potential soil erosion and sediment discharge to adjoining waterways. In addition, construction activities involve substantial use of diesel driven equipment and lubricants and cleaning agents. While construction activities are regulated under various Federal and State stormwater management programs, some potential will exist for release of contaminants to nearby surface water bodies.

During operation, the facility's cooling tower(s) would draw on a local surface water resource for make-up of evaporative losses. In addition, other plant systems may use surface waters for supplemental cooling and plant potable water needs. These may also be obtained from a surface water body. Discharges to surface waters from plant operations would also occur. These could include cooling tower blowdown and possibly treated process and sanitary wastes.

All withdrawals from and discharges to surface waters would be regulated by Federal and State programs designed to protect water quality. The staff concludes that impacts to water quality of construction and operation at a greenfield site, would be SMALL.

Groundwater

It is possible that groundwater could be used as a source of potable water for a nuclear plant developed at a greenfield site and, depending on hydrogeologic conditions at the site, possibly as a source of water for general plant purposes. In addition, process and sanitary wastes could be discharged to groundwater after receiving the appropriate level of treatment. Discharges to, and withdrawals from, groundwaters are regulated by Federal and State environmental agencies under programs designed to protect such resources. Thus, the impacts of operating a nuclear facility on groundwater resources at a greenfield site are expected to be SMALL.

- **Air Quality**

  Construction of a new nuclear plant sited at an alternate site would result in fugitive emissions during the construction process. Exhaust emissions would also come from vehicles and motorized equipment used during the construction process. An operating nuclear plant would have minor air emissions associated with diesel generators and other minor intermittent sources. Overall, air emissions and associated impacts resulting from operation of a nuclear facility at an alternate greenfield site are considered SMALL.

- **Waste**

  Siting a nuclear plant at an alternate greenfield site would not alter radwaste generation rates currently occurring at PNPS. The waste impacts associated with operation of a nuclear power plant are set out in Table B-1 of 10 CFR 51, Subpart A, Appendix B. However, considerable debris would be generated during construction of the new facility, resulting in the need to dispose of the material at an appropriate off-site disposal facility. Overall, waste impacts of constructing and operating a nuclear facility at an alternate greenfield site are considered SMALL.

- **Human Health**

  Human health impacts for an operating nuclear power plant are set out in 10 CFR 51 Subpart A, Appendix B, Table B-1. Overall, the staff concludes that human health impacts at an alternate greenfield site would be SMALL.

- **Socioeconomics**

  The construction period peak work force associated with construction of a new nuclear power plant is currently unquantified (NRC 1996). In the absence of quantitative data, the staff assumed a construction period of 6 years and a peak work force of up to 2500 for a 715 gross MW(e) nuclear facility at a greenfield site.

  The communities around the greenfield site would have to absorb the impacts of the large, temporary construction work force and a permanent work force of approximately 700 that would operate the 715 MW(e) nuclear facility. In the GEIS (NRC 1996), the staff indicated that socioeconomic impacts of the temporary and permanent work forces would be larger at a rural site than at an urban site because more of the peak construction work force would need to move into the area to work.

Consequently, the staff concludes that socioeconomic impacts of constructing and operating a nuclear facility at a greenfield site would range from MODERATE to LARGE depending on specific conditions at the greenfield location.

Transportation-related impacts associated with construction workers commuting to an alternate greenfield site are site dependent, but could be MODERATE. Transportation impacts related to commuting of plant operating personnel would also be site dependent, but typically are characterized as SMALL to MODERATE.

- **Aesthetics**

  Developing a greenfield site for a 715 MW(e) nuclear facility would result in aesthetic impacts at that site from the new structures associated with the plant including buildings, cooling towers, and the plume associated with the cooling towers. There would also be a potentially significant aesthetic impact from construction of a new transmission line to connect to the new plant to the regional transmission network.

  Noise and light due to construction and plant operations would be detectable off-site. The impact of noise and light would be mitigated if the plant is located in an industrial area adjacent to other power plants. Overall, the aesthetic impacts associated with locating a new nuclear facility at a greenfield site can be categorized as MODERATE to LARGE. The greatest contributors to this categorization are the aesthetic impacts of cooling tower plumes and the new transmission line.

- **Historic and Archaeological Resources**

  A cultural resource inventory would be needed before construction could begin at a greenfield site if that property has not been previously surveyed. Other lands, if any, that are acquired to support the plant would also likely need an inventory of field cultural resources, identification and recording of existing historic and archaeological resources, and possible mitigation of adverse effects from subsequent ground-disturbing actions related to plant construction. Impacts to cultural resources can be effectively managed under current law, and are likely to be SMALL.

- **Environmental Justice**

  Whether or not there would be disproportionate impacts to minority and low income populations resulting from construction and operation of a nuclear facility at a greenfield site would depend upon the site chosen and the nearby population distribution. Under a wide range of site circumstances, it is expected that the impacts would range from SMALL to MODERATE.

Table 8-6. Summary of Environmental Impacts of New Nuclear Power Generation at an Alternate Greenfield Site Using Closed-Cycle Cooling

	Alternate Greenfield Site	
Impact Category	**Impact**	**Comments**
Land Use	MODERATE to LARGE	Approximately 350 ac required on-site, plus additional land for transmission line.
Ecology	MODERATE to LARGE	Impact depends on location and ecology of the site, surface water body used for intake and discharge, and transmission line route; potential habitat loss and fragmentation; reduced productivity and biological diversity.
Water Use and Quality-Surface water	SMALL	Impact will depend on the volume of water withdrawn and discharged and the characteristics of the surface water body.
Water Use and Quality-Groundwater	SMALL	Impact will depend on the volume of water withdrawn and discharged and the characteristics of the local aquifers.
Air Quality	SMALL	Emissions from new nuclear plant expected to be minor.
Waste	SMALL	Debris waste will be generated during construction, and would be disposed at an appropriate off-site facility.
Human Health	SMALL	Human health impacts for nuclear facility considered small.
Socioeconomics	MODERATE to LARGE	Construction impacts depend on location. Impacts at a rural location could be LARGE.
Socioeconomics (Transportation)	SMALL to MODERATE	Transportation impacts of construction workers could be MODERATE. Transportation impacts of commuting plant personnel could be SMALL to MODERATE.
Aesthetics	MODERATE to LARGE	Greatest impact is from cooling towers and new transmission line.
Historic and Archeological Resources	SMALL	Any potential impacts can likely be effectively managed.
Environmental Justice	SMALL to MODERATE	Impacts will vary depending on population distribution and make-up at the greenfield site.

8.2.3.2 Once-Through Cooling System

This section discusses the environmental impacts of constructing a replacement nuclear power plant at a greenfield site using once-through cooling. While many impacts (SMALL, MODERATE, or LARGE) of this option are generally the same as the impacts for a nuclear power plant using a closed-cycle system, there are environmental differences between the two cooling system alternatives. Table 8-7 summarizes the incremental differences.

Table 8-7. Summary of Environmental Impacts of a New Nuclear Power Plant Sited at an Alternate Greenfield Site with Once-Through Cooling

Impact Category	Change in Impacts from Closed-Cycle Cooling System
Land Use	Impacts may be less (through elimination of cooling towers).
Ecology	Impacts would depend on ecology at the site. Potential impacts associated with entrainment of fish and shellfish in early life stages, impingement of fish and shellfish, and heat shock.
Water Use and Quality-Surface Water	Increased water withdrawal leading to possible water-use conflicts. Thermal load higher than with closed-cycle cooling.
Water Use and Quality-Groundwater	No change.
Air Quality	No change.
Waste	No change.
Human Health	No change.
Socioeconomics	No change.
Socioeconomics (Transportation)	No change.
Aesthetics	Elimination of cooling towers and plume will reduce visual impacts.
Historic and Archaeological Resources	No change.
Environmental Justice	No change.

8.2.4 Purchased Electrical Power

If available, purchased power could potentially obviate the need to renew the PNPS OL. However, while the concept of purchasing power is plausible, replacing the 715 MW(e) of capacity that would be lost if the PNPS OL were not renewed with purchased power, without any new generating facilities being built, is not a likely scenario. This is a result of the growing demand for power in New England and the fact that many of the region's power plants are close to retirement (DOE/EIA 2006a). As a result, DOE has stated that to meet demand, the region will have to invest in both new local generating capacity and new transmission capacity to bring purchased power into the area.

If power to replace PNPS capacity were to be purchased from sources within the U.S., the generating technology would likely be one of those described in this SEIS and in the GEIS (probably coal, natural gas, or nuclear). The description of the environmental impacts of other technologies in Chapter 8 of the GEIS is representative of the impacts of purchasing electrical power from a domestic source. Thus, the environmental impacts of imported power would still occur, but would be located elsewhere within the region or nation.

Beyond U.S. sources of purchased power, imported power from Canada or Mexico is unlikely to be available for replacement of PNPS capacity. In Canada, approximately 25 percent of the energy consumed within the country comes from renewable energy sources, principally hydropower (DOE/EIA 2005). Canada's output of electricity from nuclear power is projected to remain more or less flat between 2010 (114 billion kWh) and 2025 (112 billion kWh) (DOE/EIA 2005). EIA projects that total gross U.S. imports of electricity from Canada and Mexico will decrease from 42.3 billion kWh in 2010 to 29.4 billion kWh in year 2020 and to 26.9 billion kWh in year 2030 (DOE/EIA 2006a). Over the same period there is essentially no firm power projected to be exported from the U.S. to either Canada or Mexico. Consequently, it is unlikely that electricity imported from Canada or Mexico would be able to replace the PNPS lost capacity.

8.2.5 Other Alternatives

Other generation technologies considered by NRC are discussed in the following paragraphs.

8.2.5.1 Oil-Fired Generation

The EIA projects that oil-fired plants will account for very little of the new generating capacity in the U.S. during the 2004 to 2030 time frame because of continually rising fuel costs (DOE/EIA 2006a). Thus, an oil-fired replacement for the capacity that would be lost if PNPS ceases operation is not considered further in this SEIS.

8.2.5.2 Wind Power

Wind power, by itself, is not suitable for large base load capacity. As discussed in Section 8.3.1 of the GEIS, wind has a high degree of intermittency, and average annual capacity factors for wind plants are relatively low (on the order of 30 percent). Wind power, in conjunction with energy storage mechanisms, might serve as a means of providing base load power. However, current energy storage technologies are too expensive for wind power to serve as a large base load generator.

As a renewable resource, most regions of the U.S. have been classified according to wind power classes, which are based on typical wind speeds. These classes range from Class 1 (the lowest) to Class 7 (the highest). In general, at 50 meters (m) (approximately 164 ft), regions classified as being in wind power Class 4 or higher can be useful for generating wind power with large turbines. Some locations in the Class 3 category could also generate useful energy based on wind speeds at 80 m (262 ft) rather than at 50 m (164 ft) because of possibly high wind shears. Given the advances in technology, a number of locations in the Class 3 areas may be suitable for utility-scale wind development.

Massachusetts has wind resources consistent with utility-scale production. Excellent-to-outstanding wind resources can be found on the northern part of Cape Cod and good-to-excellent areas are found along the southern part of Cape Cod and along the shore of Martha's Vineyard and Nantucket. In western Massachusetts, excellent wind resources can be found along ridgelines of the Berkshires (DOE/NREL 2003).

As of July 31, 2006 there were 10,039 MW(e) of installed wind energy capacity in the U.S. Of this capacity, only about three MW(e) is installed in Massachusetts. However, several wind energy projects are in the planning stages within the Commonwealth including Berkshire Wind Farm [15 MW(e)], Hoosac Wind [30 MW(e)], and Cape Wind [468 MW(e)] (AWEA 2006). Cape Wind planned for Nantucket Sound is the largest wind energy project contemplated for Massachusetts. Cape Wind would take advantage of the strong prevailing winds occurring along the New England coastline.

Construction of a new 715 MW(e) generating facility using New England’s available wind resources would disturb a significant land area. A reliable 715 MW(e) wind generating facility would require placement of generators with two or three times as much capacity as the PNPS facility, which operates with capacity factors over 85 percent typically, and in some years with capacity factors of over 95 percent. Several thousand acres of land would be needed for the alternate wind farm and the land would have to be situated in Class 3 or better wind resource areas of Massachusetts or elsewhere in New England. Given the extensive land requirements and the variability of energy output, developing a wind facility to replace PNPS is not considered to be reasonable.

8.2.5.3 Solar Power

Solar technologies use the sun's energy and light to provide heat and cooling, light, hot water, and electricity for homes, businesses, and industry. In the GEIS, the staff noted that by its nature, solar power is intermittent. Therefore, solar power by itself is not suitable for base load capacity and is not a feasible alternative to license renewal of PNPS. The average capacity factor of photovoltaic cells is about 25 percent, and the capacity factor for solar thermal systems is about 25 to 40 percent. Solar power, in conjunction with energy storage mechanisms, might serve as a means of providing base load power. However, current energy storage technologies are too expensive to permit solar power to serve as a large base load generator. Therefore, solar power technologies (photovoltaic and thermal) cannot currently compete with conventional fossil-fueled technologies in grid-connected applications, due to high costs per kilowatt of capacity (NRC 1996).

There may be significant impacts to natural resources (wildlife habitat, land use, and aesthetic impacts) from construction of solar-generating facilities. As stated in the GEIS, land requirements are high at 35,000 ac per 1000 MW(e) for photovoltaic and approximately 14,000 ac per 1000 MW(e) for solar thermal systems. Neither type of solar electric system would fit at the PNPS site, and both would have large environmental impacts at a greenfield site.

The PNPS site receives approximately 3 to 3.5 kWh of solar radiation per square meter per day, compared to 6 to 8 kWh of solar radiation per square meter per day in areas of the western U.S., such as California, which are most promising for solar technologies. Because of the natural resource impacts (land and ecological), the area’s relatively low rate of solar radiation, and high cost, solar power is not deemed a feasible baseload alternative to renewal of the PNPS OL. Some solar power may substitute for electric power in rooftop and building applications. Implementation of non-rooftop solar generation on a scale large enough to replace PNPS would likely result in LARGE environmental impacts.

8.2.5.4 Hydropower

In Section 8.3.4 of the GEIS, the staff points out hydropower’s percentage of U.S. generating capacity is expected to decline because hydroelectric facilities have become difficult to site as a result of public concern about flooding, destruction of natural habitat, and alteration of natural river courses.

The staff estimated in the GEIS that land requirements for hydroelectric power are approximately 1 million ac per 1000 MW(e). Due to the relatively low amount of undeveloped hydropower resource in Massachusetts and elsewhere in New England, and the large land use and related environmental and ecological resource impacts associated with siting hydroelectric facilities large enough to replace PNPS, the staff concludes that hydropower is not a feasible alternative to PNPS OL renewal.

8.2.5.5 Geothermal Energy

Geothermal energy has an average capacity factor of 90 percent and can be used for baseload power where available. However, geothermal technology is not widely used as baseload generation due to the limited geographical availability of the resource and immature status of the technology (NRC 1996). As illustrated by Figure 8.4 in the GEIS, geothermal plants are most likely to be sited in the western continental U.S., Alaska, and Hawaii where hydrothermal reservoirs are prevalent. There is no feasible eastern location for geothermal capacity to serve as an alternative to PNPS. The staff concludes that geothermal energy is not a feasible alternative to renewal of the PNPS OL.

8.2.5.6 Wood Waste

The use of wood waste to generate electricity is largely limited to those states with significant wood resources, such as California, Maine, Georgia, Minnesota, Oregon, Washington, and Michigan. Electric power is generated in these states by the pulp, paper, and paperboard industries, which consume wood and wood waste for energy, benefitting from the use of waste materials that could otherwise represent a disposal problem.

A wood-burning facility can provide baseload power and operate with an average annual capacity factor of around 70 to 80 percent and with 20 to 25 percent efficiency (NRC 1996). However, the fuels required are variable and site-specific. A significant barrier to the use of wood waste to generate electricity is the high delivered-fuel cost and high construction cost per MW of generating capacity. The larger wood-waste power plants are only 40 to 50 MW(e) in size. Estimates in the GEIS suggest that the overall level of construction impact per MW of installed capacity should be approximately the same as that for a coal-fired plant, although facilities using wood waste for fuel would be built at smaller scales. Like coal-fired plants, wood-waste plants require large areas for fuel storage and processing and involve the same type of combustion equipment.

Due to uncertainties associated with obtaining sufficient wood and wood waste to fuel a base load generating facility, ecological impacts of large-scale timber cutting (e.g., soil erosion and loss of wildlife habitat), and low efficiency, the staff has determined that wood waste is not a feasible alternative to renewing the PNPS OL.

8.2.5.7 Municipal Solid Waste

Municipal waste combustors incinerate the waste and use the resultant heat to generate steam, hot water, or electricity. The combustion process can reduce the volume of waste by up to 90 percent and the weight of the waste by up to 75 percent. Municipal waste combustors use two basic types of technologies: mass burn and refuse-derived fuel. Mass burning technologies are most commonly used in the U.S. These technologies process raw municipal solid waste "as is," with little or no sizing, shredding, or separation before combustion. Growth in the municipal waste combustion industry slowed dramatically during the 1990s after rapid growth during the 1980s. The slower growth was due to three primary factors: (1) the Tax Reform Act of 1986, which made capital-intensive projects such as municipal waste combustion facilities more expensive relative to less capital-intensive waste disposal alternative such as landfills; (2) the 1994 Supreme Court decision *(C&A Carbone, Inc. v. Town of Clarkstown*), which 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; and (3) increasingly stringent environmental regulations that increased the capital cost necessary to construct and maintain municipal waste combustion facilities (DOE/EIA 2006a).

The decision to burn municipal waste to generate energy is usually driven by the need for an alternative to landfills rather than by energy considerations. The use of landfills as a waste disposal option is likely to increase in the near term; however, it is unlikely that many landfills will begin converting waste to energy because of unfavorable economics, particularly with electricity prices declining in real terms. EIA projects that between 2004 and 2030, the average price of electricity in constant dollars (2004) will rise in the near term, then decline and finally rise steadily resulting in a net modest decline over the entire study period (DOE/EIA 2006a).

Municipal solid waste combustors generate an ash residue that is buried in landfills. The ash residue is composed of bottom ash and fly ash. Bottom ash refers to that portion of the unburned waste that falls to the bottom of the grate or furnace. Fly ash represents the small particles that rise from the furnace during the combustion process. Fly ash is generally removed from flue-gases using fabric filters and/or scrubbers.

Currently there are approximately 89 waste-to-energy plants operating in the U.S. These plants generate approximately 2700 MW(e), or an average of approximately 30 MW(e) per plant (IWSA 2006), much smaller than needed to replace the 715 MW(e) of PNPS.

The initial capital costs for municipal solid-waste plants are greater than for comparable steam-turbine technology at wood-waste facilities. This is due to the need for specialized waste-separation and -handling equipment for municipal solid waste (NRC 1996). Furthermore, estimates in the GEIS suggest that the overall level of construction impact from a waste-fired plant should be approximately the same as that for a coal-fired plant. Additionally, waste-fired plants have the same or greater operational impacts (including impacts on the aquatic environment, air, and waste disposal). Some of these impacts would be moderate, but still larger than the environmental effects of license renewal of PNPS. Therefore, municipal solid waste would not be a feasible alternative to renewal of the PNPS OL, particularly at the scale required.

8.2.5.8 Other Biomass-Derived Fuels

In addition to wood and municipal solid-waste fuels, there are several other concepts for fueling electric generators, including burning crops, converting crops to a liquid fuel such as ethanol, and gasifying crops (including wood waste). In the GEIS, the staff points out that none of these technologies has progressed to the point of being competitive on a large scale, or of being reliable enough to replace a baseload plant such as PNPS. For these reasons, such fuels do not offer a feasible alternative to renewal of the PNPS OL.

8.2.5.9 Fuel Cells

Fuel cells work without combustion and its environmental side effects. Power is produced electrochemically by passing a hydrogen-rich fuel over an anode and air over a cathode and separating the two by an electrolyte. The only by-products are heat, water, and CO_2. Hydrogen fuel can come from a variety of hydrocarbon resources by subjecting them to steam under pressure. Natural gas is typically used as the source of hydrogen.

Phosphoric acid fuel cells are generally considered first-generation technology. These fuel cells are commercially available at a cost of approximately $4500 per kW of installed capacity (DOE/NETL 2005). Higher-temperature second-generation fuel cells achieve higher fuel-to-electricity and thermal efficiencies. The higher temperatures contribute to improved efficiencies and give the second-generation fuel cells the capability to generate steam for cogeneration and combined-cycle operations.

The DOE has an initiative to reduce fuel cell costs to as low as $400 per kW of installed capacity. For comparison, the installed capacity cost for a natural gas-fired combined-cycle plant is about $456 per kW (DOE/NETL 2005). As market acceptance and manufacturing capacity increase, natural gas fuel cells plants in the 50- to 100-MW(e) range are expected to become available. At the present time, however, fuel cells are not economically competitive with other alternatives for base-load electricity generation. Fuels cells are, consequently, not a feasible alternative to renewal of the PNPS OL.

8.2.5.10 Delayed Retirement

According to Entergy, delaying the retirement of existing plants they own would be unlikely to off set the loss of 715 MW(e) of PNPS capacity over the 20 year OL renewal period (Entergy 2006). Also, as stated by DOE (August 2006), New England depends on a number of older plants that are close to retirement. Thus, delaying retirement of older facilities is not considered to be a viable alternative to the reliable base load capacity of PNPS.

8.2.5.11 Conservation

Massachusetts, as have most other New England states, has initiated state-wide programs to reduce both peak demands and daily energy usage (Commonwealth of Massachusetts 2004). On a state-wide basis, energy savings ascribed to the Massachusetts Energy Efficiency Programs were estimated to be 241 million kWh in 2002 (Commonwealth of Massachusetts 2004). However, demand-side energy consumption reductions are incorporated in State and Federal load forecasts and continue to show an increase in energy demand, both nationally and for New England, over the next several decades (DOE/EIA 2006a). Thus, conservation alone cannot be used as an alternative to the PNPS facility; and demand-side management cannot be considered a reasonable alternative to replacement of the entire output of PNPS.

8.2.6 Combination of Alternatives

There are numerous possible combinations of alternatives that can be considered to replace the 715 gross MW(e) capacity of PNPS. However, many of these combinations would not be realistic based on the economics of developing central electric generating stations. For instance, it would be possible to consider a reduced scale coal or nuclear alternative to PNPS in combination with a technology based on renewable resources. However, the economics of owning and operating coal and nuclear plants largely preclude construction of intermediate size or small units. Thus, any realistic combination of alternatives would not include reduced scale coal or nuclear facilities.

It would, however, be plausible to consider a gas-fired system to replace a portion of PNPS output since gas-fired facilities are modular in nature and can be developed economically at output capacities well below 715 MW(e). The scale of a gas-fired system that would be installed at PNPS as part of a strategy to replace its 715 MW(e) output would be heavily dependent upon the generating capacity that could realistically be picked up by new systems based on renewable resources and by conservation. As presented in Section 8.2.5.11, conservation by means of Demand Side Management (DSM) would appear to offer only a modest opportunity to replace some of PNPS output. Thus, a combination that considers a reduced scale gas-fired system together with conservation would not have impacts significantly different than those presented in Section 8.2.2 for a full scale gas-fired replacement, because conservation could not be reasonably assumed to replace much of the PNPS output.

Therefore, the combination considered herein, for illustrative purposes, is to replace the output of PNPS with 350 MW(e) of gas-fired capacity at the PNPS site, 250 MW(e) of renewable wind capacity at upland locations in New England, and only 115 MW(e) of conservation derived from DSM programs. Table 8-8 contains a summary of the environmental impacts of this assumed combination of alternatives.

Table 8-8. Summary of Environmental Impacts of 350 MW(e) of Natural Gas-Fired Generation, 250 MW(e) from Wind Generation, and 115 MW(e) from DSM Measures

	PNPS Site		**Wind Farm Site**	
Impact Category	**Impact**	**Comments**	**Impact**	**Comments**
Land Use	MODERATE	30 ac for power block, offices, roads, and parking areas. Additional impact of 10 ac for construction of an underground gas pipeline.	LARGE	1500 ac for wind farm exclusive of transmission lines.
Ecology	SMALL	Uses some undeveloped area at PNPS for cooling tower.	LARGE	Impact depends on location and ecology of the site, but significant habitat disruption likely.
Water Use and Quality-Surface Water	SMALL	Uses cooling towers.	MODERATE	May impact natural drainage patterns of 1500 ac site.
Water Use and Quality-Groundwater	SMALL	Uses less potable water than PNPS.	SMALL	Significant ground water use not anticipated.
Air Quality	MODERATE	Natural Gas-Fired Units at PNPS • Sulfur oxides (10 tons/yr) • Nitrogen oxides (148 tons/yr) • Carbon Monoxide (141 tons/yr) • PM_{10} particulates (324 tons/yr) Some hazardous air pollutants.	SMALL	None during operation. Fugitive dust during construction.

Table 8-8. (contd)

	PNPS Site		Wind Farm Site	
Impact Category	Impact	Comments	Impact	Comments
Waste	SMALL	Small amount of ash produced from gas-fired plant.	SMALL	No significant waste streams.
Human Health	SMALL	Impacts considered to be minor.	SMALL	None.
Socioeconomics	SMALL to MODERATE	During construction, impacts would be MODERATE. Up to 500 additional workers during the peak of the 2-3-year construction period, followed by reduction from current PNPS work force of 700; tax base reduced.	MODERATE	Construction impacts depend on location, but could be significant since location is probably a rural area.
Socioeconomics (Transportation)	MODERATE	Transportation impacts associated with construction workers.	MODERATE	Potential impacts associated with construction workers at a rural greenfield location.
Aesthetics	MODERATE	MODERATE aesthetic impacts due to impacts of cooling tower plumes.	LARGE	Significant impact from wind generators and transmission line at a rural site.
Historic and Archeological Resources	SMALL	Any potential impacts at PNPS can likely be effectively managed.	SMALL to LARGE	Large area disturbed with potential significant impact to resources depending on site location.
Environmental Justice	SMALL	Impacts on minority and low-income communities should be similar to those experienced by the population as a whole.	SMALL to LARGE	Impacts vary depending on population distribution and makeup at rural site.

8.3 Summary of Alternatives Considered

The environmental impacts of the proposed action, renewal of the PNPS OL, are SMALL or MODERATE for all impact categories, except for collective off-site radiological impacts from the fuel cycle and from high-level waste (HLW) and spent fuel disposal. Collective off-site radiological impacts from the fuel cycle and from HLW and spent fuel disposal were not assigned a single significance level but were determined by the Commission to be Category 1 issues nonetheless. The alternative actions, i.e., no-action alternative (discussed in Section 8.1), new generation alternatives (from coal, natural gas, and nuclear; discussed in Sections 8.2.1 through 8.2.3, respectively), purchased electrical power (discussed in Section 8.2.4), alternative technologies (discussed in Section 8.2.5), and the combination of alternatives (discussed in Section 8.2.6) were considered.

The no-action alternative would require the replacement of electrical generating capacity by (1) DSM and energy conservation, (2) power purchased from other electricity providers, (3) generating alternatives other than PNPS, or (4) some combination of these options. For each of the new generation alternatives (coal, natural gas, and nuclear), the environmental impacts would not be less than the impacts of license renewal, and in most cases would likely be greater. For example, the land-disturbance impacts resulting from construction of any new facility would be greater than the impacts of continued operation of PNPS. The impacts of electrical power purchased outside the New England region would still occur, but would occur elsewhere as well. Alternative technologies are not considered feasible at this time and it is very unlikely that the environmental impacts of any reasonable combination of generation and conservation options could be reduced to the level of impacts associated with renewal of the PNPS OL.

In conclusion, the staff has determined that the alternative actions, including the no-action alternative, may have environmental effects in at least some impact categories that reach MODERATE or LARGE significance.

8.4 References

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

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

10 CFR Part 52. Code of Federal Regulations, Title 10, *Energy,* Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."

40 CFR Part 50. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 50, "National Primary and Secondary Ambient Air Quality Standards."

40 CFR Part 51. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 51, "Requirements for Preparation, Adoption, and Submittal of Implementation Plans."

40 CFR Part 60. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 60, "Standards of Performance for New Stationary Sources."

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9.0 Summary and Conclusions

By letter dated January 25, 2006, Entergy Nuclear Operations, Inc. (Entergy) submitted an application to the U.S. Nuclear Regulatory Commission (NRC) to renew the operating license (OL) for Pilgrim Nuclear Power Station (PNPS) for an additional 20-year period (Entergy 2006a). If the OL is renewed, State and Federal (other than NRC) regulatory agencies and Entergy would ultimately decide whether the plant will continue to operate based on factors such as the need for power, power availability from other sources, regulatory mandates, or other matters within the agencies' jurisdictions or the purview of the owners. If the OL is not renewed, then the plant must be shut down at or before the expiration of the current OL, which expires on June 8, 2012.

Section 102 of the National Environmental Policy Act of 1969, as amended (NEPA) (42 USC 4321), directs that an environmental impact statement (EIS) is required for major Federal actions that significantly affect the quality of the human environment. The NRC has implemented Section 102 of NEPA in Title 10 of the Code of Federal Regulations (CFR) Part 51. Part 51 identifies licensing and regulatory actions that require an EIS. In 10 CFR 51.20(b)(2), NRC requires preparation of an EIS or a supplement to an EIS for renewal of a reactor OL; 10 CFR 51.95(c) states that the EIS prepared at the OL renewal stage will be a supplement to the *Generic Environmental Impact Statement for License Renewal of Nuclear Plant*s (GEIS), NUREG-1437, Volumes 1 and 2 (NRC 1996; 1999).(a)

Upon acceptance of the PNPS application, the NRC began the environmental review process described in 10 CFR Part 51 by publishing a notice of intent to prepare an EIS and conduct scoping (NRC 2006a; 71 FR 19554) on April 14, 2006. The staff visited the PNPS site in March 2006 and held public scoping meetings on May 17, 2006, in Plymouth, Massachusetts (NRC 2006b). The staff reviewed the PNPS Environmental Report (ER) (Entergy 2006b) and compared it to the GEIS, consulted with other agencies, and conducted an independent review of the issues following the guidance set forth in NUREG-1555, Supplement 1, the *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal* (NRC 2000). The staff also considered the public comments received during the scoping process for preparation of the draft Supplemental Environmental Impact Statement (SEIS) for PNPS. The public comments received during the scoping process that were considered to be within the scope of the environmental review are provided in Appendix A, Part 1, of this SEIS.

The draft SEIS was published and distributed for public comment on December 8, 2006. The staff held two public meetings in Plymouth, Massachusetts, in January 2007 to describe the results of the NRC environmental review, answer questions, and to provide members of the public with information to assist them in formulating their comments on the draft SEIS. The

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(a) 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.

comment period ended on February 28, 2007. Comments made during the 75-day comment period, including those made at the two public meetings, are presented in Appendix A, Part 2, of this SEIS.

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

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

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

The evaluation criterion for the staff's environmental review, as defined in 10 CFR 51.95(c)(4) and the GEIS, is to determine:

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

Both the statement of purpose and need and the evaluation criterion implicitly acknowledge that there are factors, in addition to license renewal, that would contribute to NRC's ultimate determination of whether an existing nuclear power plant continues to operate beyond the period of the current OL.

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

> The supplemental environmental impact statement for license renewal is not required to include discussion of need for power or the economic costs and economic benefits of the proposed action or of alternatives to the proposed action except insofar as such benefits and costs are either essential for a determination regarding the inclusion of an alternative in the range of alternatives considered or relevant to mitigation. In addition, the supplemental environmental impact statement prepared at the license renewal stage need not discuss other issues not related to the environmental effects of the proposed

action and the alternatives, or any aspect of the storage of spent fuel for the facility within the scope of the generic determination in § 51.23(a) and in accordance with § 51.23(b).[b]

The GEIS contains the results of a systematic evaluation of the consequences of renewing an OL and operating a nuclear power plant for an additional 20 years. It evaluates 92 environmental issues using the NRC's three-level standard of significance—SMALL, MODERATE, or LARGE—developed using the Council on Environmental Quality guidelines. The following definitions of the three significance levels are set forth in the footnotes to Table B-1 of 10 CFR Part 51, Subpart A, Appendix B:

> SMALL - Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.
>
> MODERATE - Environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.
>
> LARGE - Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

For 69 of the 92 issues considered in the GEIS, the staff analysis in the GEIS shows the following:

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

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

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

These 69 issues were identified in the GEIS as Category 1 issues. In the absence of new and significant information, the staff relied on conclusions as amplified by supporting information in

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(b) The title of 10 CFR 51.23 is "Temporary storage of spent fuel after cessation of reactor operations–generic determination of no significant environmental impact."

the GEIS for issues designated Category 1 in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B.

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

This SEIS documents the staff's consideration of all 92 environmental issues identified in the GEIS and one new issue (aquatic habitat) identified in a public comment. The staff considered the environmental impacts associated with alternatives to license renewal and compared the environmental impacts of license renewal and the alternatives. The alternatives to license renewal that were considered include the no-action alternative (not renewing the OL for PNPS), alternative methods of power generation, and conservation. These alternatives were evaluated assuming that the replacement power generation plant is located at either the PNPS site or some other unspecified location.

9.1 Environmental Impacts of the Proposed Action - License Renewal

Entergy and the staff have established independent processes for identifying and evaluating the significance of any new information on the environmental impacts of license renewal. Neither Entergy nor the staff has identified information that is both new and significant related to Category 1 issues that would call into question the conclusions in the GEIS. With the exception of the requirement for an essential fish habitat (EFH) consultation (see Appendix E for the EFH assessment), the staff has not identified any new issue applicable to PNPS that has a significant environmental impact. Therefore, the staff relies upon the conclusions of the GEIS for all Category 1 issues that are applicable to PNPS.

Entergy's license renewal application presents an analysis of the Category 2 issues that are applicable to PNPS, plus environmental justice and chronic effects from electromagnetic fields. The staff has reviewed the Entergy analysis for each issue and has conducted an independent review of each issue plus environmental justice and chronic effects from electromagnetic fields. Six Category 2 issues are not applicable because they are related to plant design features or site characteristics not found at PNPS. Four Category 2 issues are not discussed in this SEIS because they are specifically related to refurbishment. Entergy has stated that its evaluation of structures and components, as required by 10 CFR 54.21, did not identify any major plant refurbishment activities or modifications as necessary to support the continued operation of

PNPS for the license renewal period (Entergy 2006b). In addition, any replacement of components or additional inspection activities are within the bounds of normal plant component replacement and, therefore, are not expected to affect the environment outside of the bounds of the plant operations evaluated in the *Final Environmental Statement Related to Operation of Pilgrim Nuclear Generating Station* (AEC 1972).

Eleven Category 2 issues (including 10 Category 2 issues plus the severe accident mitigation alternatives (SAMAs) issue from Chapter 5) related to operational impacts and postulated accidents during the renewal term, as well as environmental justice and chronic effects of electromagnetic fields, are discussed in detail in this SEIS. Five of the Category 2 issues and environmental justice apply both to refurbishment and to operation during the renewal term and are only discussed in this SEIS in relation to operation during the renewal term. For eight of the Category 2 issues and environmental justice, the staff concludes that the potential environmental effects would be of SMALL significance in the context of the standards set forth in the GEIS. For entrainment of the local winter flounder (*Pseudopleuronectes americanus*) population and impingement of Jones River population of rainbow smelt (*Osmerus mordax*), the NRC staff concludes that the potential environmental impacts would be MODERATE. For all other marine aquatic species, the staff concludes that potential environmental impacts due to entrainment and impingement would be SMALL to MODERATE. In addition, the staff determined that appropriate Federal health agencies have not reached a consensus on the existence of chronic adverse effects from electromagnetic fields. Therefore, no further evaluation of this issue is required*.* For SAMAs, the staff concludes that a reasonable, comprehensive effort was made to identify and evaluate SAMAs. Based on its review of the SAMAs for PNPS, and the plant improvements already made, the staff concludes that Entergy identified five potentially cost-beneficial SAMAs. The staff concludes that two additional SAMAs are potentially cost-beneficial. However, these SAMAs do not relate to adequately managing the effects of aging during the period of extended operation. Therefore, they need not be implemented as part of license renewal pursuant to 10 CFR Part 54.

In addition to considering the 92 issues listed in the GEIS, the staff considered a potential issue associated with aquatic habitat. The staff concludes that this issue, while new, is not significant.

Cumulative impacts of past, present, and reasonably foreseeable future actions were considered, regardless of what agency (Federal or non-Federal) or person undertakes such other actions. The staff concludes that cumulative impacts of PNPS license renewal would be SMALL for most potentially affected resources, with the exception of the local winter flounder population and the Jones River population of rainbow smelt, for which impacts would be MODERATE. Overall, the cumulative impacts on marine aquatic resources within the Cape Cod Bay ecosystem would be SMALL to MODERATE.

Mitigation measures were considered for each Category 2 issue. For most issues, current measures to mitigate the environmental impacts of plant operation were found to be adequate. However, due to the potential for impacts to marine aquatic resources, additional mitigation measures for the cooling system components and operations may further reduce entrainment and impingement impacts. It is expected that any additional mitigation measures would be evaluated in the U.S. Environmental Protection Agency's review of Entergy's National Pollutant Discharge Elimination System permit renewal application.

The following sections discuss unavoidable adverse impacts, irreversible or irretrievable commitments of resources, and the relationship between local short-term use of the environment and long-term productivity.

9.1.1 Unavoidable Adverse Impacts

An environmental review conducted at the license renewal stage differs from the review conducted in support of a construction permit because the plant is in existence at the license renewal stage and has operated for a number of years. As a result, adverse impacts associated with the initial construction have been avoided, have been mitigated, or have already occurred. The environmental impacts to be evaluated for license renewal are those associated with refurbishment and continued operation during the renewal term.

Most adverse impacts of continued operation identified would be of SMALL significance with the exception of impacts of the cooling system, which would have MODERATE impacts on the local population of winter flounder and rainbow smelt, and SMALL to MODERATE impacts on other marine aquatic species. The adverse impacts of likely alternatives if PNPS ceases operation at or before the expiration of the current OL would not be smaller than those associated with continued operation of this unit, and they may be greater for some impact categories in some locations.

9.1.2 Irreversible or Irretrievable Resource Commitments

The commitment of resources related to construction and operation of PNPS during the current license period was made when the plant was built. The resource commitments to be considered in this SEIS are associated with continued operation of the plant for an additional 20 years. These resources include materials and equipment required for plant maintenance and operation, the nuclear fuel used by the reactors, and ultimately, permanent off-site storage space for the spent fuel assemblies.

The most significant resource commitments related to operation during the renewal term are the fuel and the permanent storage space. PNPS replaces a portion of its fuel assemblies during every refueling outage, which occurs on a 24-month cycle (Entergy 2006b).

The likely power generation alternatives if PNPS ceases operation on or before the expiration of the current OLs would require a commitment of resources for construction of the replacement plants as well as for fuel to run the plants.

9.1.3 Short-Term Use Versus Long-Term Productivity

An initial balance between short-term use and long-term productivity of the environment at PNPS was set when the plant was approved and construction began. That balance is now well established. Renewal of the OL for PNPS and continued operation of the plant would not alter the existing balance, but may postpone the availability of the site for other uses. Denial of the application to renew the OL would lead to shutdown of the plant and would alter the balance in a manner that depends on subsequent uses of the site.

9.2 Relative Significance of the Environmental Impacts of License Renewal and Alternatives

The proposed action is renewal of the OL for PNPS. Chapter 2 describes the site, power plant, and interactions of the plant with the environment. As noted in Chapter 3, no refurbishment and no refurbishment impacts are expected at PNPS. Chapters 4 through 7 discuss environmental issues associated with renewal of the OL. Environmental issues associated with the no-action alternative and alternatives involving power generation and use reduction are discussed in Chapter 8.

The significance of the environmental impacts from the proposed action (approval of the application for renewal of the OL), the no-action alternative (denial of the application), alternatives involving coal, gas, or nuclear-fired generating capacity at an unspecified greenfield site, gas-fired generation of power at PNPS, and a combination of alternatives are compared in Table 9-1. Continued use of once-through cooling is assumed for PNPS. All fossil fueled alternatives presented in Table 9-1 are assumed to use closed-cycle cooling systems. In the evaluation of the nuclear, gas, and coal-fired generation alternatives, substitution of once-through cooling for closed-cycle cooling would result in greater environmental impacts related to water use and aquatic ecology. However, land use and aesthetic impacts are somewhat reduced with once-through cooling.

Table 9-1 shows that the significance of the plant-specific environmental effects of the proposed action would be SMALL for all impact categories except for the following:

- entrainment and impingement of the local winter flounder population and Jones River population of rainbow smelt, respectively, for which MODERATE levels of significance were assigned, and entrainment and impingement of the other marine aquatic species, for which SMALL to MODERATE levels of significance were assigned (see Chapter 4);

- collective offsite radiological impacts from the fuel cycle and from high-level radioactive waste, for which a single significance level was not assigned (see Chapter 6); and
- spent fuel disposal, for which a single significance level was not assigned (see Chapter 6).

Cumulative impacts on the proposed action would be SMALL with the exception of impacts to marine aquatic resources, which may experience SMALL to MODERATE cumulative impacts.

The alternative actions, excluding the no-action alternative, may have environmental effects in at least some impact categories that reach MODERATE or LARGE significance.

9.3 Staff Conclusions and Recommendations

Based on (1) the analysis and findings in the GEIS (NRC 1996), (2) the ER submitted by Entergy, (3) consultations with Federal, State, and local agencies, (4) the staff's own independent review, and (5) the staff's consideration of public comments received, the recommendation of the staff is that the Commission determine that the adverse environmental impacts of license renewal for PNPS are not so great that preserving the option of license renewal for energy planning decisionmakers would be unreasonable.

9.4 References

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

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

Atomic Energy Commission (AEC)*. 1972. Final Environmental Statement Related to Operation of Pilgrim Nuclear Generating Station,* Docket Number 50-293*,* Washington*,* DC.

Clean Water Act of 1977 (CWA) 33 USC 1326, et seq.

Entergy Nuclear Operations, Inc. (Entergy). 2006a. *License Renewal Application, Pilgrim Nuclear Power Station*, Docket Number 50-293, Facility Operating License Number DPR-35. Plymouth, Massachusetts.

Entergy Nuclear Operations, Inc. (Entergy). 2006b**.** *Applicant's Environmental Report – Operating License Renewal Stage, Pilgrim Nuclear Power Station*. Docket Number 50-293, Plymouth, Massachusetts.

National Environmental Policy Act of 1969, as amended (NEPA), 42 USC 4321, et seq.

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

Nuclear Regulatory Commission (NRC). 1999. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants: Main Report*, *Section 6.3, Transportation, Table 9.1, Summary of findings on NEPA issues for license renewal of nuclear power plants*, *Final Report*. NUREG-1437, Volume 1, Addendum 1, Washington, DC.

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

Nuclear Regulatory Commission (NRC). 2006a. “Notice of Acceptance for Docketing of the Application and Notice of Opportunity for a Hearing Regarding Renewal of Facility Operating License No. DPR-35 and for an Additional 20-Year Period.” *Federal Register* Volume 71, pgs. 15222-15223. March 27, 2006.

Nuclear Regulatory Commission (NRC). 2006b. “Notice of Intent to Prepare an Environmental Impact Statement and Conduct Scoping Process.” *Federal Register* Volume 71, pgs. 19554-19556. April 14, 2006.

Table 9-1. Summary of Environmental Significance of License Renewal, the No Action Alternative, and Alternative Methods of Generation

	Proposed Action	No Action Alternative	Coal-Fired Generation[(a)]	Natural-Gas-Fired Generation[(a)]		New Nuclear Generation[(a)]	Combination of Alternatives
Impact Category	**License Renewal**	**Denial of Renewal**	**Alternate Greenfield Site**	**PNPS Site**	**Alternate Greenfield Site**	**Alternate Greenfield Site**	**Gas-Fired at PNPS Site[(a)], Wind Farm, Conservation**
Land Use	**SMALL**	**SMALL**	**MODERATE to LARGE**	**MODERATE**	**MODERATE to LARGE**	**MODERATE to LARGE**	**MODERATE to LARGE**
Ecology	**SMALL to MODERATE**	**SMALL**	**MODERATE to LARGE**	**SMALL**	**MODERATE**	**MODERATE to LARGE**	**SMALL to LARGE**
Water Use and Quality-Surface Water	**SMALL**	**SMALL**	**SMALL to MODERATE**	**SMALL**	**SMALL**	**SMALL**	**SMALL to MODERATE**
Water Use and Quality-Groundwater	**SMALL**	**SMALL**	**SMALL to MODERATE**	**SMALL**	**SMALL**	**SMALL**	**SMALL**
Air Quality	**SMALL**	**SMALL**	**MODERATE**	**MODERATE**	**MODERATE**	**SMALL**	**SMALL to MODERATE**
Waste	**SMALL**	**SMALL**	**MODERATE**	**SMALL**	**SMALL**	**SMALL**	**SMALL**
Human Health	**SMALL**[(b)]	**SMALL**	**SMALL**	**SMALL**	**SMALL**	**SMALL**	**SMALL**
Socio-economics	**SMALL**	**MODERATE**	**MODERATE to LARGE**	**SMALL to MODERATE**	**SMALL to MODERATE**	**MODERATE to LARGE**	**SMALL to MODERATE**
Transportation	**SMALL**	**SMALL**	**MODERATE to LARGE**	**SMALL to MODERATE**	**MODERATE**	**SMALL to MODERATE**	**MODERATE**
Aesthetics	**SMALL**	**SMALL**	**MODERATE to LARGE**	**MODERATE**	**MODERATE to LARGE**	**MODERATE to LARGE**	**MODERATE to LARGE**
Historic and Archaeological Resources	**SMALL**	**SMALL**	**SMALL**	**SMALL**	**SMALL**	**SMALL**	**SMALL to LARGE**
Environmental Justice	**SMALL**	**SMALL**	**SMALL to MODERATE**	**SMALL**	**SMALL**	**SMALL to MODERATE**	**SMALL to LARGE**

(a) Analyses based on use of a closed-cycle cooling system.

(b) Except for collective off-site radiological impacts from the fuel cycle and from high-level waste and spent-fuel disposal, for which a significance level was not assigned. See Chapter 6 for details.

NRC FORM 335 **(9-2004)** **NRCMD 3.7** **U.S. NUCLEAR REGULATORY COMMISSION** **BIBLIOGRAPHIC DATA SHEET** *(See instructions on the reverse)*	1. REPORT NUMBER **(Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.)** NUREG-1437, Supplement 29 Vol 1
2. TITLE AND SUBTITLE Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 29 Regarding Pilgrim Nuclear Power Station Final Report - Appendices	3. DATE REPORT PUBLISHED MONTH: July YEAR: 2007 4. FIN OR GRANT NUMBER
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8. PERFORMING ORGANIZATION - NAME AND ADDRESS *(If NRC, provide Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)*

Division of License Renewal
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commision
Washington, D.C. 20555-0001

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

Docket No. 50-293

11. ABSTRACT *(200 words or less)*

This supplemental environmental impact statement (SEIS) has been prepared in response to an application submitted by Entergy Nuclear Operations, Inc. (Entergy), a subsidiary of Entergy Corporation, to the NRC to renew the OL for Pilgrim Nuclear Power Station (PNPS) for an additional 20 years under 10CFR Part54. This SEIS includes the NRC staff's analysis that considers and weighs the environmental impacts of the proposed action, the environmental impacts of alternatives to the proposed action, and mitigation measures available for reducing or avoiding adverse impacts. It also includes the staff's recommendation regarding the proposed action.

The NRC staff's recommendation is that the Commission determine that the adverse environmental impacts of license renewal for PNPS are not so great that preserving the option of license renewal for energy-planning decisionmakers would be unreasonable. This recommendation is based on (1) the analysis and findings in the GEIS; (2)the Environmental Report submitted by Entergy; (3) consultations with Federal, State, and local agencies; (4) the staff's own independent review; and (5) the staff's consideration of public comments.

12. KEY WORDS/DESCRIPTORS *(List words or phrases that will assist researchers in locating the report.)* Pilgrim Nuclear Power Station Supplement to the Generic Environmental Impact Statement GEIS 29 NUREG 1437, Supplement 29 National Environmental Policy Act NEPA License Renewal PNPS	13. AVAILABILITY STATEMENT unlimited 14. SECURITY CLASSIFICATION *(This Page)* unclassified *(This Report)* unclassified 15. NUMBER OF PAGES 16. PRICE