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United States Nuclear Regulatory Commission
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NUREG-1437, Vol. 1
Supplement 45

Generic Environmental Impact Statement for License Renewal of Nuclear Plants

Supplement 45

Regarding Hope Creek Generating Station and Salem Nuclear Generating Station, Units 1 and 2

Draft Report for Comment
Main Report

Office of Nuclear Reactor Regulation

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Proposed Action	Issuance of renewed operating license NPF-57 for Hope Creek Generating Station and operating licenses DPR-70 and DPR-75 for Salem Nuclear Generating Station, Units 1 and 2 in Lower Alloway Creek Township, Salem County, New Jersey.
Type of Statement	Draft Supplemental Environmental Impact Statement
Agency Contact	Leslie Perkins U.S. Nuclear Regulatory Commission Office of Nuclear Reactor Regulation Mail Stop O-11F1 Washington, D.C. 20555-0001 Phone: 301-415-2375 Email: Leslie.Perkins@nrc.gov
Comments	Any interested party may submit comments on this supplemental environmental impact statement. Please specify NUREG-1437, Supplement 45, draft, in your comments. Comments must be received by December 17, 2010. Comments received after the expiration of the comment period will be considered if it is practical to do so, but assurance of consideration of late comments will not be given. Comments may be emailed to HopeCreekEIS@nrc.gov, SalemEIS@nrc.gov, or mailed to: Chief, Rulemaking, Directives, and Editing Branch U.S. Nuclear Regulatory Commission Mail Stop T6-D59 Washington, D.C. 20555-0001 Please be aware that any comments that you submit to the NRC will be considered a public record and entered into the Agencywide Documents Access and Management System (ADAMS). Do not provide information you would not want to be publicly available.

ABSTRACT

This draft supplemental environmental impact statement (SEIS) has been prepared in response to an application submitted by PSEG Nuclear, LLC (PSEG) to renew the operating licenses for Hope Creek Generating Station (HCGS) and Salem Nuclear Generating Station, Units 1 and 2 (Salem) for an additional 20 years.

This draft SEIS provides a preliminary analysis that evaluates the environmental impacts of the proposed action and alternatives to the proposed action. Alternatives considered include replacement power from a new supercritical coal-fired generation and natural gas combined-cycle generation plant; a combination of alternatives that includes natural gas combined-cycle generation, energy conservation/energy efficiency, and wind power; and not renewing the operating licenses (the no-action alternative).

The preliminary recommendation is that the Commission determined that the adverse environmental impacts of license renewal for Salem and HCGS are not so great that preserving the option of license renewal for energy-planning decision makers would be unreasonable.

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EXECUTIVE SUMMARY

BACKGROUND

By a letter dated August 18, 2009, PSEG Nuclear, LLC (PSEG) submitted an application to the U.S. Nuclear Regulatory Commission (NRC) to issue renewed operating licenses for Salem Nuclear Generating Station, Units 1 and 2 (Salem) and Hope Creek Generating Station (HCGS) for an additional 20-year period.

The following document and the review it encompasses are requirements of NRC regulations implementing Section 102 of the National Environmental Policy Act (NEPA) of 1969, of the *United States Code* (42 U .S.C. 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 indicates that issuing a renewed power reactor operating license requires preparation of an environmental impact statement (EIS) or a supplement to an existing EIS. In addition, 10 CFR 51.95(c) states that the EIS prepared at the operating license renewal stage will be a supplement to the *Generic Environmental Impact Statement (GEIS) for License Renewal* of *Nuclear Plants,* N U R EG-1437, Volumes 1 and 2 (NRC 1996, 1999).

Upon acceptance of the PSEG application, the Staff began the environmental review process described in 10 CFR Part 51 by publishing a Notice of Intent to prepare an EIS and conduct a public scoping process. The Staff held public scoping meetings on November 5, 2009 at the Salem County Emergency Services Building in Woodstown, New Jersey, and conducted a site regulatory audit of both facilities in March 2010.

In preparing this supplemental environmental impact statement (SEIS) for Salem and HCGS, the Staff performed the following:

- Reviewed PSEG's environmental reports (ERs) and compared them to the GEIS
- Consulted with other agencies
- Conducted a review of the issues following the guidance set forth in NUREG-1555, Supplement 1, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal*
- Considered the public comments received during the scoping process.

PROPOSED ACTION

PSEG initiated the proposed Federal action-issuance of a renewed power reactor operating license-by submitting applications for license renewal of Salem for which the existing licenses DPR-70 (Unit 1) and DPR-75 (Unit 2) expire August 13, 2016, and April 18, 2020, respectively; and HCGS for which the existing license NPF-57 expires April 11, 2026. NRC's Federal action is the decision of whether or not to renew each license for an additional 20 years.

PURPOSE AND NEED FOR ACTION

The purpose and need for the proposed action (issuance of renewed licenses) 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 (AEA) or findings in the NEPA environmental analysis that would lead the NRC to not grant a license renewal, 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.

If the renewed licenses are issued, State regulatory agencies and PSEG will ultimately decide whether or not 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 operating licenses are not renewed, then the facilities must be shut down on or before the expiration date of the current operating licenses: August 13, 2016 and April 18, 2020 for Salem Unit 1 and Unit 2, respectively; and April 11, 2026 for HCGS.

ENVIRONMENTAL IMPACTS OF LICENSE RENEWAL

The SEIS evaluates the potential environmental impacts of the proposed action. The environmental impacts of the proposed action can be assigned values of SMALL, MODERATE, or LARGE. The Staff established a process for identifying and evaluating the significance of any new and significant information on the environmental impacts of license renewal of Salem and HCGS. The NRC did not identify information that is both new and significant related to Category 1 issues that would call into question the conclusions in the GEIS. Similarly, neither the scoping process nor the Staff's review has identified any new issue applicable to Salem or HCGS that has a significant environmental impact. The Staff, therefore, relies upon the conclusions of the GEIS for all the Category 1 issues applicable to Salem and HCGS.

LAND USE

SMALL. The Staff did not identify any Category 2 impact issues for land use, nor did the staff identify any new and significant information during the environmental review; therefore, there would be no impacts beyond those discussed in the GEIS.

AIR QUALITY

SMALL. The Staff did not identify any Category 2 issues for the impact on air quality, nor did the staff identify any new or significant information during the environmental review; therefore, for plant operation during the license renewal term, there are no impacts beyond those discussed in the GEIS.

GROUNDWATER USE AND QUALITY

SMALL. Groundwater use conflicts: potable and service water-plants using greater than 100 gallons per minute (gpm) is a Category 2 issue related to license renewal at Salem and HCGS. Groundwater use conflicts were enough of a regional concern to cause designation of two Critical Areas, but the Salem and HCGS facility location was not included within either of the areas. Also, the success in allowing groundwater levels to recover suggests that groundwater use conflicts in western Salem County are likely to become less of a concern, rather than greater. Therefore, although groundwater production at Salem and HCGS may be contributing to a gradual reduction in groundwater availability, this reduction is not likely to impact any potential groundwater users.

SURFACE WATER USE AND QUALITY

SMALL. The Staff did not identify any Category 2 issues for the impact on surface water use and quality, nor did the staff identify any new or significant information during the environmental review; therefore, for plant operation during the license renewal term, there are no impacts beyond those discussed in the GEIS.

AQUATIC RESOURCES

SMALL to MODERATE. The Staff reviewed studies conducted by PSEG on the impacts of entrainment, impingement, and heat shock on the aquatic environment. The results of the studies indicate that the processes of entrainment, impingement, and thermal discharge collectively have not had a noticeable adverse effect on the aquatic resources. The Staff considered these results and reviewed the available information, including that provided by the applicant, the staff's site visit, the States of New Jersey and Delaware, the NJPDES permits and applications, and other public sources. The Staff concludes that impacts to fish and shellfish from the collective effects of entrainment, impingement, and heat shock at Salem during the renewal term would be SMALL. However, future anthropogenic and natural environmental stressors would cumulatively affect the aquatic community of the Delaware Estuary sufficiently that they would noticeably alter important attributes, such as species ranges, populations, diversity, habitats, and ecosystem processes. Based on this assessment, the Staff concludes that cumulative impacts during the relicensing period from past, present, and future stressors affecting aquatic resources in the Delaware Estuary would range from SMALL to MODERATE.

TERRESTRIAL RESOURCES

SMALL to MODERATE. With regard to operation of Salem and HCGS during the license renewal term, the NRC did not identify any Category 2 issues for terrestrial resources, nor did the staff identify any new or significant information during the environmental review; therefore, there are no impacts beyond those discussed in the GEIS. However, while the level of impact due to direct and indirect impacts of Salem and HCGS on terrestrial communities is SMALL, the cumulative impact when combined with all other sources, even if Salem and HCGS were excluded, would be MODERATE.

THREATENED AND ENDANGERED SPECIES

SMALL. The Staff reviewed information from the site audit, Environmental Reports for Salem and HCGS, other reports, and coordination with FWS and State regulatory agencies in New Jersey and Delaware regarding listed species. The Staff concludes that the impacts on federally listed terrestrial and freshwater aquatic species from an additional 20 years of operation and maintenance of the Salem and HCGS facilities and associated transmission line ROWs would be SMALL.

HUMAN HEALTH

SMALL. With regard to Category 1 human health issues during the license renewal term-microbiological organisms (occupational health), noise, radiation exposures to public, occupational radiation exposures, and electromagnetic fields (chronic effects), the Staff did not identify any new or significant information during the environmental review. Therefore, there are no impacts beyond those discussed in the GEIS.

The applicant has no plans to conduct refurbishment activities during the license renewal term, thus, no change to radiological conditions is expected to occur. Continued compliance with regulatory requirements is expected during the license renewal term; therefore, the impacts from radioactive effluents are not expected to change during the license renewal term.

The chronic effects of electromagnetic fields from power lines were not designated as Category 1 issues, and will not be until a scientific consensus is reached on the health implications of these fields. The Staff considers the GEIS finding of "uncertain" for electromagnetic fields-chronic effects still appropriate and will continue to follow developments on this issue.

Microbiological organisms (public health) and electromagnetic fields-acute effects (electric shock) are Category 2 human health issues which are discussed below.

The Staff concludes that thermophilic microbiological organisms are not likely to present a public health hazard as a result of discharges to the Delaware Estuary. The Staff concludes that impacts on public health from thermophilic microbiological organisms from continued operation of Salem and HCGS in the license renewal period would be SMALL.

The Staff reviewed PSEG's analysis of electromagnetic fields-acute shock resulting from induced charges in metallic structures, and verified that there are no locations under the transmission lines that have the capacity to induce more than 5 milliamps (mA) in a vehicle parked beneath the line. No induced shock hazard to the public should occur, since the lines are operating within original design specifications and meet current National Electric Safety Code (NESC) clearance standards. The Staff has reviewed the available information, including the applicant's evaluation and computational results. Based on this information, the staff concludes that the potential impacts from electric shock during the renewal period would be SMALL.

SOCIOECONOMICS

SMALL to LARGE. The Staff identified no Category 1 public services and aesthetic impacts, or new and significant information during the environmental review; therefore, there would be no impacts beyond those discussed in the GEIS. Category 2 socioeconomic impacts include housing impacts, public services (public utilities), offsite land use, public services (public transportation), and historic and archaeological resources.

Salem and HCGS are located in a high population area, and Cumberland, Gloucester, Salem, and New Castle Counties are not subject to growth control measures that would limit housing development. Any changes in employment at Salem and HCGS would have little noticeable effect on housing availability in these counties. Since PSEG has indicated that they have no plans to add non-outage employees during the license renewal period, there would be no impact on housing during the license renewal term beyond what has already been experienced. Also, there would be no transportation impacts during the license renewal term beyond those already being experienced.

PSEG operations during the license renewal term would also not increase plant-related population growth demand for public water and sewer services. Since there are no planned refurbishment activities at PSEG, there would be no land use impacts related to population or tax revenues, and no transportation impacts. As previously stated, PSEG has no plans to add non-outage employees during the license renewal period, employment levels at Salem and HCGS would remain relatively unchanged. Therefore, there would be no increase in the assessed value of Salem and HCGS, and annual property tax payments to Lower Alloways Creek Township would be expected to remain relatively constant throughout the license renewal period. Based on this information, there would be no tax revenue-related land-use impacts during the license renewal term beyond those already being experienced.

Based on the Staff's review of the New Jersey State Museum (NJSM) files, there are no previously recorded archaeological or above ground historic architectural resources identified on the Salem/Hope Creek property. There is little potential for historic and archaeological resources to be present on most of the Salem/Hope Creek property. No new facilities, service roads, or transmission lines are proposed for the Salem/Hope Creek site as a part of this operating license renewal, nor are refurbishment activities proposed. Therefore, there is little potential for National Register eligible historic or archaeological resources to be impacted by renewal of this operating license.

With respect to environmental justice, an analysis of minority and low-income populations residing within a 50-mile (80-km) radius of Salem and HCGS indicated there would be no disproportionately high and adverse impacts to these populations from the continued operation of Salem and HCGS during the license renewal period. Monitoring results have demonstrated that concentrations of contaminants in native vegetation, crops, soils and sediments, surface water, fish, and game animals in areas surrounding Salem and HCGS have been quite low (at or near the threshold of detection) and seldom above background levels. Consequently, no disproportionately high and adverse human health impacts would be expected in special pathway receptor populations in the region as a result of subsistence consumption of fish and wildlife.

Based on this information, the Staff concludes that the potential direct and indirect impacts to socioeconomics from continued operation of the Salem and HCGS would be SMALL. However, if PSEG decides to proceed with the construction of a new nuclear plant at the Salem and HCGS site, the cumulative impacts to socioeconomics could be SMALL to LARGE. This specific impact would depend on the actual design, characteristics and construction practices proposed by the applicant for the new nuclear plant. If a combined license application is submitted to the NRC, the detailed socioeconomic impacts would be analyzed and addressed in a separate NEPA document that would be prepared by the NRC.

SEVERE ACCIDENT MITIGATION ALTERNATIVES

Since Salem and HCGS had not previously considered alternatives to reduce the likelihood or potential consequences of a variety of highly uncommon but potentially serious accidents, NRC regulation 10 CFR 51.53(c)(3)(ii)(L) requires that Salem and HCGS evaluate Severe Accident Mitigation Alternatives (SAMAs) in the course of license renewal review. SAMAs are potential ways to reduce the risk or potential impacts of uncommon but potentially severe accidents, and may include changes to plant components, systems, procedures, and training. Based on the review of potential SAMAs, the staff concludes that Salem and HCGS made a reasonable, comprehensive effort to identify and evaluate SAMAs. Based on the review of the SAMAs for Salem and HCGS, and the plant improvements already made, the staff concludes that 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.

ALTERNATIVES

The Staff considered the environmental impacts associated with alternatives to license renewal. These alternatives include other methods of power generation and not renewing the Salem and HCGS operating licenses (the No-Action alternative). Replacement power options considered were supercritical coal-fired generation, natural gas combined-cycle generation, and, as part of the combination alternative, wind power generation combined with energy conservation/energy efficiency. Each alternative was evaluated using the same impact areas that were used in evaluating impacts from license renewal. The results of this evaluation are summarized in the Table 1.

COMPARISON OF ALTERNATIVES

A comparison of the impacts of Salem and HCGS license renewal with its three reasonable alternatives is provided in Table 1. In the Staff's best professional opinion, the coal-fired alternative is the least environmentally favorable alternative due to impacts to air quality from nitrogen oxides (NO_X), sulfur oxides (SO_X), particulate matter (PM), polycyclic aromatic hydrocarbons (PAHs), carbon monoxide (CO), carbon dioxide (CO_2), and mercury, and also due to the corresponding human health impacts. Construction impacts to transportation, aquatic, and terrestrial resources are also factors that added to this conclusion. The gas-fired alternative would have lower air emissions, but construction-related impacts to transportation, aquatic, and terrestrial resources would be similar to those from the coal-fired alternative. The combination alternative would have lower air emissions and waste management impacts than both the gas-fired and coal-fired alternatives; however, it would have relatively higher construction impacts from aquatic and terrestrial resources and potential impacts on historic and archaeological resources, primarily as a result of the wind turbine component

Under the No-Action alternative, plant shutdown would begin to eliminate most of the approximately 1,614 jobs at Salem and HCGS and would reduce general tax revenue in the region. Depending on the jurisdiction, the economic loss could have a significant impact.

Renewal of the Salem and HCGS licenses would have a small impact on environmentally-related issues; therefore, in the Staff's professional opinion, renewal of the licenses is the environmentally preferred action. All other alternatives capable of meeting the needs currently served by Salem and HCGS entail potentially greater impacts than the proposed action involving license renewal. The No-Action alternative does not meet the purpose and need of this draft SEIS.

Table 1. Summary of Environmental Impacts of Proposed Action and Alternatives

Alternative	Impact Area						
	Air Quality	**Groundwater**	**Surface Water**	**Aquatic and Terrestrial Resources**	**Human Health**	**Socio-economics**	**Waste Management**
License Renewal	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL to LARGE	SMALL[(a)]
Supercritical Coal-fired Alternative	MODERATE	SMALL	SMALL	SMALL to MODERATE	MODERATE	SMALL to MODERATE	MODERATE
Gas-fired Alternative	SMALL to MODERATE	SMALL	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL
Combination Alternative	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL	SMALL to LARGE	SMALL
No Action Alternative	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL to LARGE	SMALL

[(a)] For the Salem and HCGS license renewal alternative, waste management was evaluated in Chapter 6. Consistent with the findings in the GEIS, these impacts were determined to be SMALL with the exception of collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal.

RECOMMENDATION

The Staff's preliminary recommendation is that the Commission determines that the adverse environmental impacts of license renewals for Salem and HCGS are not so great that preserving the option of license renewal for energy planning decision makers would be unreasonable. This recommendation is based on:

(1) Analysis and findings in the GEIS,

(2) Information submitted in the Salem and HCGS ERs,

(3) Consultation with other Federal, State, and local agencies,

(4) Review of other pertinent studies and reports, and

(5) Consideration of public comments received during the scoping process

REFERENCES

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

National Environmental Policy Act of 1969, as amended, 42 U.S.C. 4321 et seq.

PSEG Nuclear, LLC (PSEG). 2009a. Salem Nuclear Generating Station, Units 1 and 2, License Renewal Application, Appendix E - Applicant's Environmental Report – Operating License Renewal Stage. Lower Alloways Creek Township, New Jersey. August, 2009. ADAMS Nos. ML092400532, ML092400531, ML092430231

PSEG. 2009b. Hope Creek Generating Station, License Renewal Application, Appendix E - Applicant's Environmental Report – Operating License Renewal Stage. Lower Alloways Creek Township, New Jersey. August, 2009. ADAMs No. ML092430389

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

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

ABBREVIATIONS AND ACRONYMS

‘	Minute(s)
°C	Degree(s) Celsius
°F	Degree(s) Fahrenheit
ΔT	Difference in Temperature
ac	Acre(s)
ADAMS	Agency Document Access and Management System
AEA	Atomic Energy Act of 1954
AEC	U.S. Atomic Energy Commission
AEO	Annual Energy Outlook
AFCM	Aggregated Food Chain Model
AIT	Alternative Intake Technology
ALARA	as low as is reasonably achievable
AQCR	Air Quality Control Region
ASMFC	Atlantic States Marine Fisheries Council
AWEA	American Wind Energy Association
BA	Biological Assessment
Barnwell	Barnwell LLW Facility
bgs	Below Ground Surface
BMWP	Biological Monitoring Work Plan
BNE	Bureau of Nuclear Engineering
BP	Before Present
BPJ	Best Professional Judgment
BPU	Board of Public Utilities
BTA	Best Technology Available
BTU	British Thermal Unit(s)
BWR	Boiling Water Reactor
CAA	Clean Air Act
CAFRA	Coastal Areas Facility Review Act
CAIR	Clean Air Interstate Rule
CAMR	Clean Air Mercury Rule

CDS	Comprehensive Demonstration Study
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CH_4	Methane
cm	Centimeter(s)
cm/s	Centimeter(s) per Second
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COLA	Combined Operating License Application
CPC	Center for Plant Conservation
CR	County Route
CSS	Colonial Swedish Society
CST	Condensate Storage Tank
CVCS	Chemical and Volume Controlled System
CWA	Clean Water Act
CWIS	Cooling Water Intake Structure
CWS	Circulating Water System
DAW	Dry Active Waste
dBA	Decibels
DCE	Dichloroethylene
DCR	Discharge Cleanup and Removal
DDL	Delaware Department of Labor
DDT	dichlorodiphenyltrichloroethane
DMR	Discharge Monitoring Reports
DNREC	Delaware Department of Natural Resources and Environmental Control
DOE	U.S. Department of Energy
DOT	Department of Transportation
DPC	Delaware Population Consortium
DPCC	Discharge Prevention, Containment, and Countermeasure
DPR	Demonstration Power Reactor
DRBC	Delaware River Basin Commission
DSC	Discover Salem County

DSM	Demand-Side Management
DSN	Discharge Serial Number
DVRPC	Delaware Valley Regional Planning Commission
ECHO	Enforcement and Compliance History Online
EEP	Estuary Enhancement Program
EFH	Essential Fish Habitat
EIA	Energy Information Administration (of DOE)
EIS	Environmental Impact Statement
ELF-EMF	extremely low frequency-electromagnetic field
EO	Executive Order
EPCRA	Emergency Planning and Community Right-to-know
ER	environmental report
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ER	Environmental Report
ESA	Endangered Species Act of 1973
ESMP	Environmental Surveillance and Monitoring Program
ESP	Early Site Permit
FEMA	Federal Emergency Management Act
FHB	Fuel Handling Building
FMP	Fishery Management Plan
fpm	Foot (Feet) per Minute
fps	Foot (Feet) per Second
FR	Federal Register
ft	Foot (feet)
ft^3	cubic foot
FWS	U.S. Fish and Wildlife Service
FWW	Freshwater Wetland
Gal	gallon(s)
GCPD	Gloucester County Planning Division
GE	GE Power Systems

GEIS	Generic Environmental Impact Statement for License Renewal of Nuclear Plants, NUREG-1437
GHC	Geo-Heat Center
GHG	Greenhouse Gas
gpm	Gallon(s) per Minute
GRS	Groundwater Recovery System
H_2O	Light Water
^2H_2O	Heavy Water
ha	Hectare(s)
HAP	Hazardous Air Pollutants
HCGS	Hope Creek Generating Station
HDA	Heat Dissipation Area(s)
HEPA	High Energy Particulate Air
HFC	Hydrofluorocarbons
HFE	Hydrofluorinated ethers
HLW	High-Level Waste
hr	Hour(s)
HUD	Housing and Urban Development
Hz	Hertz
IBA	Important Bird Area
IBMWP	Improved Biological Monitoring Work Program
IEEE	Institute of Electrical and Electronics Engineers, Inc.
INEEL	Idaho National Energy and Environmental Laboratory
IPA	Integrated Plant Assessment
IPCC	Intergovernmental Panel on Climate Change
ISFSI	Independent Spent Fuel Storage Installation
ITS	Incidental Take Statement
J	Joule
kg	Kilogram(s)
km	Kilometer(s)
km^2	Square Kilometer(s)
kwh	Kilowatt(s) Hour

kv	Kilovolt(s)
LACT	Lower Alloways Creek Township
lb	Pound(s)
LLRSF	Low Level Radwaste Storage Facility
LLW	Low Level Waste
LUR	Land Use Regulation
LWMS	Liquid Waste Management System
m	Meter(s)
m^2	Square Meter(s)
m^3	Cubic Meter(s)
mA	Milliampere(s)
MAFMC	Mid Atlantic Fishery Management Council
MANE-VU	Mid-Atlantic/Northeast Visibility Union
MBTU/hr	Million British Thermal Units per Hour
MDNR	Maryland Department of Natural Resources
mg/l	Milligrams per Liter
MGD	Million Gallons per Day
mi	Mile(s)
mi^2	Square Mile(s)
min	Minute(s)
mm	Millimeter(s)
MMS	Minerals Management Service
mps	Meter(s) per Second
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSL	Mean Sea Level
MSX	Multinucleated Sphere Unknown
MT	Metric Ton(s)
MW	megawatt
MW(d)	megawatt days
MW(e)	Megawatt-Electric
MW(h)	Megawatt Hour
MW(t)	Megawatt-Thermal
NAAQS	National Ambient Air Quality Standards

NAS	National Academy of Sciences
NCES	National Center for Educational Statistics
NEFMC	New England Fisheries Management Council
NEFSC	North East Fisheries Science Center
NEI	Nuclear Energy Institute
NEPA	National Environmental Policy Act of 1969
NERC	North American Electric Reliability Council
NESC	National Electric Safety Code NESC
NF_3	Nitrogen Trifluoride
ng	Nanograms
NHP	National Heritage Program
NHPA	National Historic Preservation Act
NIEHS	National Institute of Environmental Health Sciences
NJAC	New Jersey Administrative Code
NJAW	New Jersey American Water
NJDEP	New Jersey Department of Environmental Protection
NJDFW	New Jersey Division of Fish and Wildlife
NJDLWD	New Jersey Department of Labor and Workforce Development
NJGS	New Jersey Geological Survey
NJPDES	New Jersey Pollutant Discharge Elimination System
NJSA	New Jersey State Atlas
NJSM	New Jersey State Museum
NJWSA	New Jersey Water Science Center
NMFS	National Marine Fisheries Service
N_2O	Nitrous Oxide
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxide(s)
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRC	U.S. Nuclear Regulatory Commission
NRCS	Natural Resource Conservation Service

NREL	National Renewable Energy Laboratory
NRHP	National Register of Historic Places
NRLWDS	Non-Radioactive Liquid Waste Disposal System
NUREG	NRC Regulatory Guide
NWFMC	New England Fisheries Management Council
NWI	National Wetlands Inventory
NWR	National Wildlife Refuge
NYNHP	New York Natural Heritage Program
OMB	Office of Management and Budget
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCE	Perchloroethene or Tetrachloroethene
pCi/L	Picocuries per Liter
PFC	Perfluorocarbons
PHI	Pepco Holding, Inc.
PM	Particulate Matter
$PM_{2.5}$	Particulate Matter, 2.5 Microns or Less in Diameter
PM_{10}	Particulate Matter, 10 Microns or Less in Diameter
PNR	Pinelands National Reserve
ppm	Parts per Million
ppt	Parts per Thousand
PRM	Potomac-Rantan-Magothy
PSD	Prevention of Significant Deterioration
PSEG	PSEG Nuclear, LLC
PSE&G	Public Service Electric and Gas Company
Psia	Pound(s) per Square Inch
PTE	Potential to Emit
PWR	Pressurized Water Reactor
RAWP	Remedial Action Work Plan
RCS	Reactor Coolant System
RCRA	Resource Conservation and Recovery Act
RGGI	Regional Greenhouse Gas Initiative
REMP	Radiological Environmental Monitoring Program

RGPP	Radiological Groundwater Protection Program
RIS	Representative Impact Species
RK	River Kilometer
RLWS	Radioactive Liquid Waste System
RM	river mile
ROI	Region of Influence
ROW(s)	Right-of-Way(s)
RPO	Regional Planning Organization
RPS	Renewable Portfolio Standard
RS	Representative Species
SADC	State Agriculture Development Committee
SAFMC	South Atlantic Fishery Management Council
Salem	Salem Nuclear Generating Station, Units 1 & 2
SAMA	Severe Accident Mitigation Alternative
SAR	Safety Analysis Report
SARA	Superfund Amendments and Reauthorization Act
SCR	Selective Catalytic Reduction
SEIS	Supplemental Environmental Impact Statement
SER	Safety Evaluation Report
SF_6	Hexafluoride
SFP	Spent Fuel Pool
SHPO	State Historic Preservation Office
Site	Combined Site
SO_2	Sulfur Dioxide
SO_x	Sulfur Oxides
SPCC	Spill Prevention, Control, and Countermeasure
SSB	Spawning Stock Biomass
SSBPR	Spawning Stock Biomass per Recruit
Staff	NRC staff
STP	Sewage Treatment Plant
SWPPP	Stormwater Pollution Prevention Plan
SWS	Service Water System

TCPA	Toxic Catastrophe Prevention Act
TLD	Thermo Luminescent Dosimeter
TSP	Total Suspended Particles
UO_2	Uranium Dioxide
UNESCO	United Nations Educational, Scientific, and Cultural Organization
U.S.	United States
USACE	United States Army Corps of Engineers
U.S.C.	United States Code
USCB	United Stated Census Bureau
USDA	United States Department of Agriculture
USGS	U.S. Geological Survey
VOC	Volatile Organic Compound
WMA	Wildlife Management Areas
WQM	Water Quality Management

1.0 PURPOSE AND NEED FOR ACTION

Pursuant to the U.S. Nuclear Regulatory Commission's (NRC's) environmental protection regulations in Title 10, Part 51, of the U.S. *Code of Federal Regulations* (10 CFR 51), which implement the U.S. National Environmental Policy Act of 1969 (NEPA), an environmental impact statement (EIS) is required to be prepared for issuance of a new nuclear power plant operating license.

The Atomic Energy Act of 1954 (AEA) originally specified that licenses for commercial power reactors be granted for up to 40 years with an option to renew for up to another 20 years. The 40-year licensing period is based on economic and antitrust considerations rather than on technical limitations of the nuclear facility.

The decision to seek a license renewal rests entirely with nuclear power facility owners and typically is based on the facility's economic viability and the investment necessary to continue to meet NRC safety and environmental requirements. The NRC staff (Staff) makes the decision to grant or deny a license renewal, based on whether or not the applicant has demonstrated that the environmental and safety requirements in the NRC's regulations can be met during the period of extended operation.

1.1 Proposed Federal Action

PSEG Nuclear, LLC (PSEG) initiated the proposed Federal action by submitting applications for license renewal of Salem Nuclear Generating Station, Units 1 and 2 (Salem) for which the existing licenses DPR-70 (Unit 1) and DPR-75 (Unit 2) expire on August 13, 2016, and April 18, 2020, respectively and Hope Creek Generating Station (HCGS), for which the existing license NPF-57 expires April 11, 2026. NRC's Federal action is the decision whether or not to renew these licenses for an additional 20 years.

1.2 Purpose and Need for the Proposed Federal Action

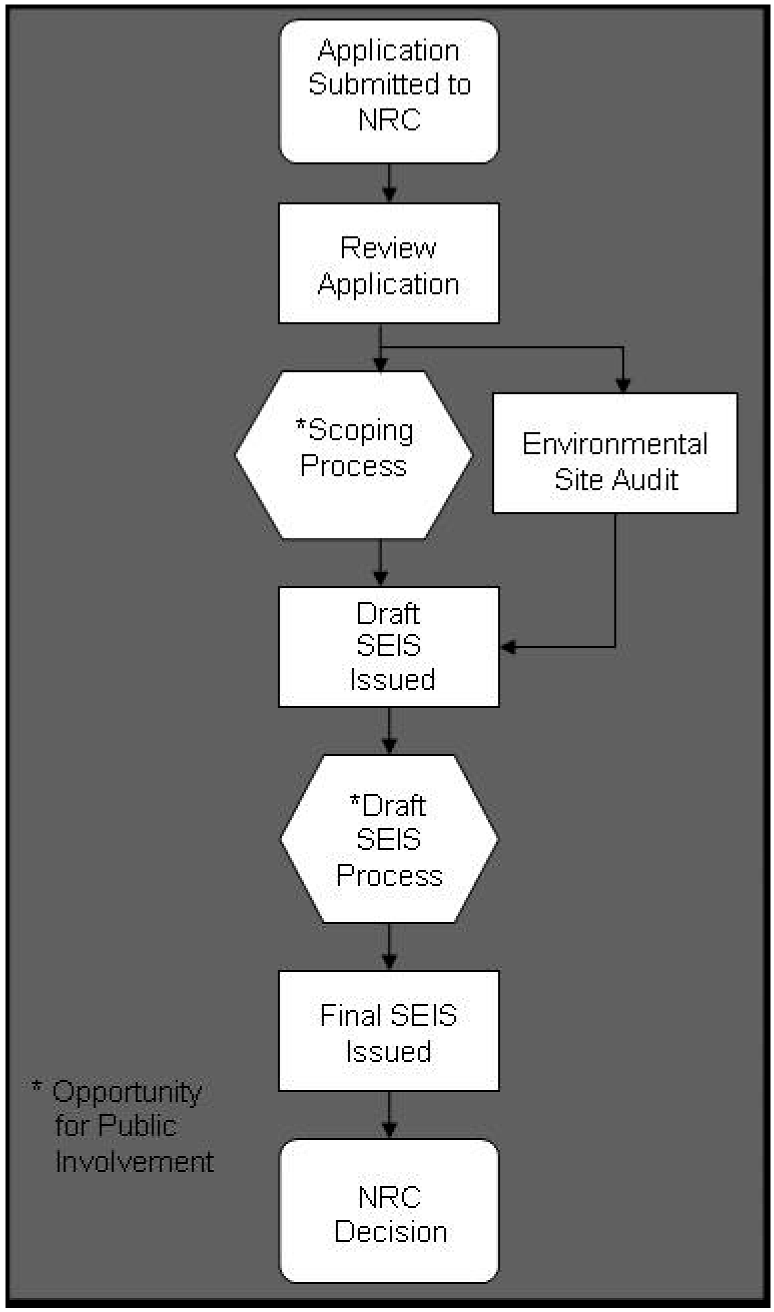
The purpose and need for the proposed action (issuance of a renewed license) is to provide an option that allows for power generation capability beyond the term of a current nuclear power plant operating license to meet future system generating needs, which may be determined by applicable energy-policy 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 AEA or findings in the NEPA environmental analysis that would lead the NRC to not grant a license renewal, the NRC does not have a role in the energy-planning decisions as to whether or not a particular nuclear power plant should continue to operate.

If the renewed license is issued, the appropriate regulatory agencies (other than NRC) and PSEG will ultimately decide whether the plant will continue to operate based on additional factors such as the need for power, other matters within the regulator's jurisdiction, or the purview of the owners. If the operating license is not renewed, the appropriate facility must be shut down on or before the expiration date of the current operating licenses, August 13, 2016 for Unit 1 at Salem, April 18, 2020 for Unit 2 at Salem, and April 11, 2026 at HCGS.

1.3 Major Environmental Review Milestones

As part of the license renewal application, PSEG submitted an environmental report (ER), dated August 18, 2009, for each Salem unit (PSEG, 2009a) and the HCGS (PSEG, 2009b). After reviewing the application and the ERs for sufficiency, the Staff published a notice of acceptance for docketing of the application on October 23, 2009, in the *Federal Register* (FR) (Volume 74, p. 54854, (74 FR 54854) for Salem; and Volume 74, p. 54856, (74 FR 54856) for HCGS). Also, on October 23, 2009, the NRC published another notice in the FR (74 FR 54859) on its intent to conduct scoping, thereby beginning the 60-day scoping period for the supplemental environmental impact statement (SEIS).

Figure 1-1. Environmental Review Process.
The environmental review provides opportunities for public involvement.



The NRC conducted two public scoping meetings on November 5, 2009 in Woodstown, New Jersey. The Staff prepared an SEIS scoping process summary report dated September 2010, which presents the comments received during the scoping process (NRC, 2010). Appendix A to this SEIS presents comments considered to be within the scope of the environmental license renewal review and the NRC's consideration of those comments.

To independently verify information provided in the ER, the Staff conducted a site audit at the Salem and HCGS site in March 2010. During the site audit, the Staff met with plant personnel, reviewed specific documentation, toured the facility, and met with interested Federal, State, and local agencies.

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

Upon completion of the scoping period and site audit, the Staff compiled its findings in this draft SEIS. An illustration of this process is provided in Figure 1-1. This SEIS is made publicly available for a period of 45 days during which the Staff will host public meetings and collect public comments. Based on the information gathered, the Staff will amend the draft SEIS findings as necessary, and then publish the final SEIS.

The Staff has established a license renewal process that can be completed in a reasonable period of time with clear requirements to assure safe plant operation for up to an additional 20 years. The safety review, which documents its finding in a Safety Evaluation Report (SER), is conducted simultaneously with the environmental review process. Both the findings in the SEIS and the SER are factors considered in the Commission's decision to either grant or deny the issuance of a new license.

1.4 Generic Environmental Impact Statement

To improve the efficiency of the license renewal process, the Staff prepared a generic assessment of the environmental impacts associated with license renewal. Specifically, the agency prepared NUREG-1437, *Generic Environmental Impact Statement (GEIS) for License Renewal of Nuclear Power Plants,* which evaluates the environmental consequences of renewing the licenses of individual nuclear power plants and operating them for an additional 20 years (NRC, 1996; NRC, 1999).[1] The Staff analyzed those environmental issues that could be resolved generically in the GEIS.

The GEIS establishes 92 separate issues for the Staff to consider. Of these, the staff determined that 69 are generic to all plants (Category 1), while 21 issues do not lend themselves to generic consideration (Category 2). Two other issues, which must be evaluated on a site-specific basis, are environmental justice and the chronic effects of electromagnetic fields. Appendix B to this report lists all 92 issues.

For each 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 or not, and (6) considers whether additional mitigation measures are warranted or not for impacts that would have the same significance level for all plants.

[1] The NRC originally issued the GEIS in 1996 and issued Addendum 1 to the GEIS in 1999. Hereafter, all references to the "GEIS" include the GEIS and Addendum 1.

The GEIS assesses the significance of these issues, using the Council on Environmental Quality (CEQ) terminology for "significant." The GEIS established three levels of significance for potential impacts—SMALL, MODERATE, and LARGE. The three levels of significance are defined below:

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

MODERATE – Environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.

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

The GEIS includes a determination of whether or not the analysis of the environmental issue could be applied to all plants and whether or not additional mitigation measures are warranted (Figure 1-2). Issues are assigned a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1 issues are those that meet all of the following criteria:

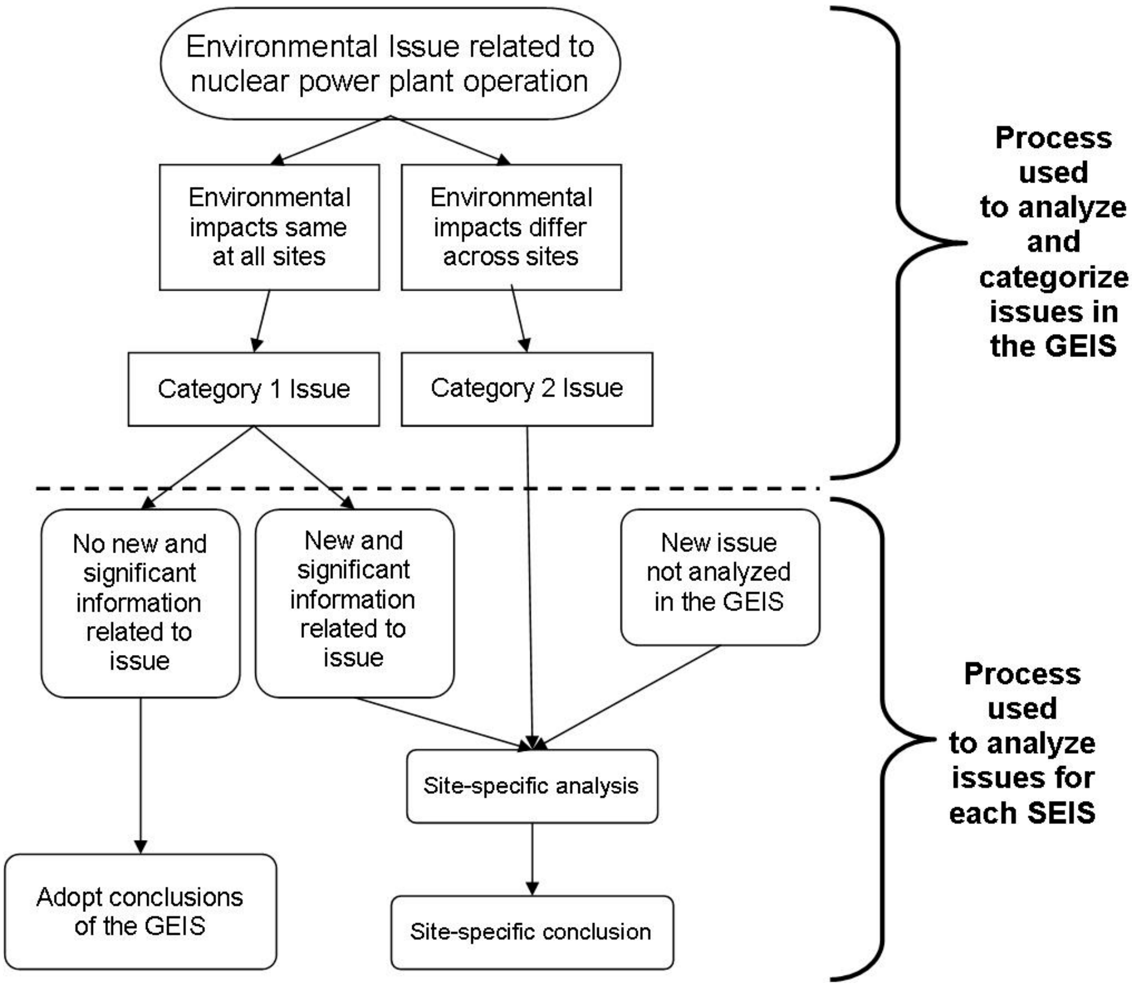
(1) The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristics.

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

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

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

Figure 1-2. Environmental Issues Evaluated During License Renewal. *92 issues were initially evaluated in the GEIS. A site-specific analysis is required for 23 of those 92 issues.*



1.5 Supplemental Environmental Impact Statement

The SEIS presents an analysis that considers the environmental effects of the continued operation of Salem and HCGS, potential alternatives to license renewal, and potential mitigation measures for minimizing adverse environmental impacts. Chapter 8 contains analysis and comparisons of the environmental impacts of alternatives. Chapter 9 presents the preliminary recommendation to the Commission as to whether or not the environmental impacts of license renewal are so great that preserving the option of license renewal would be unreasonable. The recommendation will be made after consideration of comments received during the public scoping period for the draft SEIS.

During the preparation of this SEIS, the Staff:

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

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

New and significant information either:
(1) identifies a significant environmental issue not covered in the GEIS, or
(2) was not considered in the analysis in the GEIS and leads to an impact finding that is different from the finding presented in the GEIS.

1.6 Cooperating Agencies

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

1.7 Consultations

Pursuant to the following acts, Federal agencies are required to consult with applicable State and Federal agencies and groups before taking action that may affect endangered species, fisheries, or historic and archaeological resources, respectively:

- Endangered Species Act of 1973, as amended;
- Magnuson-Stevens Fisheries Conservation and Management Act of 1996, as amended; and
- National Historic Preservation Act of 1966, as amended.

Listed below are the agencies and groups that have been consulted; Appendix D of this report includes copies of consultation documents:

Delaware Division of Historical and Cultural Affairs, Dover, New Jersey

Maryland Historical Trust, Crownsville, Maryland

New Jersey Historic Preservation Office, Trenton, New Jersey

Pennsylvania Bureau for Historic Preservation, Harrisburg, PA

Delaware Division of Historical and Cultural Affairs, Dover, Delaware

U.S. Fish and Wildlife Services, Pleasantville, New Jersey

National Oceanographic and Atmospheric Administration, National Marine Fisheries Service, Gloucester, Massachusetts

National Oceanographic and Atmospheric Administration, National Marine Fisheries Service, Highlands, New Jersey

New Jersey Department of Environmental Protection, Division of Land Use Regulation, Trenton, New Jersey

Pocomoke Indian Nation, Mount Airy, Maryland

1.8 Correspondence

Table 1-1 lists persons and organizations to which a copy of this draft SEIS is sent. Appendix E to this report contains a chronological list of documents sent and received during the environmental review. During the course of the environmental review, the Staff contacted the following Federal, State, regional, local, or tribal agencies:

Accohannock Indian Tribe, Salisbury, Maryland

Delaware Nation, Andarko, Oklahoma

Delaware Tribe of Indians, Bartlesville, Oklahoma

Eastern Lenape Nation of PA, Mountville, Pennslyvania

Echota Chickamauga Cherokee Tribe of New Jersey, Irvington, New Jersey

Lenape Tribe of Delaware, Cheshold, Delaware

Nanticoke Indians Association, Inc., Millsboro, Delaware

Nanticoke Lenni-Lenape Indians of New Jersey, Brigeton, New Jersey

Nause-Waiwash Tribe, Cambridge, Maryland

Osprey Band of Free Cherokees, Mays Landing, New Jersey

Piscataway-Conoy Confederacy and Sub-Tribes, Inc., LaPlata, Maryland

Piscataway Indian Nation, Accokeek, Maryland

Pocomoke Indian Nation, Mount Airy, Maryland

Powhatan Renape Nation, Rancocas, New Jersey

Ramapough Mountain Lenape, Mahway, New Jersey

Unalachtigo Band of the Nanticoke-Lenni Lenape Nation, Bridgeton, New Jersey

Younghiogheny Shawnee Band, Bethesda Maryland

Table 1-1. List of persons who are sent a copy of this draft SEIS

State Historic Preservation Officer, Delaware Division of Historical and Cultural Affairs, Dover, New Jersey	Director and State Historic Preservation Officer, Maryland Historical Trust, Crownsville, Maryland	Historic Preservation Officer, New Jersey Historic Preservation Office, Trenton, New Jersey
Historic Preservation Officer, Pennsylvania Bureau for Historic Preservation, Harrisburg, PA	Delaware Division of Historical and Cultural Affairs, Dover, Delaware	U.S. Fish and Wildlife Services, Pleasantville, New Jersey
National Oceanographic and Atmospheric Administration, National Marine Fisheries Service, Gloucester, Massachusetts	National Oceanographic and Atmospheric Administration, National Marine Fisheries Service, Highlands, New Jersey	Joseph Sindoni, PSEG Nuclear LLC
New Jersey Department of Environmental Protection, Division of Land Use Regulation, Trenton, New Jersey	Nanticoke Lenni-Lenape Indians of New Jersey, Brigeton, New Jersey	Jerry Humphreys, NJ Bureau of Nuclear Engineering
Jamie Turner, Delaware Emergency Management Agency	Cheryl Reardon, ANJEC	Tanya Baker, Office of Senator Kaufman
Jane Nogaki, NJ Environmental Federation	Kate Roher, Kent/Sussex County Director	Garth Spencer, Office of Senator Tome Carper (DE)
Julie Acton, Salem County Freeholder	Karen Tuccillo, NJDEP	Kathryn Sutton, Morgan Lewis
Tom Figlio	Michael Tuosto, PSEG Nuclear LLC	Al Fulvio, Exelon
Rich Pinney, State of New Jersey	James Stavely, PSEG Nuclear LLC	Nancy Ranek, Excelon

1.9 Status of Compliance

PSEG is responsible for complying with all NRC regulations and other applicable Federal, State, and local requirements; Appendix C describes some of the principal Federal statutes for which PSEG must comply. Table 1-2 lists the numerous permits and licenses issued by Federal, State, and local authorities for activities at Salem and HCGS, respectively.

Table 1-2. Licenses and Permits. *Existing environmental authorizations for Salem and HCGS*

Salem Nuclear Generating Station, Units 1 and 2

Permit	Number	Dates	Responsible Agency
Operating Licenses	DPR-70 and DPR-75	Issued: 8/13/1976 and 4/18/1980 Expires: 8/13/2016 and 4/18/2020	U.S. Nuclear Regulatory Commission
Groundwater Allocation Permit	D-90-71	Issued: 11/15/2000 Expires: 11/15/2010 Renewal request submitted 8/5/2010	Delaware River Basin Commission
Surface Water Permit	DRBC Docket No. D-68-20-CP (revision 2)	Issued: 09/13/2001 Expires: 09/13/2026	Delaware River Basin Commission
Water Use Contract	76-EP-482	Issued: 01/13/1977 Expires: None	Delaware River Basin Commission
Industrial Waste Treatment Facility	D-83-36	Issued: 01/25/1984 Expires: None	Delaware River Basin Commission
Approval of wells and installation/allocation of ground water	D75-94	Issued: 08/27/1975 Expires: None	Delaware River Basin Commission
Conditional Use Approval/Variance for temporary storage of spent nuclear fuel	SP-1-09; VR-1-09	Issued: 08/26/2009 Expires: 08/26/2014	Lower Alloways Creek Township
Preliminary and Final Site Plan Approval – Operating a Shooting Range	SP-1-05	Issued: 05/25/2005 Expires: None	Lower Alloways Creek Township
Preliminary and Final Site Plan Approval – Improvements to Employee Parking Lots B & C	SP-2-05	Issued: 08/24/2005 Expires: None	Lower Alloways Creek Township

Permit	Number	Dates	Responsible Agency
Minor Site Plan Approval – Salem HCGS Dimineralized water (DM) Plant Upgrades	SP-3-04	Issued: 10/27/2004 Expires: None	Lower Alloways Creek Township
Renewal of Conditional Use Permit – Continued Storage of Radioactive Material (Spent Fuel Storage Pools)	CU-07-1	Issued: 12/19/2007 Expires: 12/19/2012	Lower Alloways Creek Township
New Jersey Pollutant Discharge Elimination System Permit	NJ0005622	Issued: 06/29/2001 Effective: 08/01/2001 Expires: 07/31/2006 (Administratively continued while renewal application is being reviewed.)	New Jersey Department of Environmental Protection
Discharge Prevention, Containment, and Countermeasure (DPCC) Plan; Discharge Cleanup and removal (DCR) Plan	170400041000	Issued: 03/04/2009 Expires: 07/27/2011	New Jersey Department of Environmental Protection
Waterfront Development Permit	170-02-001.4 WFD 050001	Issued: 08/16/2005 Expires: 08/16/2010 Activity-based permit; No renewal required	New Jersey Department of Environmental Protection
Coastal Areas Facility Review Act (CAFRA) Permit (DM Plant)	1704-02-001.3 CAF 040001	Issued: 09/23/2004 Expires: 09/23/2009 Activity-based permit; No renewal required	New Jersey Department of Environmental Protection
Coastal Areas Facility Review Act (CAFRA) Permit (Maintenance and Project Support Building)	1704-02-001.3 CAF 040002	Issued: 03/24/2005 Expires: 03/24/2010 Activity-based permit; No renewal required	New Jersey Department of Environmental Protection
Coastal Areas Facility Review Act (CAFRA) Permit (Security Vehicle Barrier System)	1704-02-001.4 CAF 050002	Issued: 08/16/2005 Expires: 08/16/2010 Activity-based permit; No renewal required	New Jersey Department of Environmental Protection

Permit	Number	Dates	Responsible Agency
Coastal Areas Facility Review Act (CAFRA) Permit (Nuclear Administration Building (NAB) Parking Lot)	1704-02-001.4 CAF 050003	Issued: 12/01/2005 Expires: 12/01/2010 Activity-based permit; No renewal required	New Jersey Department of Environmental Protection
Freshwater Wetland (FWW) Permit (Security Vehicle Barrier System)	1704-02-001.4 FWW 050001	Issued: 08/16/2005 Expires: 08/16/2010 Activity-based permit; No renewal required	New Jersey Department of Environmental Protection
Freshwater Wetland (FWW) Permit (NAB Parking Lot)	1704-02-001.4 FWW 050002	Issued: 12/01/2005 Expires: 12/01/2010 Activity-based permit; No renewal required	New Jersey Department of Environmental Protection
Water Allocation Permit for Salem and HCGS	Activity No: WAP04001 Program Interest ID: 2216P	Issued: 01/01/2005 Expires: 01/31/2011	New Jersey Department of Environmental Protection
Public Water Supply Identification Number	1704300	Issued: 09/04/1980 Expires: None	New Jersey Department of Environmental Protection
Air Pollution Control Operating Permit (Title V Operating Permit)	BOP080001	Issued: 02/02/2005 Modified: 03/27/2009 Expires: 02/01/2011	New Jersey Department of Environmental Protection
Grant of Permanent Right-of-Way	None	Issued: 11/04/1971 Expires: None	New Jersey Department of Environmental Protection
Medical Waste Generator Certificate	34571	Issued: 08/14/1992 Expires: Renewed annually	New Jersey Department of Environmental Protection
Riparian Easement Grant	68-12	Issued: 01/10/1974 Expires: None	The State of New Jersey
Riparian License	69-80	Issued: 08/29/1972	The State of New

Permit	Number	Dates	Responsible Agency
		Expires: None	Jersey
South Carolina Radioactive Waste Transport Permit	0018-29-10-X	Issued: 12/29/2009 Renewed Annually	South Carolina Department of Health and Environmental Control – Division of Waste Management
Tennessee Radioactive Waste Transport Permit	T-NJ002-L10	Issued: 12/29/2009 Renewed Annually	State of Tennessee Department of Environmental and Conservation Division of Radiological Health
Maintenance Dredging	CENAP-OP-R-2006-6232-45	Issued: 07/14/2008 Expires: 07/27/2020	U.S. Army Corps of Engineers
Deed of Easement	None	Issued: 04/24/1968 Expires: None	U.S. Department of the Army
Incidental Take Statement – sea turtles and shortnose sturgeon	N/A	Issued: 05/15/1993 Expires: None	U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Marine Fisheries Service
Hazardous Material Shipments Registration	US DOT ID 997370 061908 002 018QS	Issued: 07/01/2008 Expires: 06/30/2011	U.S. Department of Transportation
Spill Prevention, Control, and Countermeasure (SPCC) Plan Approval	None	Pending	U.S. Environmental Protection Agency
Facility Response Plan Approval	0200087	Submitted: 02/15/2008 Status: Pending	U.S. Environmental Protection Agency
Hazardous Waste Generator	NJD07707811	Acknowledged: 09/13/1989 Expires: None	U.S. Environmental Protection Agency

Hope Creek Generating Station

Permit	Number	Dates	Responsible Agency
Operating Licenses	NPF-57	Issued: 4/11/1986 Expires: 4/11/2026	NRC
Conditional Use and Variance for temporary storage of spent nuclear fuel	SP-1-09 and VR-1-09	Issued: 08/26/2009 Expires: 06/24/2014	Lower Alloways Creek Township
Preliminary and Final Site Plan Approval – Operating a Shooting Range	SP-1-05	Issued: 05/25/2005 Expires: None	Lower Alloways Creek Township
Preliminary and Final Site Plan Approval – Improvements to Employee Parking Lots B & C	SP-2-05	Issued: 08/24/2005 Expires: None	Lower Alloways Creek Township
Discharge Prevention, Containment, and Countermeasure (DPCC) Plan; Discharge Cleanup and removal (DCR) Plan	170400041000	Issued: 03/04/2009 Expires: 07/27/2011	New Jersey Department of Environmental Protection
Waterfront Development Permit	170-02-001.4 WFD 050001	Issued: 08/16/2005 Expires: 08/16/2010 Activity-based permit; No renewal required	New Jersey Department of Environmental Protection
Coastal Areas Facility Review Act (CAFRA) Permit (Land use associated with HCGS)	74-014	Issued: 09/03/1975 Expires: None	New Jersey Department of Environmental Protection
Coastal Areas Facility Review Act (CAFRA) Permit (Land use associated with Sandblast Facility Modifications)	1704-90-004-5-CAM	Issued: 04/25/1995 Expires: None	New Jersey Department of Environmental Protection
Coastal Areas Facility Review Act (CAFRA) Permit (DM Plant)	1704-02-001.3 CAF 040001	Issued: 09/23/2004 Expires: 09/23/2009 Activity-based permit; No renewal required	New Jersey Department of Environmental Protection

Permit	Number	Dates	Responsible Agency
Coastal Areas Facility Review Act (CAFRA) Permit (NAB Parking Lot)	1704-02-001.4 CAF 050003	Issued: 12/01/2005 Expires: 12/01/2010 Activity-based permit; No renewal required	New Jersey Department of Environmental Protection
Freshwater Wetland (FWW) Permit (NAB Parking Lot)	1704-02-001.4 FWW 050002	Issued: 12/01/2005 Expires: 12/01/2010 Activity-based permit; No renewal required	New Jersey Department of Environmental Protection
Water Allocation Permit for Salem and HCGS	Activity No: WAP09001 Program Interest ID: 2216P	Issued: 01/01/2005 Expires: 06/30/2020	New Jersey Department of Environmental Protection
Public Water Supply Identification Number	1704300	Issued: 09/04/1980 Expires: None	New Jersey Department of Environmental Protection
Type “B” Wetlands Permit	W74-02	Issued: 02/28/1975 Expires: None	New Jersey Department of Environmental Protection
Medical Waste Generator Certificate	34571	Issued: 08/14/1992 Renewed annually	New Jersey Department of Environmental Protection
South Carolina Radioactive Waste Transport Permit	0018-29-10-X	Issued: 12/29/2009 Renewed Annually	South Carolina Department of Health and Environmental Control – Division of Waste Management

Permit	Number	Dates	Responsible Agency
Tennessee Radioactive Waste Transport Permit	T-NJ002-L10	Issued: 12/29/2009 Renewed Annually	State of Tennessee Department of Environmental and Conservation Division of Radiological Health
Spill Prevention, Control, and Countermeasure (SPCC) Plan	None	Last Reviewed: 02/29/2008 Next Scheduled Review: 02/28/2013	U.S. Environmental Protection Agency
Facility Response Plan Approval	0200087	Submitted: 02/15/2008 Pending	U.S. Environmental Protection Agency
Notification of Hazardous Waste Activity	NJD07707811	Acknowledged: 09/13/1989 Expires: None	U.S. Environmental Protection Agency

1.10 References

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

74 FR 54854. U.S. Nuclear Regulatory Commission. Washington D.C. "Notice of Acceptance for Docketing of the Application and Notice of Opportunity for Hearing Regarding Renewal of Facility Operating License Nos. DPR-70 and DPR-75 for an Additional 20-Year Period; PSEG Nuclear LLC, Salem Nuclear Generating Stations, Units 1 and 2." Federal Register: Vol 74, No. 204, pp 54854- 54856. October 23, 2009.

74 FR 54856. U.S. Nuclear Regulatory Commission. Washington D.C. "Notice of Acceptance for Docketing of the Application and Notice of Opportunity for Hearing Regarding Renewal of Facility Operating License No. DPR-57 for an Additional 20-Year Period; PSEG Nuclear LLC Hope Creek Generating Station, Unit 1." Federal Register: Vol 74, No. 204, pp 54856- 54858. October 23, 2009.

74 FR 54859. U.S. Nuclear Regulatory Commission. Washington D.C. "PSEG Nuclear, LLC; Notice of Intent to Prepare an Environmental Impact Statement and Conduct the Scoping Process for Salem Nuclear Generating Station, Units 1 and 2, and Hope Creek Generating Station." Federal Register: Vol 74, No. 204. pp 54859-54860. October 23, 2009.

Atomic Energy Act of 1954. 42 U.S.C. 2011, et seq.

Endangered Species Act of 1973. 16 U.S.C. 1531, et seq.

Magnuson-Stevens Fishery Conservation and Management Act, as amended by the *Sustainable Fisheries Act of 1996*. 16 U.S.C. 1855, et seq.

National Environmental Policy Act of 1969. 42 U.S.C. 4321, et seq.

National Historic Preservation Act. 16 U.S.C. 470, et seq.

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2.0 AFFECTED ENVIRONMENT

Salem Nuclear Generating Station (Salem) and Hope Creek Generating Station (HCGS) are located at the southern end of Artificial Island in Lower Alloways Creek Township, Salem County, New Jersey. The facilities are located at River Mile 50 (RM 50; River Kilometer 80 [RK 80]) and RM 51 (RK 82) on the Delaware River, respectively, approximately 17 miles (mi; 27 kilometers [km]) south of the Delaware Memorial Bridge. Philadelphia is about 35 mi (56 km) northeast and the city of Salem, New Jersey is 8 mi (13 km) northeast of the site (AEC, 1973). Figure 2-1 shows the location of Salem and HCGS within a 6-mi (10 km) radius, and Figure 2-2 is an aerial photograph of the site.

Because existing conditions are partially the result of past construction and operation at the plants, the impacts of these past and ongoing actions and how they have shaped the environment are presented in this chapter. Section 2.1 of this report describes Salem and HCGS as a combined site (site), the individual facilities, and their operations; Section 2.2 discusses the affected environment; and Section 2.3 describes related Federal and State activities near the site.

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

Artificial Island is a 1,500-acre (ac; 600 hectare [ha]) island that was created by the U.S. Army Corps of Engineers (USACE) beginning in the early 20th century. The island began as buildup of hydraulic dredge spoils within a progressively enlarged diked area established around a natural sandbar that projected into the river. The island is characterized by low and flat tidal marsh and grassland with an average elevation of about 9 feet (ft; 3 meters [m]) above mean sea level (MSL) and a maximum elevation of about 18 ft (5.5 m) above MSL (AEC, 1973).

Public Service Enterprise Group Incorporated Nuclear, LLC (PSEG) owns approximately 740 ac (300 ha) on the southern end of Artificial Island. The Salem and HCGS facilities occupy 373 ac (150 ha; 220 ac [89 ha] for Salem and 153 ac [62 ha] for HCGS) in the southwestern corner of the island. The remainder of Artificial Island is undeveloped.

The remainder of the island is owned by the U.S. Government and the State of New Jersey. The northern portion of Artificial Island, a very small portion of which is within the State of Delaware boundary, and a 1-mi (1.6-km) wide inland strip of land abutting the island are owned by the U.S. Government (AEC, 1973). The State of New Jersey owns the remainder of Artificial Island, as well as much of the nearby inland property. The distance to the PSEG property boundary from the two Salem reactor buildings is approximately 4,200 ft (1,300 m). Distance to the PSEG property boundary from the HCGS reactor building is 2,960 ft (902 m).

There are no major highways or railroads within about 7 mi (11 km) of the site. Land access is provided via Alloway Creek Neck Road to Bottomwood Avenue. The site is located at the end of Bottomwood Avenue and there is no traffic that bypasses the site. Barge traffic has access to the site by way of the Intracoastal Waterway channel maintained in the Delaware River (AEC, 1973).

Figures 2-3 and 2-4 show the property boundaries and facility layouts for the Salem and HCGS facilities, respectively.

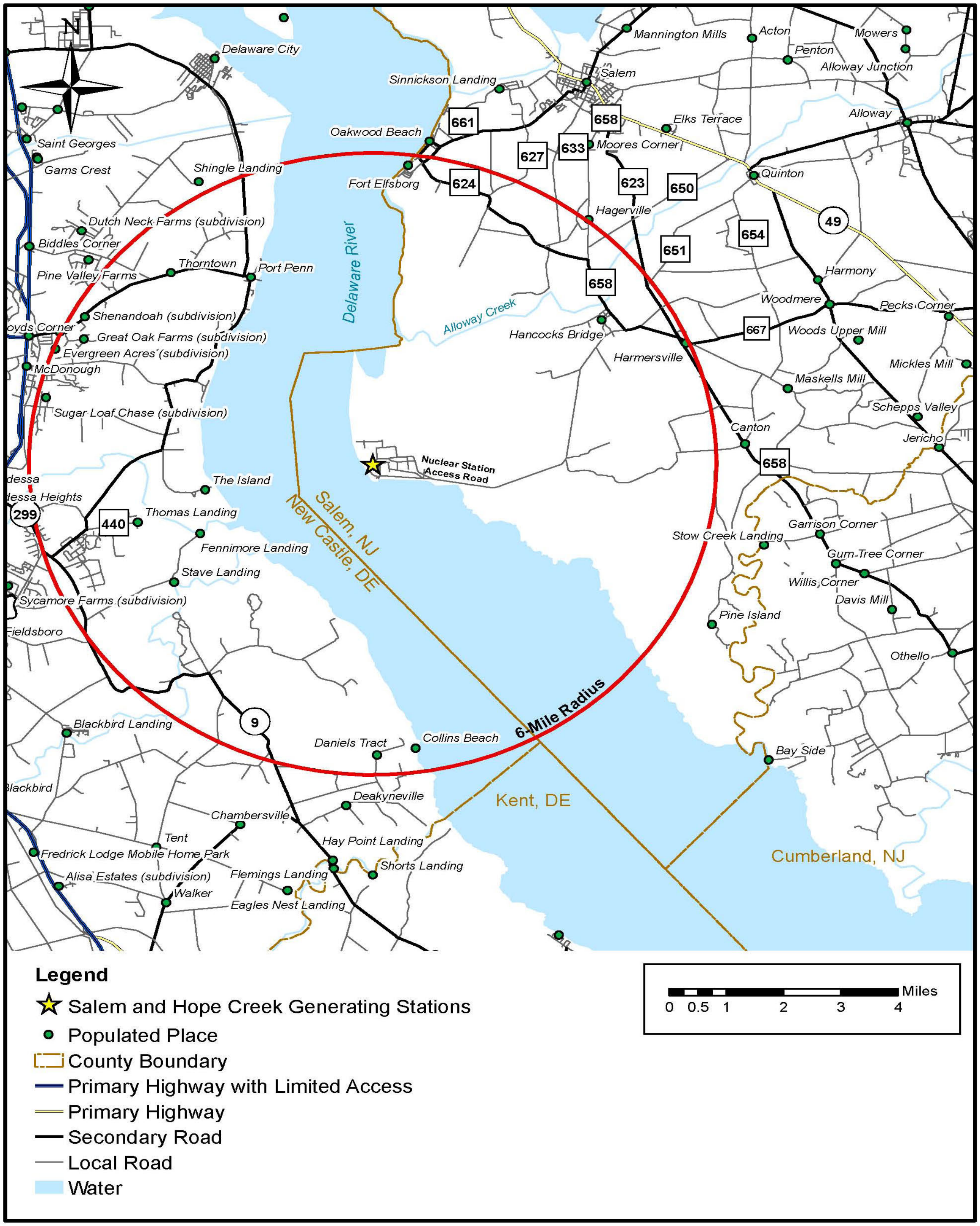
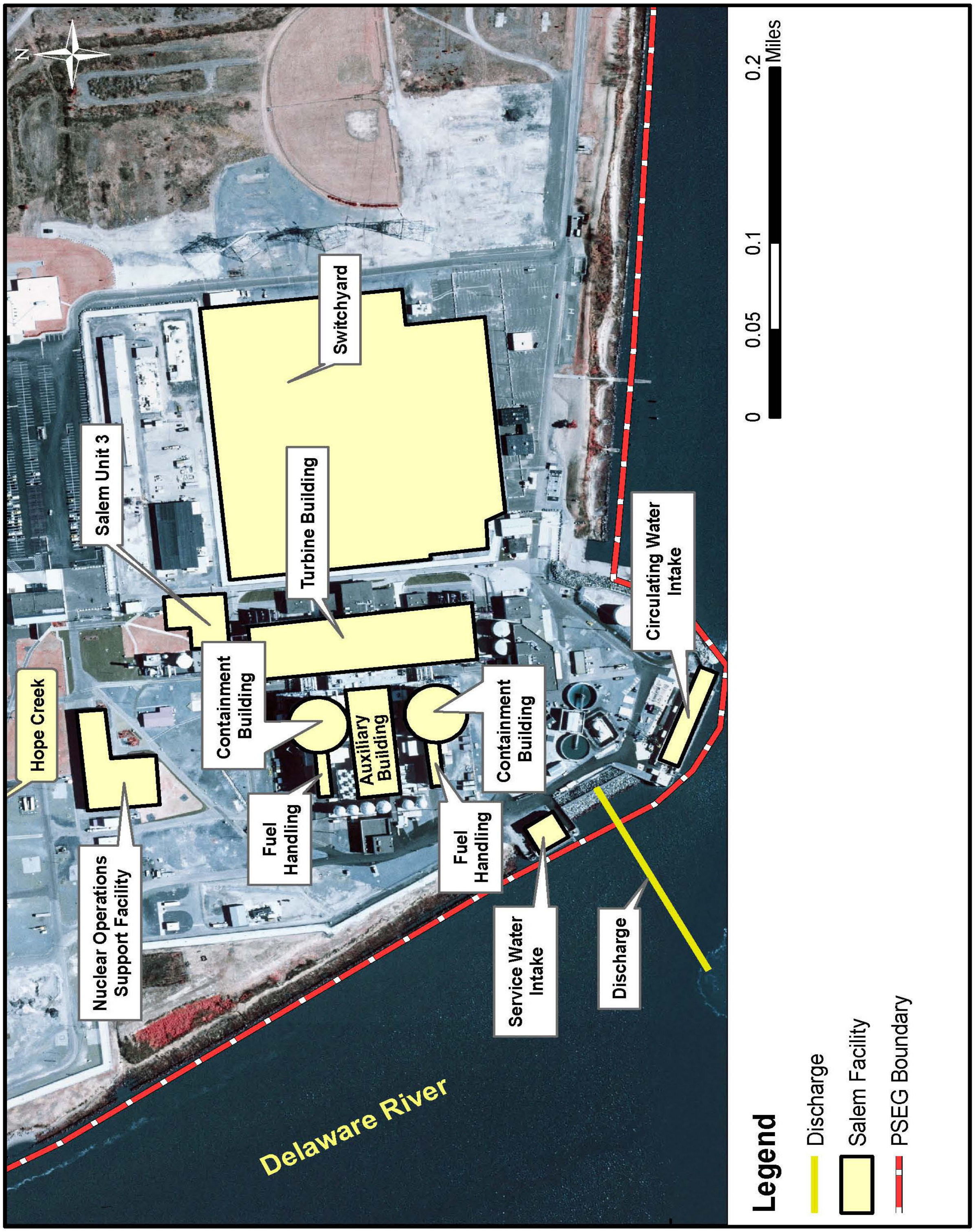
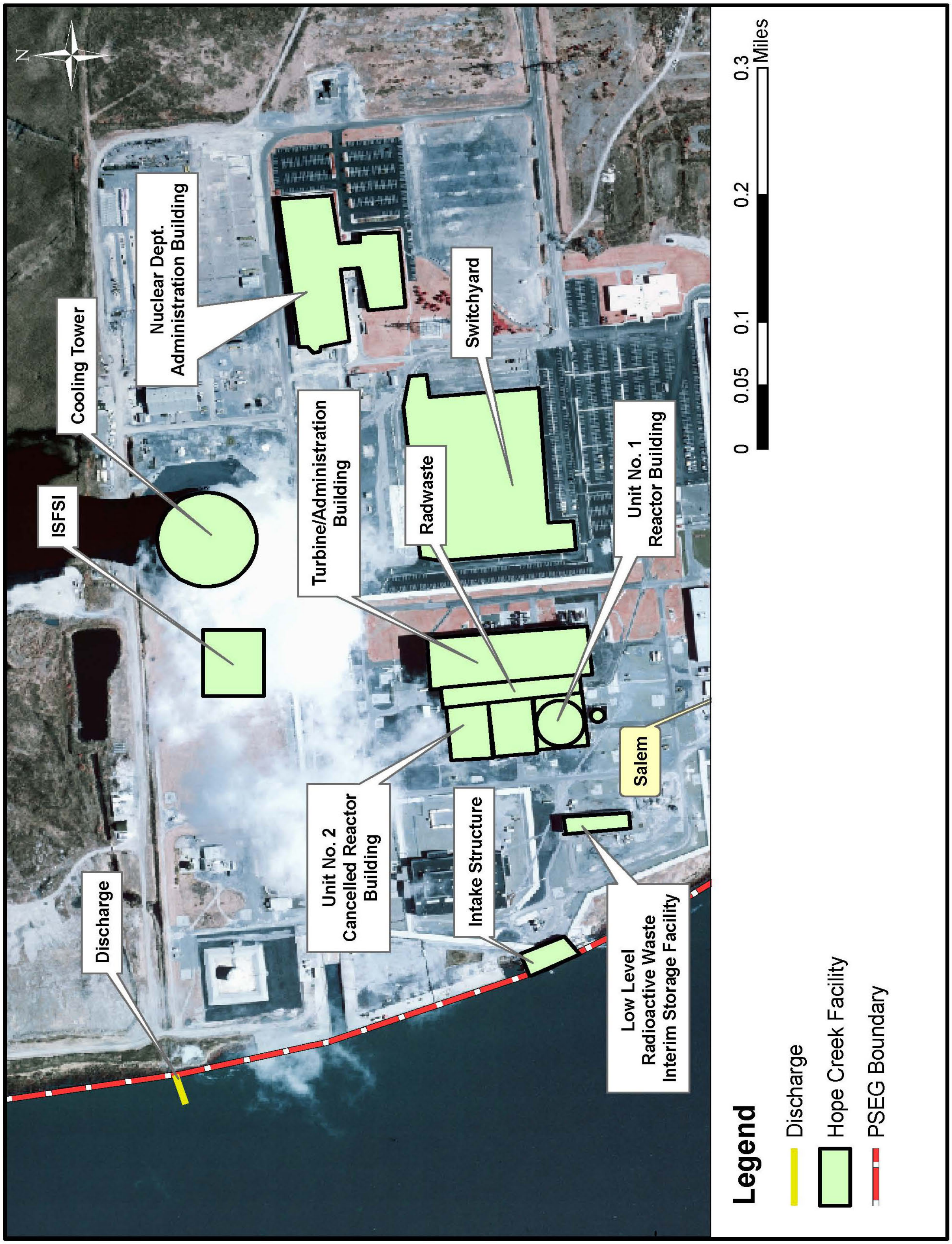


Figure 2-1. Location of the Salem Nuclear Generating Station and Hope Creek Generating Station Site, within a 6-Mile Radius (Source: PSEG, 2009a; 2009b)

Figure 2-2. Aerial Photo (Source: PSEG, 2009a; 2009b)



1 **Figure 2-3. Salem Nuclear Generating Station Facility Layout (Source: PSEG, 2009a)**



1 **Figure 2-4. Hope Creek Generating Station Facility Layout (Source: PSEG, 2009b)**

Three metropolitan areas lie within 50 mi (80 km) of the PSEG site: Wilmington, DE, the closest city, approximately 15 mi (24 km) to the northwest; Philadelphia, PA, approximately 35 mi (56 km) to the northeast; and Baltimore, MD, approximately 45 mi (72 mi) to the southwest (Figure 2-5 shows a map of the site within a 50-mi [80 km] radius).

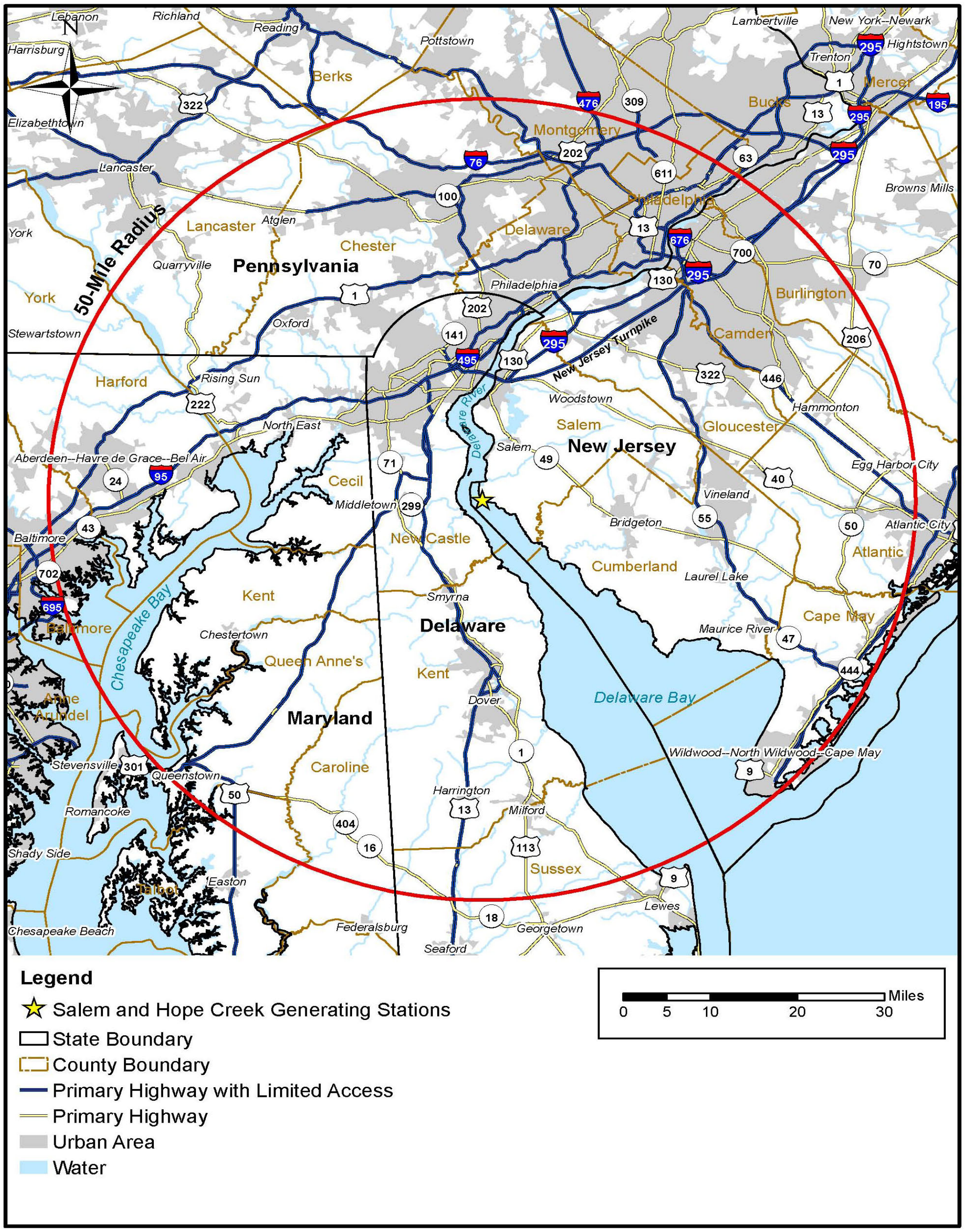


Figure 2-5. Location of the Salem Nuclear Generating Station and Hope Creek Generating Station Site, within a 50-Mile Radius (Source: PSEG, 2009a; 2009b)

Industrial activities within 10 mi (16 km) of the site are confined principally to the west bank of the Delaware River, north of Artificial Island, in the cities of Delaware City, New Castle, and Wilmington. There is no significant industrial activity near the site. With little industry in the region, construction and retail trade account for nearly 40 percent of the revenues generated in the Salem County economy (USCB, 2006). Smaller communities in the vicinity of the site (Haddock's Bridge, NJ; Salem, NJ; Quinton, NJ; and Shenandoah, DE) consist primarily of small retail businesses. Much of the surrounding marshland is owned by the U.S. Government and the State of New Jersey and is further described in section 2.2.1.

Located about 2 mi (3 km) west of the site on the western shore of the Delaware River is the Augustine State Wildlife Management Area, a 2,667-ac (1,079 ha) wildlife management area managed by the Delaware Division of Fish and Wildlife (Delaware Division of Fish and Wildlife, 2010a). Southwest of the site, also on the Delaware side of the Delaware River, is the Appoquinimink Wildlife Area. Located less than a mile (less than one km) northeast of the site is the upper section of the Mad Horse Creek Fish and Wildlife Management Area. This is a noncontiguous, 9,500-ac (3,800 ha) wildlife area managed by the New Jersey Division of Fish and Wildlife (NJDFW) with sections northeast, east, and southeast of the site (NJDFW, 2009a). Recreational activities at these wildlife areas within 10 mi (16 km) of the site consist of boating, fishing, hunting, camping, hiking, picnicking, and swimming.

2.1.1 Reactor and Containment Systems

2.1.1.1 Salem Nuclear Generating Station

Salem is a two-unit plant, which uses pressurized water reactors (PWR) designed by Westinghouse Electric. Each unit has a current licensed thermal power at 100 percent power of 3,459 megawatt-thermal (MW[t]). Salem Units 1 and 2 entered commercial service June 1977 and October 1981, respectively. At 100 percent reactor power, the currently anticipated net electrical output is approximately 1,169 megawatt-electric (MW[e]) for Unit 1 and 1,181 MW(e) for Unit 2. The Salem units have once-through circulating water systems for condenser cooling that withdraws brackish water from the Delaware Estuary through one intake structure located at the shoreline on the south end of the site. An air-cooled combustion turbine peaking unit rated at approximately 40 MW(e) (referred to as "Salem Unit 3") is also present (PSEG, 2009a; 2009b).

In the PWR power generation system (Figure 2-6); reactor heat is transferred from the primary coolant to a lower pressure secondary coolant loop, allowing steam to be generated in the steam supply system. The primary coolant loops each contain one steam generator, two centrifugal coolant pumps, and the interconnected piping. Within the reactor coolant system (RCS), the reactor coolant is pumped from the reactor through the steam generators and back to the reactor inlet by two centrifugal coolant pumps located at the outlet of each steam generator. Each steam generator is a vertical, U- tube-and-shell heat exchanger that produces superheated steam at a constant pressure over the reactor operating power range. The steam is directed to a turbine, causing it to spin. The spinning turbine is connected to a generator, which generates electricity. The steam is directed to a condenser, where the steam is cooled and condensed back in liquid water. This cooled water is then cycled back to the steam generator, completing the loop.

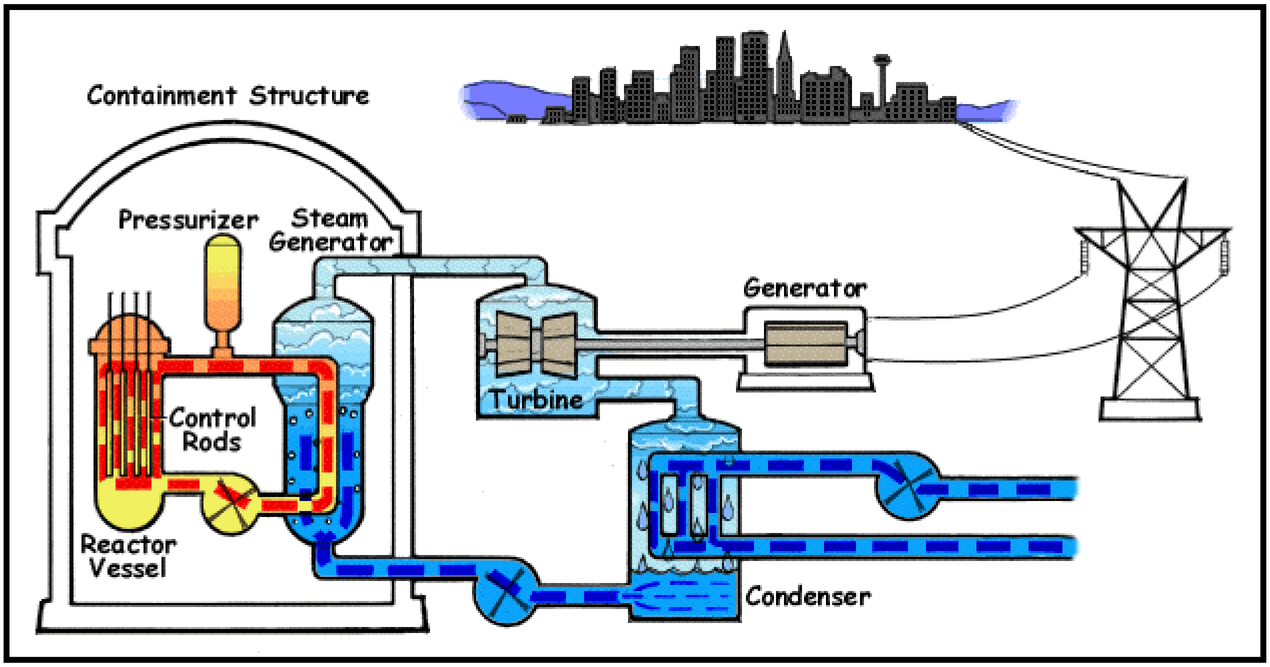


Figure 2-6. Simplified Design of a Pressurized Water Reactor

The containment building serves as a biological radiation and a pressure container for the entire RCS. The reactor containment structures are a vertical cylinders with 16-ft (4.9-m) thick flat foundation mats and 2- to 5-ft (0.6- to 1.5-m) thick reinforced concrete slab floors topped with hemispherical dome roofs. The side walls of each containment building are 142 ft (43.3 m) high and the inside diameter is 140 ft (43 m). The concrete walls are 4.5 ft (1.4 m) thick and the containment building dome roofs are 3.5 ft (1.1 m) thick. The inside surface of the reactor building is lined with a carbon steel liner with varying thickness ranging from 0.25 inch (0.64 centimeter [cm]) to 0.5 inch (1.3 cm) (PSEG, 2007a).

The nuclear fueled cores of the Salem reactors are moderated and cooled by a moderator, which slows the speed of neutrons thereby increasing the likelihood of fission of an uranium-235 atom in the fuel. The cooling water is circulated by the reactor coolant pumps. These pumps are vertical, single-stage centrifugal pumps equipped with controlled-leakage shaft seals (PSEG, 2007b).

Both Salem units use slightly enriched uranium dioxide (UO_2) ceramic fuel pellets in zircaloy cladding (PSEG, 2007b). Fuel pellets are loaded into fuel rods, and fuel rods are joined together in fuel assemblies. The fuel assemblies consist of 264 fuel rods arranged in a square array. Salem uses fuel that is nominal enriched to 5.0 percent (percent uranium-235 by weight). The combined fuel characteristics and power loading result in a fuel burn-up of about 60,000 megawatt-days (MW [d]) per metric ton uranium (PSEG, 2009a).

The original Salem steam generators have been replaced. In 1997, the Unit 1 steam generators were replaced and in 2008 the Unit 2 steam generators were replaced (PSEG, 2009a).

2.1.1.2 Hope Creek Generating Station

HCGS is a one-unit station, which uses a boiling water reactor (BWR) designed by General Electric. The power plant has a current licensed thermal power output of 3,840 MW(t) with an electrical output estimated to be approximately 1,083 MW(e) (73 FR 13032). HCGS has a closed-cycle circulating water system for condenser cooling that consists of a natural draft cooling tower and associated withdrawal, circulation, and discharge facilities. HCGS withdraws brackish water with the service water system (SWS) from the Delaware Estuary (PSEG, 2009b).

In the BWR power generation system (Figure 2-7), heat from the reactor causes the cooling water which passes vertically through the reactor core to boil, producing steam. The steam is directed to a turbine, causing it to spin. The spinning turbine is connected to a generator, which generates electricity. The steam is directed to a condenser, where the steam is cooled and is condesned back in liquid water. This water is then cycled back to the reactor core, completing the loop.

The containment is the reactor building. The structure serves as a biological radiation shield and a pressure container for the entire RCS. The reactor building is a vertical cylinder with 14-ft (4.3-m) thick flat foundation mats and 2- to 5-ft (0.6- to 1.5-m) thick reinforced concrete slab floors. The side walls of the cylinder are approximately 250 ft (76 m) high, topped with a torispherical dome roof, and surrounded by a rectangular structure that is 132 ft (40 m) tall (PSEG, 2006a).

The HCGS reactor uses slightly enriched UO_2 ceramic fuel pellets in zircaloy cladding (PSEG, 2007b). Fuel pellets are loaded into fuel rods and fuel rods are joined together in fuel assemblies. HCGS uses fuel that is nominal enriched to 5.0 percent (percent uranium-235 by weight) and the combined fuel characteristics and power loading result in a fuel burn-up of about 60,000 MW(d) per metric ton uranium.

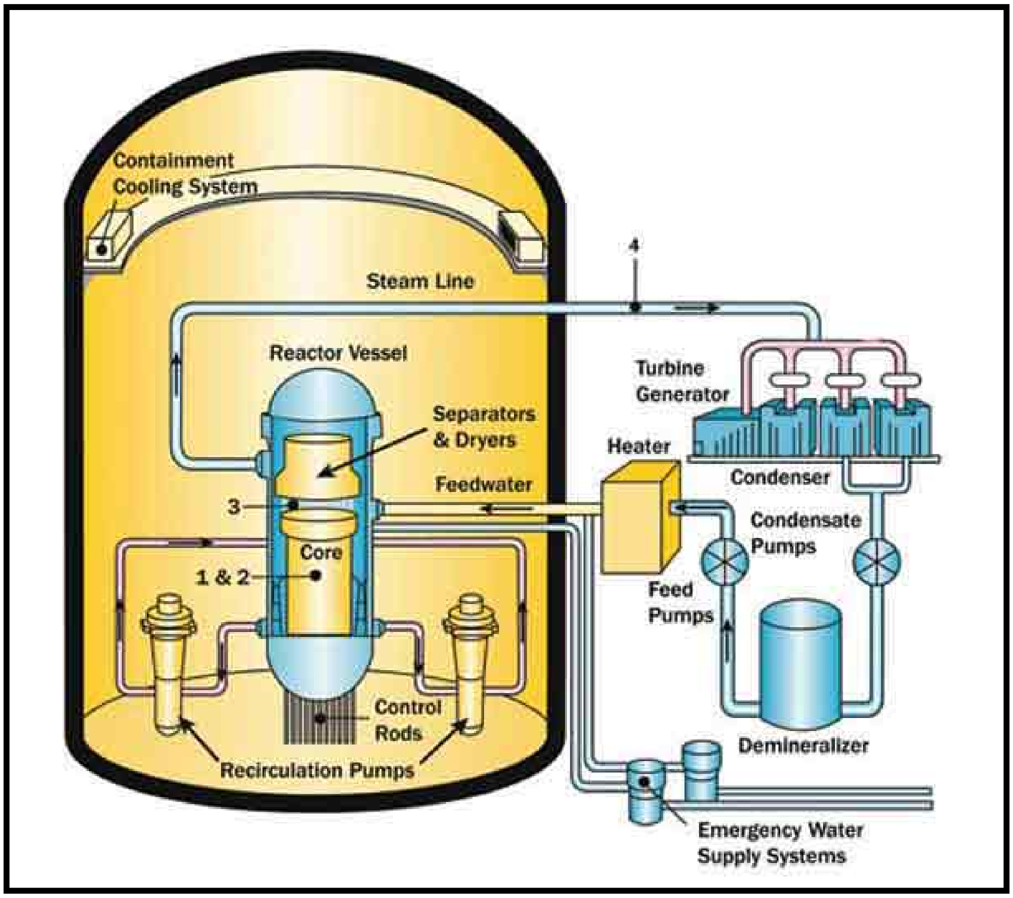


Figure 2-7. Simplified Design of a Boiling Water Reactor

2.1.2 Radioactive Waste Management

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

The Salem and HCGS facilities include radioactive waste systems which collect, treat, and provide for the disposal of radioactive and potentially radioactive wastes that are byproducts of plant operations. Radioactive wastes include activation products resulting from the irradiation of reactor water and impurities therein (principally metallic corrosion products) and fission products resulting from defective fuel cladding or uranium contamination within the RCS. Radioactive waste system operating procedures ensure that radioactive wastes are safely processed and discharged from the plant within the limits set forth in Title 10 of the *Code of Federal*

Regulations (CFR) Part 20, "Standards for Protection against Radiation," and 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities."

When reactor fuel has exhausted a certain percentage of its fissile uranium content, it is referred to as spent fuel. Spent fuel assemblies are removed from the reactor core and replaced with fresh fuel assemblies during routine refueling outages, typically every 18 months. Spent fuel assemblies are stored in the spent fuel pool (SFP). Salem's SFP storage capacity for each unit is 1,632 fuel assemblies, which will allow sufficient storage up to the year 2011 for Unit 1 and 2015 for Unit 2 (PSEG, 2009a). The HCGS SFP facility is designed to store up to 3,976 fuel assemblies (PSEG, 2009b).

In 2005, the NRC issued a 10 CFR Part 72 general license to PSEG, which authorized that spent nuclear fuel could be stored at an independent spent fuel storage installation (ISFSI) at the PSEG site. The general license allows PSEG, as a reactor licensee under 10 CFR Part 50, to store spent fuel from both HCGS and Salem at the ISFSI, provided that such storage occurs in approved casks in accordance with the requirements of 10 CFR Part 72, subpart K (General License for Storage of Spent Fuel at Power Reactor Sites) (NRC, 2005). At this time, only HCGS spent fuel is stored at the ISFSI. However, transfers of spent fuel from the Salem SFP to the ISFSI are expected to begin approximately one year before the remaining capacity of the pool is less than the capacity needed for a complete offload to spent fuel pool (PSEG, 2009b).

2.1.2.1 Radioactive Liquid Waste

Both the Salem and HCGS facilities operate systems to provide controlled handling and disposal of small quantities of low-activity, liquid radioactive wastes generated during station operation. However, because the Salem units are cooled by a once-through RCS and the HCGS unit is cooled by a closed-cycle RCS, the management of potentially radioactive liquids is different. Potentially radioactive liquid waste streams at the Salem facility are managed by the radioactive liquid waste system (RLWS) and the chemical and volume controlled system (CVCS). At HCGS, potentially radioactive liquid waste streams are managed under the liquid waste management system (LWMS).

The bulk of the radioactive liquids discharged from the Salem RCS are processed and retained inside the plant by the CVCS recycle train. This minimizes liquid input to the RLWS. Liquid radioactive waste entering the RLWS is released in accordance with NRC regulations. Prior to release, liquids are collected in tanks, sampled, and analyzed. Based on the results of the analysis, the waste is processed to remove radioactivity before releasing it to the Delaware Estuary via the circulating water system and a permitted outfall. Discharge streams are monitored, and safety features are incorporated to preclude releases in excess of the limits prescribed in 10 CFR Part 20, "Standards for Protection Against Radiation" (PSEG, 2009a).

In 2003, PSEG identified tritium in groundwater from onsite sampling wells near the Salem Unit 1 fuel handling building (FHB). The source of tritium was identified as the Salem Unit 1 SFP. In November 2004, the New Jersey Department of Environmental Protection (NJDEP), Bureau of Nuclear Engineering (BNE) approved a groundwater remediation strategy and by September 2005, a full-scale groundwater recovery system (GRS) had been installed (PSEG, 2009a). The GRS pulls groundwater toward the recovery system and away from the site boundary.

Since 2005, tritium-contaminated groundwater from the GRS is transferred to the LWMS where it mixes with other liquid plant effluent before being discharged into the Salem once-through, condenser cooling water system discharge line. The recovered groundwater is sampled prior to entering the discharge line to demonstrate compliance with offsite dose requirements. The water is subsequently released to the Delaware Estuary via a permitted outfall in accordance with plant procedures and NRC requirements for the effluent release of radioactive liquids. Surface water sampling as part of the radiological environmental monitoring program (REMP) does not show an increase in measurable tritium levels since the GRS was initiated.

Potentially radioactive liquid wastes entering the HCGS LWMS are collected in tanks in the auxiliary building. Radioactive contaminants are removed from the wastewater either by demineralization or filtration. This ensures that the water quality is restored before being returned to the condensate storage tank (CST) or discharged via the cooling tower blowdown line to the Delaware Estuary via a permitted outfall. If the liquid is recycled to the plant, it meets the purity requirements for CST makeup. Liquid discharges to the Delaware Estuary are maintained in compliance with 10 CFR Part 20, "Standards for Protection Against Radiation" (PSEG, 2009b).

Radioactivity removed from the liquid wastes is concentrated in the filter media and ion exchange resins, which are managed as solid radioactive wastes.

2.1.2.2 Radioactive Gaseous Waste

The Salem and HCGS radioactive gaseous waste disposal systems process and dispose of routine radioactive gases removed from the gaseous effluent and released to the atmosphere. Gaseous wastes are processed to reduce radioactive materials in gaseous effluents before discharge to meet the dose limits in 10 CFR Part 20 and the dose design objectives in Appendix I to 10 CFR Part 50.

At both facilities, radioactive gases are collected so that the short-lived gaseous isotopes (principally air with traces of krypton and xenon) are allowed to decay. At Salem, these gases are collected in tanks in the auxiliary building and released intermittently in a controlled manner.

At HCGS, gases are held up in holdup pipes prior to entering a treatment section where adsorption of gases on charcoal provides additional time for decay. At HCGS, gases are then filtered using high-efficiency particulate air (HEPA) filters before being released to the atmosphere from the north plant vent.

2.1.2.3 Radioactive Solid Waste

Solid radioactive waste generated at the Salem and HCGS facilities are managed by a single solid radioactive waste system. This system manages radioactive solid waste, including packaging and storage, until the waste is shipped offsite. Offsite wastes are processed by volume reduction and/or shipped for disposal at a licensed disposal facility. PSEG provides a quarterly waste storage report to the Township of Haddock's Bridge.

The State of South Carolina's licensed low level waste (LLW) disposal facility, located in Barnwell, has limited the access from radioactive waste generators located in States that are not part of the Atlantic Interstate Low-Level Radioactive Waste Compact. New Jersey is a member of the Atlantic Interstate Low-Level Radioactive Waste Compact. To control releases to the environment, these wastes are packaged in the Salem and HCGS auxiliary buildings.

The PSEG low-level radwaste storage facility (LLRSF) supports normal dry active waste (DAW) handling activities for HCGS and Salem. DAW consists of compactable trash, such as contaminated or potentially contaminated rags, clothing, and paper. This waste is generally bagged, placed in Sea-van containers, and stored prior to being shipped to a licensed offsite vendor for volume reduction. The volume-reduced DAW is repackaged at the vendor and shipped for disposal at a licensed LLW disposal facility (PSEG, 2009a; 2009b). DAW and other non-compactable contaminated wastes are typically shipped to the Energy Solutions' disposal facility in Clive, UT.

The LLRSF also maintains an NRC-approved process control program. The process control program helps to ensure that waste is properly characterized, profiled, labeled, and shipped in accordance with the waste disposal facility's waste acceptance criteria and U.S. Department of Transportation (DOT) and NRC requirements. The LLRSF is a large facility that was designed to store and manage large volumes of waste. However, the facility is operated well below its designed capacity. The facility is also designed to ensure that worker radiation exposures are controlled in accordance with facility and regulatory criteria.

2.1.2.4 Mixed Waste

The term "mixed waste" refers to waste that contains both radioactive and hazardous constituents. Neither Salem nor HCGS have processes that generate mixed wastes and there are no mixed wastes stored at either facility.

2.1.3 Nonradioactive Waste Management

The Resource Conservation and Recovery Act (RCRA) governs the disposal of solid and hazardous waste. RCRA regulations are contained in Title 40, "Protection of the Environment," Parts 239 through 299 (40 CFR 239, et seq.). Parts 239 through 259 of these regulations cover solid (nonhazardous) waste, and Parts 260 through 279 regulate hazardous waste. RCRA Subtitle C establishes a system for controlling hazardous waste from "cradle to grave," and RCRA Subtitle D encourages States to develop comprehensive plans to manage nonhazardous solid waste and mandates minimum technological standards for municipal solid waste landfills.

RCRA regulations are administered by the NJDEP and address the identification, generation, minimization, transportation, and final treatment, storage, or disposal of hazardous and nonhazardous wastes. Salem and HCGS generate nonradiological waste, including oils, hazardous and nonhazardous solvents and degreasers, laboratory wastes, expired shelf-life chemicals and reagents, asbestos wastes, paints and paint thinners, antifreeze, project-specific wastes, point-source discharges regulated under the National Pollutant Discharge Elimination System (NPDES), sanitary waste (including sewage), and routine and daily refuse (PSEG, 2009a; 2009b).

2.1.3.1 Hazardous Waste

The U.S. Environmental Protection Agency (EPA) classifies certain nonradioactive wastes as "hazardous" based on characteristics, including ignitability, corrosivity, reactivity, or toxicity (identification and listing of hazardous wastes is available in 40 CFR 261). State-level regulators may add wastes to the EPA's list of hazardous wastes. RCRA provides standards for the treatment, storage, and disposal of hazardous waste for hazardous waste generators (40 CFR 262). The Salem and HCGS facilities generate small amounts of hazardous wastes, including spent and expired chemicals, laboratory chemical wastes, and occasional project-specific wastes.

PSEG is currently a small-quantity hazardous waste generator (PSEG, 2010b), generating less than 220 pounds (lb)/month (100 kilograms (kg)/month). Hazardous waste storage (180-day) areas include the hazardous waste storage facility, the combo shop, and two laydown areas east of the combo shop.

Hazardous waste generated at the facility include: F003, F005 (spent non-halogenated solvents), F001, F002 (spent halogenated solvents), D001 (ignitable waste), D002 (corrosive wastes), D003 (reactive wastes), and D004-D011 (toxic [heavy metal] waste) (PSEG, 2008b).

The EPA authorized the State of New Jersey to regulate and oversee most of the solid waste disposal programs, as recognized by Subtitle D of the RCRA. Compliance is assured through State-issued permits. The EPA's Enforcement and Compliance History Online (ECHO) database showed no violations for PSEG (EPA, 2010b).

Proper facility identification numbers for hazardous waste operations include:

- DOT Hazardous Materials Registration No. 061908002018QS
- EPA Hazardous Waste Identification No. NJD 077070811
- NJDEP Hazardous Waste Program ID No. NJD 077070811

Under the Emergency Planning and Community Right-to-Know Act (EPCRA), applicable facilities are required to provide information on hazardous and toxic chemicals to local emergency planning authorities and the EPA (Title 42, Section 11001, of the United States Code [U.S.C.] [42 U.S.C. 11001]). PSEG is subject to Federal EPCRA reporting requirements, and thus submits an annual Section 312 (TIER II) report on hazardous substances to local emergency agencies.

2.1.3.2 Solid Waste

A solid waste is defined by New Jersey Administrative Code (N.J.A.C.) 7:26-1.6 as, "any garbage, refuse, sludge, or any other waste material except it shall not include the following: 1. Source separated food waste collected by livestock producers, approved by the State Department of Agriculture, who collect, prepare and feed such wastes to livestock on their own farms; 2. Recyclable materials that are exempted from regulation pursuant to N.J.A.C. 7:26A; [and] 3. Materials approved for beneficial use or categorically approved for beneficial use pursuant to N.J.A.C. 7:26-1.7(g)." The definition of solid waste in N.J.A.C. 7:26-1.6 applies only to wastes that are not also defined as hazardous in accordance with N.J.A.C. 7:26G.

During the site audit, the Staff observed an active solid waste recycling program. Solid waste ("trash") is segregated and about 55 percent is transferred to recycling vendors (PSEG, 2009a). The remaining volume of solid waste is disposed at a local landfill.

A common sewage treatment system treats domestic wastewater from both facilities. Following treatment, solids (i.e., sludge) are either returned to the system's oxidation ditch or removed to a sludge-holding tank, based upon process requirements. Sludge directed to the sludge-holding tank is aerated and dewatered before being trucked offsite for disposal. During the site audit, the Staff viewed the PSEG sewage sludge waste volumes from 2005 through 2009. The average annual volume for these years was about 50,000 lbs (22,700 kg). Site officials stated that the disposal volume is generally driven by the facilities' budgets.

2.1.3.3 Universal Waste

In accordance with N.J.A.C. 7:26G-4.2, "Universal waste" means any of the following hazardous wastes that are managed under the universal waste requirements of N.J.A.C. 7:26A-7, whether incorporated prospectively by reference from 40 CFR Part 273, "Standards for Universal Waste Management," or listed additionally by the NJDEP: paint waste, batteries, pesticides, thermostats, fluorescent lamps, mercury-containing devices, oil-based finishes, and consumer electronics.

PSEG is a small quantity handler of universal waste (meaning the facility cannot accumulate more than 11,000 lbs (5,000 kg) of universal waste at any one time), generating common operational wastes, such as lighting ballasts containing polychlorinated biphenyls (PCBs), lamps, and batteries. Universal waste is segregated and disposed of through a licensed broker. Routine building space renovations and computer equipment upgrades can lead to substantial short-term increases in universal waste volumes.

2.1.3.4 Permitted Discharges

The Salem facility maintains a New Jersey Pollutant Discharge Elimination System (NJPDES) permit, NJ0005622, which authorizes the discharge of wastewater to the Delaware Estuary and stipulates the conditions of the permit. HCGS maintains a separate NJPDES permit, NJ0025411 for discharges to the Delaware Estuary. All monitoring is conducted in accordance with the NJDEP's "Field Sampling Procedures Manual" applicable at the time of sampling (N.J.A.C. 7:14A-6.5 (b)4), and/or the method approved by the NJDEP in Part IV of the site permits (NJDEP, 2002a).

As discussed previously, a common sewage treatment system treats domestic wastewater from both HCGS and Salem. The sewage treatment system liquid effluent discharges through the HCGS cooling tower blowdown outfall to the Delaware Estuary. The residual cooling tower blowdown dechlorination chemical, ammonium bisulfite, dechlorinates the sewage treatment effluent (PSEG, 2009a; 2009b).

Salem and HCGS share the nonradioactive liquid waste disposal system (NRLWDS) chemical waste treatment system. The NRLWDS is located at the Salem facility and operated by Salem staff. The NRLWDS collects and processes nonradioactive secondary plant wastewater prior to discharge into the Delaware Estuary. The waste water originates during plant processes, such as demineralizer regenerations, steam generator blowdown, chemical handling operations, and reverse osmosis reject waste. The outfall is monitored in accordance with the current HCGS NJPDES Permit No. NJ0025411 (PSEG, 2009a; 2009b).

Oily waste waters are treated at HCGS using an oil water separator. Treated effluent is then discharged through the internal monitoring point, which is combined with cooling tower blowdown before discharge to the Delaware Estuary. The outfall is monitored in accordance with the current HCGS NJPDES Permit No. NJ0025411.

Section 2.1.7 of this report provides more information on the site's NPDES permits and effluent limitations.

2.1.3.5 Pollution Prevention and Waste Minimization

As described in Section 2.1.3.2, PSEG operates an active solid waste recycling program that results in about 55 percent of its "trash" being recycled. PSEG also maintains a discharge prevention and response program. This program incorporates the requirements of the NJDEP, EPA Facility Response Plan, and National Oceanic and Atmospheric Administration (NOAA) Natural Resource Damage Assessment Protocol. Specific documents making up the program include:

- Spill/Discharge Prevention Plan
- Hazardous Waste Contingency Plan
- Spill/Discharge Response Plan
- Environmentally Sensitive Areas Protection Plan

PSEG also maintains the following plans to support pollution prevention and waste minimization:

- Discharge Prevention, Containment, and Countermeasure Plan
- Discharge Cleanup and Removal Plan
- Facility Response Plan
- Spill Prevention, Control, and Countermeasure Plan
- Stormwater Pollution Prevention Plan
- Pollution Minimization Plan for PCBs

2.1.4 Facility Operation and Maintenance

Various types of maintenance activities are performed at the Salem and HCGS facilities, including inspection, testing, and surveillance to maintain the current licensing basis of the facility and to ensure compliance with environmental and safety requirements. Various programs and activities currently exist at Salem and HCGS to maintain, inspect, test, and monitor the performance of facility equipment. These maintenance activities include inspection requirements for reactor vessel materials, boiler and pressure vessel inservice inspection and testing, a maintenance structures monitoring program, and maintenance of water chemistry.

Additional programs include those implemented in response to NRC generic communications; those implemented to meet technical specification surveillance requirements; and various periodic maintenance, testing, and inspection procedures. Certain program activities are performed during the operation of the unit, while others are performed during scheduled refueling outages. Nuclear power plants must periodically discontinue the production of electricity for refueling, periodic inservice inspection, and scheduled maintenance. Salem and HCGS are on an 18-month refueling cycle (PSEG, 2009a; 2009b).

Aging effects at Salem and HCGS are managed by integrated plant assessments required by 10 CFR 54.21. These programs are described in Section 2 of the facilities' Nuclear Generating Station License Renewal Applications – Scoping and Screening Methodology for Identifying Structures and Components Subject to Aging Management Review, and Implementation Results (PSEG, 2009a; 2009b).

2.1.5 Power Transmission System

Three right-of-way (ROW) corridors and five 500-kilovolt (kV) transmission lines connect Salem and HCGS to the regional electric grid, all of which are owned and maintained by Public Service Electric and Gas Company (PSE&G) and Pepco Holdings Inc. (PHI). Each corridor is 350 ft (107 m) wide, with the exception of two-thirds of both the Salem-Red Lion and Red Lion-Keeney lines, which narrow to 200 ft (61 m). Unless otherwise noted, the discussion of the power transmission system is adapted from the applicant's environmental reports (ERs) (PSEG, 2009a; 2009b) or information gathered at the NRC's environmental site audit.

For the operation of Salem, three transmission lines were initially built for the delivery of electricity: two lines connecting to the New Freedom substation near Williamston, NJ (Salem-New Freedom North and Salem-New Freedom South), and one line extending north across the Delaware River terminating at the Keeney substation in Delaware (Salem-Keeney). The Salem New Freedom North and South corridors pass through Salem and Gloucester Counties before terminating at the New Freedom substation in Camden County, New Jersey. The Salem-Keeney corridor originates in Salem County, New Jersey, crosses west across the Delaware River, and terminates at the Keeney substation in New Castle County, Delaware. After construction of HCGS, several changes were made to the existing Salem transmission system, including the disconnection of the Salem-Keeney line from Salem and its reconnection to HCGS, as well as the construction of a new substation (known as Red Lion) along the Salem-Keeney transmission line. The addition of this new substation divided the Salem-Keeney transmission line into two segments: one connecting HCGS to Red Lion and the other connecting Red Lion to Keeney. Consequently, these two segments are now referred to separately as Salem-Red Lion and Red Lion-Keeney. The portion of the Salem-Keeney line located entirely within Delaware, Red Lion-Keeney, is owned and maintained by Pepco (a regulated electric utility that is a subsidiary of PHI).

The construction of HCGS also resulted in the re-routing of the Salem-New Freedom North line and the construction of a new transmission line, HCGS-New Freedom. The Salem-New Freedom North line was disconnected from Salem and re-routed to HCGS, leaving Salem without a northern connection to the New Freedom transmission system. Therefore, a new transmission line was required to connect Salem and the New Freedom substation; this line is known as the HCGS-New Freedom line and it shares a corridor with the Salem-New Freedom

North line. Prior to and following the construction of HCGS, the Salem-New Freedom South line provides a southern-route connection between Salem and the New Freedom substation.

The only new transmission lines constructed as a result of HCGS were the HCGS-New Freedom line, the line connecting HCGS and Salem (tie line), and short reconnections for Salem-New Freedom North and Salem-Keeney. The HCGS-Salem tie line and the short reconnections do not pass beyond the site boundary.

Transmission lines considered in-scope for license renewal are those constructed specifically to connect the facility to the transmission system (10 CFR 51.53(c)(3)(ii)(H)); therefore, the Salem-New Freedom North, Salem-Red Lion, Red Lion-Keeney, Salem-New Freedom South, HCGS-New Freedom, and HCGS-Salem lines are considered in-scope for this supplemental environmental impact statement (SEIS) and are discussed in detail below.

Figure 2-8 illustrates the Salem and HCGS transmission system. The five transmission lines are described below within the designated ROW corridor (see Table 2-1):

2.1.5.1 New Freedom North Right-of-Way

- Salem-New Freedom North – This 500-kV line, which is operated by PSE&G, runs northeast from HCGS for 39 mi (63 km) within a 350-ft (107-m) wide corridor to the New Freedom switching station north of Williamstown, NJ. This line shares the corridor with the 500-kV HCGS-New Freedom line.
- HCGS-New Freedom – This 500-kV line, which is operated by PSE&G, extends northeast from Salem for 43 mi (69 km) within the shared Salem-New Freedom North corridor to the New Freedom switching station, 4 mi (6 km) north-northeast of Williamstown, New Jersey. In 2008, a new substation (Orchard) was constructed along this line. The Orchard substation is located approximately 4 mi (6 km) west of Elmer, a borough in Salem County, New Jersey, and serves to divide the line into two segments, one which runs southwest from Orchard to the site and is approximately 19 mi (31 km) in length, and one that runs northeast from Orchard to the New Freedom substation and is approximately 24 mi (39 km) in length.

2.1.5.2 New Freedom South Right-of-Way

- Salem-New Freedom South – This 500-kV line, which is operated by PSE&G, extends northeast from Salem for 42 mi (68 km) within a 350-ft (107-m) wide corridor from Salem to the New Freedom substation north of Williamstown, NJ. This line runs approximately 2 to 3 mi (3 to 5 km) south of and somewhat parallel to the New Freedom North corridor.

2.1.5.3 Keeney Right-of-Way

- Salem-Red Lion – This 500-kV line extends north from HCGS for 13 mi (21 km) and then crosses over the New Jersey-Delaware State line. It continues west over the Delaware River about 4 mi (6 km) to the Red Lion substation. In New Jersey, the line is operated by PSE&G, and in Delaware it is operated by PHI.

Two thirds of the 17-mi (27-km) corridor is 200 ft (61 m) wide, and the remainder is 350-ft (107-m) wide.

- Red Lion-Keeney – This 500-kV line, which is operated by PHI, extends from the Red Lion substation 8 mi (13 km) northwest to the Keeney switch station. Two thirds of the corridor is 200 ft (61 m) wide, and the remainder is 350-ft (107-m) wide.

The ROW corridors comprise approximately 149 mi (240 km) and 4,376 ac (1,771 ha). Four of the five lines cross within Camden, Gloucester, and Salem counties in New Jersey, with the Keeney line crossing only in Camden county in New Jersey and New Castle County in Delaware. All of the ROW corridors traverse the marshes and wetlands adjacent to the Salem and HCGS sites, including agricultural and forested lands.

All transmission lines were designed and built in accordance with industry standards in place at the time of construction. All transmission lines will remain a permanent part of the transmission system and will be maintained by PSEG and PHI regardless of the Salem and HCGS facilities' continued operation (PSEG, 2009a; 2009b). The HCGS-Salem line, which connects the two substations, would be de-activated if the Salem and HCGS switchyards were no longer in use and would need to be reconnected to the grid if they were to remain in service beyond the operation of Salem and HCGS.

Five 500-kV transmission lines connect electricity from Salem and HCGS to the regional electric transmission system via three ROWs outside of the property boundary. The HCGS-Salem tie-line is approximately 2,000 ft (610 m). This line does not pass beyond the site boundary and is not discussed as an offsite ROW.

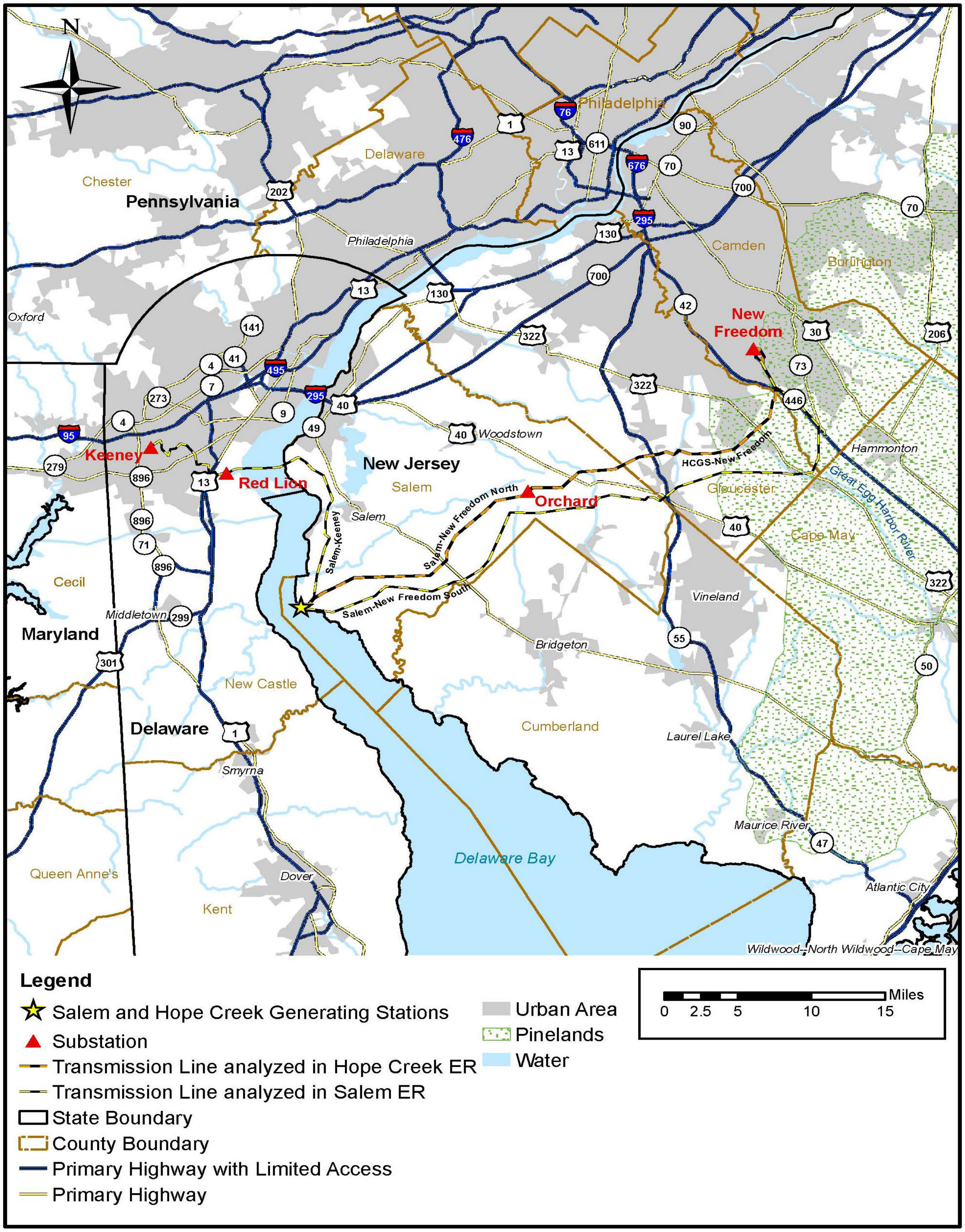


Figure 2-8. Salem Nuclear Generating Station and Hope Creek Generating Station Transmission Line System (Source: PSEG, 2009b)

Table 2-1. Salem Nuclear Generating Station and Hope Creek Generating Station Transmission System Components

Line	Approximate Length			ROW width	Approximate ROW area
	Owner	kV	mi (km)	ft (m)	ac (ha)
New Freedom North ROW					
Salem–New Freedom North	PSE&G	500	39 (63)	350 (107)	1,824 (738)
HCGS–New Freedom	PSE&G	500	43 (69)		
New Freedom South ROW					
Salem–New Freedom South	PSE&G	500	42 (68)	350 (107)	1,782 (721)
Red Lion ROW					
Salem-Red Lion	PSE&G	500	17 (27)	[a]200/350 (107)	521 (211)
Red-Lion Keeney	PHI	500	8 (13)	[a]200/350 (107)	249 (101)
Total acreage within ROW					**4,376 (1,771)**

(a) two–thirds of the corridor is 200 ft (61 m) wide
Source: PSEG, 2009a; 2009b

2.1.6 Cooling and Auxiliary Water Systems

The Delaware Estuary provides condenser cooling water and service water for both Salem and HCGS (PSEG, 2009a; 2009b). Salem and HCGS use different systems for condenser cooling, but both withdraw from and discharge water to the estuary. Salem Units 1 and 2 use once-through circulating water system (CWS). HCGS uses a closed-cycle system that employs a single natural draft cooling tower. Unless otherwise noted, the discussions below were adapted from the Salem and HCGS ERs (PSEG, 2009a; 2009b) or information gathered at the site audit.

Both sites use groundwater as the source for fresh potable water, fire protection water, industrial process makeup water, and for other sanitary water supplies. Under authorization from the NJDEP (NJDEP, 2004) and Delaware River Basin Commission (DRBC) (DRBC, 2000), PSEG can service both facilities with up to 43.2 million gallons (164,000 cubic meters [m^3]) of groundwater per month.

Discussions on surface water and groundwater use and quality are provided in Section 2.1.7.

2.1.6.1 Salem Nuclear Generating Station

The Salem facility includes two intake structures, one for the coolant water system, and the other for the service water system. Both are equipped with several features to prevent intake of debris and biota into the pumps (PSEG, 2006c):

- Ice Barriers. During the winter, removable ice barriers are installed in front of the intakes to prevent damage to the intake pumps from ice formed on the Delaware Estuary. These barriers consist of pressure-treated wood bars and underlying structural steel braces. The barriers are removed early in the spring and replaced in the late fall.

- Trash Racks. After intake water passes through the ice barriers (if installed), it flows through fixed trash racks. These racks prevent large organisms and debris from entering the pumps. The racks are made from 0.5 inch (1.3 cm) steel bars placed on 3.5-inch (8.9 cm) centers, creating a 3-inch (7.6 cm) clearance between each bar. The racks are inspected by PSEG employees, who remove any debris caught on them with mechanical, mobile, clamshell-type rakes. These trash rakes include a hopper that stores and transports removed debris to a pit at the end of each intake, where it is dewatered by gravity and disposed of off-site.

- Traveling Screens. After the course-grid trash racks, the intake water passes through finer vertical travelling screens. These are modified Ristroph screens designed to remove debris and biota small enough to have passed through the trash racks while minimizing death or injury. The travelling screens have a fine mesh with openings 0.25 inch x 0.5 inch (0.64 cm x 1.3 cm). The velocity through the Salem intake screens is approximately 1 foot per second (fps) (0.3 meters per second [m/s]) at mean low tide.

- Fish Return System. Each panel of the travelling screen has a 10-ft (3 m) long fish bucket attached across the bottom support member. As the travelling screen reaches the top of each rotation, fish and other organisms caught in the fish bucket slide along a horizontal catch screen. As the travelling screen continues to rotate, the bucket is inverted. A low-pressure water spray washes fish off the screen, and they slide through a flap into a two-way fish trough. Debris is then washed off the screen by a high-pressure water spray into a separate debris trough, and the contents of both fish and debris troughs return to the estuary. The troughs are designed so that when the fish and debris are released, the tidal flow tends to carry them away from the intake, reducing the likelihood of re-impingement. Thus, the troughs empty on either the north or south side of the intake structure depending on the direction of tidal flow.

The CWS withdraws brackish water from the Delaware Estuary using 12 circulating water pumps through a 12-bay intake structure located on the shoreline at the south end of the site. Water is discharged north of the CWS intake structure via a pipe that extends 500 ft (152 m) from the shoreline. No biocides are required in the CWS.

PSEG has an NDPDES permit for Salem from the New Jersey Department of Environmental Protection. The permit sets the maximum water usage from the Delaware Estuary to a 30-day average of 3,024 million gallons per day (MGD; 11.4 million m^3/day) of circulating water. The CWS provides approximately 1,050,000 gallons per minute (gpm; 4,000 m^3/min) to each of Salem's two reactor units.

The total design flow is 1,110,000 gpm (4,200 m^3/min) through each unit. The intake velocity is approximately 1 foot per second (fps; 0.3 meters per second [m/s]) (at mean low tide, a rate that is compatible with the protection of aquatic wildlife (EPA 2001). The CWS provides water to the main condenser to condense steam from the turbine and the heated water is returned back to estuary.

The service water system (SWS) intake is located approximately 400 ft (122 m) north of the CWS intake. The SWS intake has four bays, each containing three pumps. The 12 service-water pumps have a total design rating of 130,500 gpm (494 m^3/min). The average velocity throughout the SWS intake is less than 1 fps (0.3 m/s) at the design flow rate. The SWS intake structure is equipped with trash racks, traveling screens, and filters to remove debris and biota from the intake water stream, but do not have a modified Ristroph type travelling screen or fish return system. Backwash water is returned to the estuary.

To prevent organic buildup and biofouling in the heat exchangers and piping of the SWS, sodium hypochlorite was originally injected into the system. However, operational experience indicated that use of sodium hypochlorite was not needed, so it is no longer injected. SWS water is discharged via the discharge pipe shared with the CWS. Residual chlorine levels are maintained in accordance with the site's NJPDES Permit.

Both the Salem CWS and SWS discharge water back to the Delaware Estuary through a single return that serves both systems and is located between the Salem CWS and SWS intakes. The plan view of the Salem discharge structures is included as Figure 2-10. Cooling water from Salem is discharged through six adjacent pipes 7 ft (2 m) in diameter and spaced 15 ft (4.6 m) apart on center that merge into three pipes 10 ft (3 m) in diameter (PSEG, 2006c). The discharge piping extends approximately 500 ft (150 m) from the shore (PSEG, 1999). The discharge pipes are buried for most of their length until they discharge horizontally into the water of the estuary at a depth at mean tidal level of about 31 ft (9.5 m). The discharge is approximately perpendicular to the prevailing currents. At full power, Salem is designed to discharge approximately 3,200 MGD (12 million m^3/day) at a velocity of about 10 fps (3 m/s) (PSEG, 1999). To prevent biofouling in the heat exchangers and piping of the SWS, sodium hypochlorite is injected into the system. SWS water is discharged via the discharge pipe shared with the CWS.

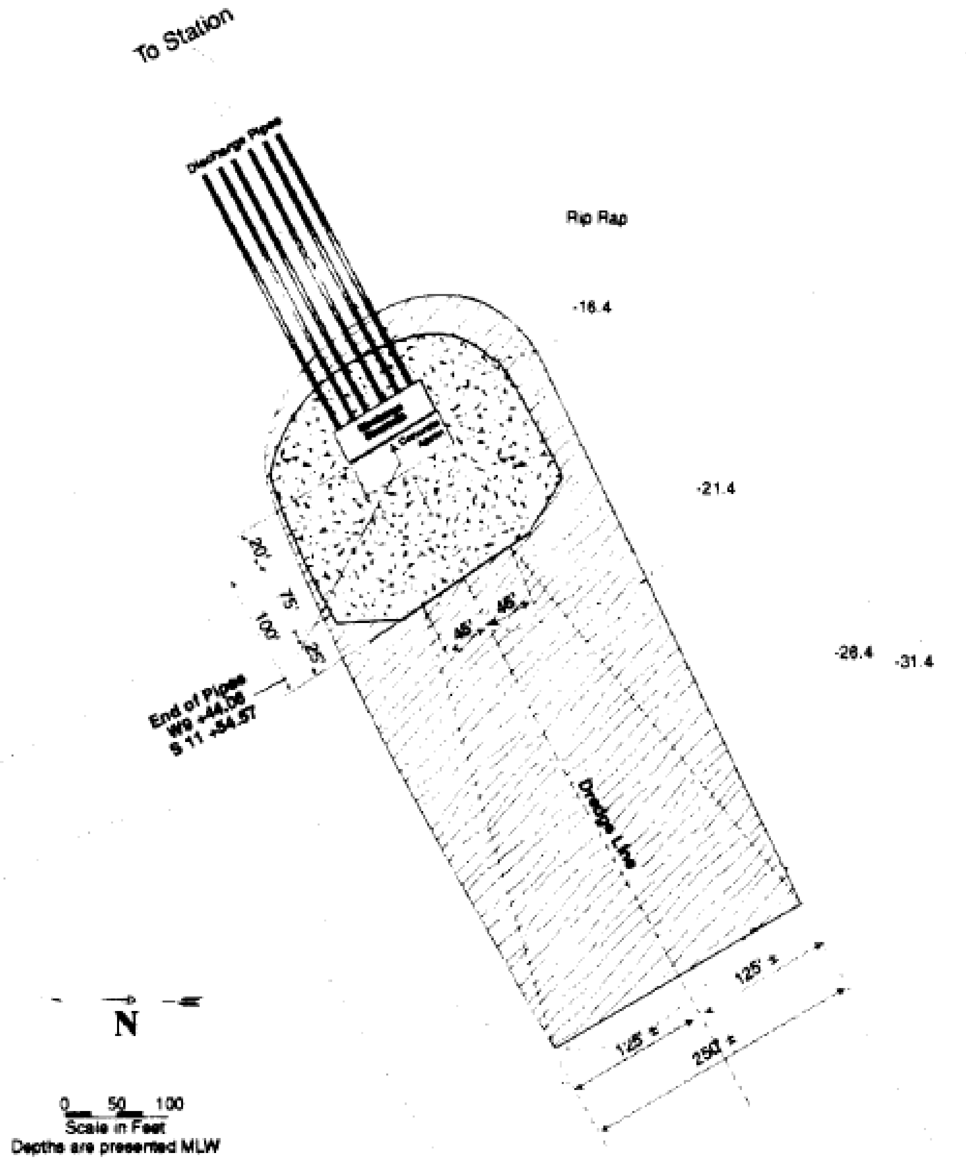


Figure 2-10. Plan View of Salem discharge pipes (Source: PSEG, 1999).

2.1.6.2 Hope Creek Generating Station

HCGS uses a single intake structure to supply water from the Delaware Estuary to the SWS. The intake structure consists of four active bays that are equipped with pumps and associated equipment (trash racks, traveling screens, and a fish-return system) and four empty bays that were originally intended to service a second reactor which was never built. Water is drawn into the SWS through trash racks and passes through the traveling screens at a maximum velocity of 0.35 fps (0.11 m/s). The openings in the wire mesh of the screens are 0.375 inches (0.95

cm) square. After passing through the traveling screens, the estuary water enters the service water pumps. Depending on the temperature of the Delaware Estuary water, two or three pumps are normally needed to supply service water. Each pump is rated at 16,500 gpm (62 m^3/min). To prevent organic buildup and biofouling in the heat exchangers and piping of the SWS, sodium hypochlorite is continuously injected into the system.

Water is them pumped into the stilling basin in the pump house. The stilling basin supplies water to the general SWS and the fire protection system. The stilling basin also supplies water for back-up residual heat removal service water and for emergency service water.

The SWS also provides makeup water for the CWS by supplying water to the cooling tower basin. The cooling tower basin contains approximately 9 million gallons (34,000 m^3) of water and provides approximately 612,000 gpm (2,300 m^3/min) of water to the CWS via four pumps. The CWS provides water to the main condenser to condense steam from the turbine and the heated water is returned back to Estuary (Figure 2-4).

The cooling tower blowdown and other facility effluents are discharged to the estuary through an underwater conduit located 1,500 ft (460 m) upstream of the HCGS SWS intake. The HCGS discharge pipe extends 10 ft (3.0 m) offshore and is situated at mean tide level. The discharge from HCGS is regulated under the terms of NJPDES permit number NJ0025411 (NJDEP, 2001a).

The HCGS cooling tower is a 512-foot (156-meter) high single counterflow, hyperbolic, natural draft cooling tower (PSEG, 2008a). While the CWS is a closed-cycle system, water is lost due to evaporation. Monthly losses average from 9,600 gpm (36 m^3/min) in January to 13,000 gpm (49 m^3/min) in July. Makeup water is provided by the SWS.

2.1.7 Facility Water Use and Quality

The Salem and HCGS facilities rely on the Delaware River as their source of makeup water for its cooling system, and they discharge various waste flows to the river. An onsite well system provides groundwater for other site needs. A description of groundwater resources at the facility location is provided in Section 2.2.8, and a description of the surface water resources is presented in Section 2.2.9. The following sections describe the water use from these resources.

2.1.7.1 Groundwater Use

The Salem and HCGS facilities access groundwater through production wells to supply fresh water for potable, industrial process makeup, fire protection, and sanitary purposes (PSEG, 2009a; 2009b). Facility groundwater withdrawal is authorized by the NJDEP and the Delaware River Basin Comission (DRBC). The total authorized withdrawal volume is 43.2 million gallons (164,000 m^3) per month for both the Salem and HCGS sites combined (NJDEP, 2004; DRBC, 2000). Although each facility has its own wells and individual pumping limits, the systems are interconnected so that water can be transferred between the facilities, if necessary (PSEG, 2009a; 2009b). The NJDEP permit is a single permit which establishes a combined permitted limit for both facilities of 43.2 million gallons (164,000 m^3) per month (NJDEP, 2004).

The groundwater for Salem is produced primarily from two wells, PW-5 and PW-6. PW-5 is installed at a depth of 840 ft (256 m) below ground surface (bgs) in the Upper Raritan Formation, and PW-6 is installed at a depth of 1,140 ft (347 m) in the Middle Raritan Formation. PW-5 has a capacity of 800 gpm (3 m^3/min), and PW-6 has a capacity of 600 gpm (2.3 m^3/min) (DRBC, 2000). The average water withdrawal from these two wells between 2002 and 2008 was 11.4 million gallons (432,000 m^3) per year (TetraTech, 2009). These wells are used to maintain water volume within two 350,000 gallon (1,300 m^3) storage tanks, of which 600,000 gallons (2,300 m^3) is reserved for fire protection (PSEG, 2009a). In addition to these two primary wells, two additional wells, PW-2 and PW-3, exist at Salem. These wells are installed within the Mount Laurel-Wenonah aquifer at depths of about 290 ft (88 m) bgs (DRBC, 2000). These wells are classified as standby wells by NJDEP (NJDEP, 2004), and had only minor usage in the period from 2002 to 2008 (TetraTech, 2009).

The groundwater for HCGS is produced from two production wells, HC-1 and HC-2, which are installed at depths of 816 ft (249 m) bgs in the Upper Potomac-Raritan-Magothy aquifer (DRBC, 2000). Each well has a pumping capacity of 750 gpm (2.8 m^3/min), and the average water withdrawal from the two wells between 2002 and 2008 was 96 million gallons (363,000 m^3) per year (TetraTech, 2009). The wells are used to maintain water supply within two 350,000 gallon (1,300 m^3) storage tanks. The bulk of the water in the storage tanks (656,000 gallons [2,500 m^3]) is reserved for fire protection, and the remainder is used for potable, sanitary, and industrial uses (PSEG, 2009b).

Overall, the combined water usage for the two facilities has averaged 210 million gallons (795,000 m^3) per year, or 17.5 million gallons (66,000 m^3) per month (TetraTech, 2009). This usage is approximately 41 percent of the withdrawal permitted under the DRBC authorization and NJDEP permit (DRBC, 2000; NJDEP, 2004).

2.1.7.2 Surface Water Use

Salem and HCGS are located on the eastern shore of the Delaware River, approximately 18 mi (29 km) south of the Delaware Memorial Bridge. The Delaware River at the facility location is an estuary approximately 2.5 mi (4 km) wide. The Delaware River is the source of condenser cooling water and service water for both the Salem and HCGS facilities (PSEG, 2009a; 2009b).

The Salem units are both once-through circulating water systems that withdraw brackish water from the Delaware River through a single CWS intake located at the shoreline on the southern end of Artificial Island. The CWS intake structure consists of 12 bays, each outfitted with removable ice barriers, trash racks, traveling screens, circulating water pumps, and a fish return system. The pump capacity of the Salem CWS is 1,110,000 gpm (4,200 m^3/min) for each unit, or a total of 2,220,000 gpm (8,400 m^3/min) for both units combined. Although the initial design included use of sodium hypochlorite biocides, these were eliminated once enough operational experience was gained to indicate that they were not needed. Therefore, the CWS water is used without treatment (PSEG, 2009a).

In addition to the CWS intake, the Salem units withdraw water from the Delaware River for the SWS, which provides cooling for auxiliary and reactor safeguard systems. The Salem SWS is supplied through a single intake structure located approximately 400 ft (122 m) north of the CWS intake. The Salem SWS intake is also fitted with trash racks, traveling screens, and fish-return troughs. The pump capacity of the Salem SWS is 65,250 gpm (247 m^3/min) for each unit, or a total of 130,500 gpm (494 m^3/min) for both units combined (PSEG, 2009a).

The withdrawal of Delaware River water for the Salem CWS and SWS systems is regulated under the terms of Salem NJPDES Permit No. NJ005622 and is also authorized by the DRBC. The NJPDES permit limits the total withdrawal of Delaware River water to 3,024 MGD (11.4 million m^3/day), for a monthly maximum of 90,720 million gallons (342 million m^3) (NJDEP, 2001a). The DRBC authorization allows withdrawals not to exceed 97,000 million gallons (367 million m^3/day) in a single 30-day period (DRBC, 1977; 2001). The withdrawal volumes are reported to NJDEP through monthly discharge monitoring reports (DMRs), and copies of the DMRs are submitted to DRBC.

Both the CWS and SWS at Salem discharge water back to the Delaware River through a single return that serves both systems. The discharge location is situated between the CWS and Salem SWS intakes, and consists of six separate discharge pipes; each extending 500 ft (152 m) into the river and discharging water at a depth of 35 ft (11 m) below mean tide. The pipes rest on the river bottom with a concrete apron at the end to control erosion and discharge water at a velocity of 10.5 fps (3.2 m/s) (PSEG, 2006c). The discharge from Salem is regulated under the terms of NJPDES Permit No. NJ005622 (NJDEP, 2001a). The locations of the intakes and discharge for the Salem facility are shown in Figure 2-3.

The HCGS facility uses a closed-cycle circulating water system, with a natural draft cooling tower, for condenser cooling. Like Salem, HCGS withdraws water from the Delaware River to supply a SWS, which cools auxiliary and other heat exchange systems. The outflow from the HCGS SWS is directed to the cooling tower basin, and serves as makeup water to replace water lost through evaporation and blowdown from the cooling tower. The HCGS SWS intake is located on the shore of the river and consists of four separate bays with service water pumps, trash racks, traveling screens, and fish-return systems. The structure includes an additional four bays that were originally intended to serve a second HCGS unit, which was never constructed. The pump capacity of the HCGS SWS is 16,500 gpm (62 m^3/min) for each pump, or a total of 66,000 gpm (250 m^3/min) when all four pumps are operating. Under normal conditions, only two or three of the pumps are typically operated. The HCGS SWS water is treated with sodium hypochlorite to prevent biofouling (PSEG, 2009b).

The discharge from the HCGS SWS is directed to the cooling tower basin, where it acts as makeup water for the HCGS CWS. The natural draft cooling tower has a total capacity of 9 million gallons (34,000 m^3) of water, and circulates water through the CWS at a rate of 612,000 gpm (2,300 m^3/min). Water is removed from the HCGS CWS through both evaporative loss from the cooling tower and from blowdown to control deposition of solids within the system. Evaporative losses result in consumptive loss of water from the Delaware River. The volume of evaporative losses vary throughout the year depending on the climate, but range from approximately 9,600 gpm (36 m^3/min) in January to 13,000 gpm (49 m^3/min) in July. Blowdown water is returned to the Delaware River (NJDEP, 2002b).

The withdrawal of Delaware River water for the HCGS CWS and SWS systems is regulated under the terms of HCGS NJPDES Permit No. NJ0025411 and is also authorized by the DRBC. Although it requires measurement and reporting, the NJPDES permit does not specify limits on the total withdrawal volume of Delaware River water for HCGS operations (NJDEP, 2003). Actual withdrawals average 66.8 MGD (253,000 m^3/day), of which 6.7 MGD (25,000 m^3/day) are returned as screen backwash, and 13 MGD (49,000 m^3/day) is evaporated. The remainder (approximately 46 MGD [174,000 m^3/day]) is discharged back to the river (PSEG, 2009b).

The HCGS DRBC contract allows withdrawals up to 16.998 billion gallons (64 million m^3) per year, including up to 4.086 billion gallons (15 million m^3) of consumptive use (DRBC, 1984a; 1984b). To compensate for evaporative losses in the system, the DRBC authorization requires releases from storage reservoirs, or reductions in withdrawal, during periods of low-flow conditions at Trenton, NJ (DRBC, 2001). To accomplish this, PSEG is one of several utilities which owns and operates the Merrill Creek reservoir in Washington, NJ. Merrill Creek reservoir is used to release water during low-flow conditions, as required by the DRBC authorization (PSEG, 2009b).

The SWS and cooling tower blowdown water from HCGS is discharged back to the Delaware River through an underwater conduit located 1,500 ft (460 m) upstream of the HCGS SWS intake. The HCGS discharge pipe extends 10 ft (3 m) offshore, and is situated at mean tide level. The discharge from HCGS is regulated under the terms of NJPDES Permit No. NJ0025411 (NJDEP, 2001a). The locations of the intake and discharge for the HCGS facility are shown in Figure 2-4.

2.2 Affected Environment

This section provides general descriptions of the environment near Salem and HCGS as background information and to support the analysis of potential environmental impacts in Chapter 4.

2.2.1 Land Use

Salem and HCGS are located at the southern end of Artificial Island located on the east bank of the Delaware River in Lower Alloways Creek Township, Salem County, New Jersey. The river is approximately 2.5 mi (4 km) wide at this location. Artificial Island is a man-made island approximately 1500-ac (600 ha) in size consisting of tidal marsh and grassland. The island was created by the U.S. Army Corps of Engineers (USACE), beginning early in the twentieth century, by the deposition of hydraulic dredge spoil material atop a natural sand bar that projected into the river. The average elevation of the island is about 9 ft (3 m) above MSL with a maximum elevation of approximately 18 ft (5.5 m) MSL (AEC, 1973). The site is located approximately 17 mi (27 km) south of the Delaware Memorial Bridge, 35 mi (56 km) southwest of Philadelphia, Pennsylvania, and 8 mi (13 km) southwest of the City of Salem, NJ.

PSEG owns approximately 740 ac (300 ha) at the southern end of the island, with Salem located on approximately 220 ac (89 ha) and HCGS occupying about 153 ac (62 ha). The remainder of Artificial Island, north of the PSEG property, is owned by the the U.S. Government and the State of New Jersey; this portion of the island remains undeveloped. The land adjacent to the eastern boundary of Artificial Island consists of tidal marshlands of the former natural shoreline. The U.S. Government owns the land adjacent to the PSEG property and the State of New Jersey owns the land adjacent to the U.S. Government-owned portion of the island. The northernmost tip of Artificial Island (owned by the U. S. Government) is within the State of Delaware boundary, which was established based on historical land grants (LACT, 1988a; 1988b; PSEG, 2009a; 2009b).

The area within 15 mi (24 km) of the site is primarily utilized for agriculture. The area also includes numerous parks and wildlife refuges and preserves such as Mad Horse Creek Fish and Wildlife Management Area to the east; Cedar Swamp State Wildlife Management Area to the south in Delaware; Appoquinimink, Silver Run, and Augustine State Wildlife Management areas to the west in Delaware; and Supawna Meadows National Wildlife Refuge to the north. The Delaware Bay and estuary is recognized as wetlands of international importance and an international shorebird reserve (NJSA, 2008). The nearest permanent residences are located 3.4 mi (5.5 km) south-southwest and west-northwest of Salem and HCGS across the river in Delaware. The nearest permanent residence in New Jersey is located 3.6 mi (5.8 km) east-northeast of the facilities (PSEG, 2009c). The closest densely populated center (with 25,000 residents or more) is Wilmington, Delaware, located 15 mi (24 km) north of Salem and HCGS. There is no heavy industry in the area surrounding Salem and HCGS; the nearest such industrial area is located approximately 10 mi (16 km) northwest of the site near Delaware City, Delaware (PSEG, 2009d).

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 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. Salem and HCGS are within New Jersey's coastal zone for purposes of the Coastal Zone Management Act. PSEG's certifications that renewal of the Salem and HCGS licenses would be consistent with the New Jersey Coastal Management Program were submitted to the NJDEP Land Use Regulation Program concurrent with submittal of the license renewal applications for the two facilities. Salem and HCGS are not within Delaware's coastal zone for purposes of the Coastal Zone Management Act (PSEG, 2009a; 2009b). Correspondence related to the certification is in Appendix D of this SEIS. By letters dated October 8, 2009, the NJDEP Division of Land Use Regulation, Bureau of Coastal Regulation concurred with the applicant's consistency of certification for Salem and HCGS.

2.2.2 Air Quality and Meteorology

2.2.2.1 Meteorology

The climate in New Jersey is generally a function of topography and distance from the Atlantic Ocean, resulting in five distinct climatic regions within the State. Salem County is located in the Southwest Zone, which is characterized by low elevation near sea level and close proximity to the Delaware Bay. These features result in the Southwest Zone generally having higher temperatures and receiving less precipitation than the northern and coastal areas of the State. Wind direction is predominantly from the southwest, except in winter when winds are primarily from the west and northwest (NOAA, 2008).

The only NOAA weather station in Salem County with recent data is the Woodstown Pittsgrove Station, located approximately 10 mi (16 km) northeast of the Salem and NCGS facilities (NOAA, 2010a). A summary of the data collected from this station from 1971 to 2001 indicates that winter temperatures average 35.2 degrees Fahrenheit (°F) (1.8 degrees Celsius [°C]) and summer temperatures average 74.8 °F (23.8 °C). Average annual precipitation in the form of rain and snow is 45.76 inches (116 cm), with the most rain falling in July and August and the most snow falling in January (NOAA, 2004).

Queries of the National Climate Data Center database for Salem County for the period January 1, 1950 to November 30, 2009 identified the following information related to severe weather events:

- 33 flood events with the majority (24) being coastal or tidal floods
- numerous heavy precipitation and prolonged rain events which also resulted in several incidences of localized flooding, but which are not included in the flood event number
- five funnel cloud sightings and two tornados ranging in intensity from F1 to F2
- 148 thunderstorm and high wind events
- 14 incidences of hail greater than 0.75 inches (1.9 cm) (NOAA, 2010b)

In 2001, unusually dry conditions were related to two wildfires that burned a total of 54 ac (22 ha). In 2009, a series of brush fires destroyed approximately 15 ac (6.1 ha) of farmland and wooded area in Salem County (NOAA, 2010c).

Climate data are available for the Woodstown Pittsgrove Station from 1901 through 2004, at which time monitoring at this location was ended (NOAA, 2010a). The closest facility which currently monitors climate data, and has an extensive historic record, is the station located at the Wilmington New Castle County Airport, located on the opposite side of the Delaware River, approximately 9 mi (14 km) northwest of the facilities (NOAA, 2010d).

2.2.2.2 Air Quality

Salem County is included in the Metropolitan Philadelphia Interstate Air Quality Control Region (AQCR), which encompasses the area geographically located in five counties of New Jersey, including Salem and Gloucester counties; New Castle County, DE; and five counties of Pennsylvania (40 CFR 81.15). Air quality is regulated by the NJDEP through their Bureau of Air Quality Planning, Bureau of Air Quality Monitoring, and Bureau of Air Quality Permitting (NJDEP, 2009a). The Bureau of Air Quality Monitoring operates a network of monitoring stations for the collection and analysis of air samples for several parameters, including carbon monoxide (CO), nitrogen dioxide (NO_2), ozone, sulfur dioxide (SO_2), particulate matter (PM), and meteorological characteristics. The closest air quality monitoring station to the Salem and HCGS facilities is in Millville, located approximately 23 mi (37 km) to the southeast (NJDEP, 2009a).

In order to enforce air quality standards, the EPA has developed National Ambient Air Quality Standards (NAAQS) under the Federal Clean Air Act. The requirements examine the six criteria pollutants, including particle pollution (PM), ground-level ozone, CO, sulfur oxides (SOx), nitrogen oxides (NOx), and lead; permissible limits are established based on human health and/or environmental protection. When an area has air quality equal to or better than the NAAQS, they are designated as an “attainment area” as defined by the EPA; however, areas that do not meet the NAAQS standards are considered “nonattainment areas” and are required to develop an air quality maintenance plan (NJDEP, 2010a).

Salem County is designated as in attainment/unclassified with respect to the NAAQSs for particulate matter, 2.5 microns or less in diameter ($PM_{2.5}$), SOx, NOx, CO, and lead. The county, along with all of southern New Jersey, is a nonattainment area with respect to the 1-hour primary ozone standard and the 8-hour ozone standard. For the 1-hour ozone standard, Salem County is located within the multi-state Philadelphia-Wilmington-Trenton non-attainment area, and for the 8-hour ozone standard, it is located in the Philadelphia-Wilmington-Atlantic City (Pennsylvania-New Jersey-Delaware-Maryland) non-attainment area. Of the adjacent counties, Gloucester County, NJ is in non-attainment for the 1-hour and 8-hour ozone standards, as well as the annual and daily $PM_{2.5}$ standard (NJDEP, 2010a). New Castle County, DE is considered to be in moderate non-attainment for the ozone standards and non-attainment for $PM_{2.5}$ (40 CFR 81.315).

Sections 101(b)(1), 110, 169(a)(2), and 301(a) of the Clean Air Act (CAA), as amended (42 U.S.C. 7410, 7491(a)(2), 7601(a)), established 156 mandatory Class I Federal areas where visibility is an important value that cannot be compromised. There is one mandatory Class I Federal area in the State of New Jersey, which is the Brigantine National Wildlife Refuge (40 CFR 81.420), located approximately 58 mi (93 km) southeast of the Salem and HCGS facilities. There are no Class I Federal areas in Delaware, and no other areas located within 100 mi (160 km) of the facilities (40 CFR 81.400).

PSEG has a single Air Pollution Control Operating Permit (Title V Operating Permit), No. BOP080001, from the NJDEP to regulate air emissions from all sources at Salem and HCGS (PSEG, 2009a; 2009b). This permit was last issued on February 2, 2005, and expired on February 1, 2010. PSES was required to submit an application for renewal no later than February 2009. An application for a new Title V permit was submitted in October 2008 and the EPA review was scheduled to begin on May 20, 2010 (EPA, 2010a). The expired permit remains in effect until the new permit is approved and issued. The facilities qualify as a major source[1] under the Title V permit program and, therefore, are operated under a Title V permit (NJDEP, 2009b). The air emissions sources regulated by permit and located at Salem, include:

- a boiler for heating purposes
- Salem Unit 3, a 40 MW fuel-oil fired peaking unit used intermittently
- six emergency generators, tested monthly
- a boiler at the circulating water house, used for heating only in winter
- miscellaneous volatile organic compounds (VOC) emissions from fuel tanks

[1] Under the Title V Operating Permit program, the EPA defines a major source as a stationary source with the potential to emit (PTE) any criteria pollutant at a rate greater than 100 tons/year (91 metric tons [MT]/year), or any single hazardous air pollutant (HAP) at a rate of greater than 10 tons/year (9.1 MT/year)or a combination of HAPs at a rate greater than 25 tons/year (23 MT/year).

The air emissions sources located at HCGS, which are regulated under the permit, include:

- the cooling tower
- a boiler for house heating and use for startup steam for the BWR
- four emergency generators, tested monthly
- miscellaneous VOC emissions from fuel tanks
- a small boiler used to heat the service water house

Meteorological conditions at the facilities are monitored at a primary and a backup meteorological tower located at the entrance of the facilities, on the southeast side of the property. The primary tower is a 300-ft (91-m) high tower supported by guy wires, and the backup tower is a 33-ft (10-m) high telephone pole located approximately 500 ft (152 m) south of the primary tower. Measurements collected at the primary tower include temperature, wind speed, and wind direction at elevations of 300, 150, and 33 ft (91, 46, and 10 m) above ground level; dew point measured at the 33-ft (10-m) level; and rainfall, barometric pressure, and solar radiation measured at less than 10 ft (3 m) above the ground surface. Measurements collected at the backup tower include wind speed and wind direction (PSEG, 2006b).

2.2.3 Groundwater Resources

2.2.3.1 Description

Groundwater at the Salem and HCGS facilities is present in Coastal Plain sediments, an assemblage of sand, silt, and clay formations that comprise a series of aquifers beneath the facilities. Four primary aquifers underlie the facility location. The shallowest of these is the shallow water-bearing zone, which is contained within the dredge spoil and engineered fill sediments of Artificial Island. Groundwater is found within this zone at a depth of 10 to 40 ft (3 to 12 m) below ground surface (bgs) (PSEG, 2007a). The groundwater in the shallow zone is recharged through direct infiltration of precipitation on Artificial Island and is brackish. Groundwater in the shallow zone flows toward the southwest, toward the Delaware River (PSEG, 2009b).

Beneath the shallow water-bearing zone, the Vincentown Aquifer is found at a depth of 55 to 135 ft (17 to 41 m) bgs. The aquifer is confined and semi-confined beneath Miocene clays of the Kirkwood Formation. Groundwater within the Vincentown Aquifer flows toward the south. Water within the Vincentown Aquifer is potable and accessed through domestic wells in eastern Salem County, upgradient of the facility. In western Salem County, including near the facility, saltwater intrusion from the Delaware River has occurred, resulting in brackish, non-potable groundwater within this aquifer (PSEG, 2007a).

The Vincentown Aquifer is underlain by the Hornerstown and Navesink confining units, which in turn overlie the Mount Laurel-Wenonah Aquifer. The Mount Laurel-Wenonah Aquifer exists at a depth of 170 to 270 ft (52 to 82 m) bgs and is recharged through leakage from the overlying aquifers (Rosenau et al., 1969).

Beneath the Mount Laurel-Wenonah Aquifer is a series of clay and fine sand confining units and poor quality aquifers, including the Marshalltown Formation, Englishtown Formation, Woodbury Clay, and Merchantville Formation. These units overlie the Potomac-Raritan-Magothy (PRM)

Aquifer, which is found at a depth of 450 ft (137 m), with freshwater encountered to a depth of 900 ft (274 m) bgs at the facility location (PSEG, 2007a). The PRM Aquifer is a large aquifer of regional importance for municipal and domestic water supply. In order to protect groundwater resources within this aquifer, the State of New Jersey has established Critical Water-Supply Management Area 2, in which groundwater withdrawals are limited and managed through allocations (USGS, 2007). Critical Water-Supply Management Area 2 includes Ocean, Burlington, Camden, Atlantic, Gloucester, and Cumberland counties, as well as the eastern portion of Salem County. The area does not include the western portion of Salem County where the facility is located, so groundwater withdrawals at the facility location are not subject to withdrawal restrictions associated with this management area.

2.2.3.2 Affected Users

The use of groundwater by the facility is discussed in Section 2.1.7.1. Groundwater is the source of more than 75 percent of the freshwater supply within the Coastal Plain region, and wells used for public supply commonly yield 500 to more than 1,000 gpm (1.9 to 3.8 m^3/min) (EPA, 1988). The water may have localized concentrations of iron in excess of 460 miligrams per liter (mg/L) and may be contaminated locally by saltwater intrusion and waste disposal; however, water quality is considered satisfactory overall (NJWSC, 2009).

Groundwater is not accessed for public or domestic water supply within 1 mi (1.6 km) of the Salem and HCGS facilities (PSEG, 2009a; 2009b). However, groundwater is the primary source of municipal water supply within Salem and the surrounding counties. There are 18 public water supply systems in Salem County. New Jersey American Water (NJAW) is the largest of these, providing groundwater from the PRM Aquifer to more than 14,000 customers in Pennsgrove, located approximately 18 mi (29 km) north of the Salem and HCGS facilities (EPA, 2010e; NJAW, 2010). The other two major suppliers are Pennsville Township and the City of Salem (EPA, 2010e). The City of Salem is the closest public water supply system in Salem County to the facilities, but provides water from surface water sources (EPA, 2010e). The Pennsville Township water system is located approximately 15 mi (24 km) north of the Salem and HCGS facilities and supplies water to approximately 13,500 residents from the PRM Aquifer (EPA, 2010e; NJDEP, 2007).

There are 27 water systems in New Castle County, Delaware. Municipal and investor-owned utilities provide drinking water to the county. The majority of the potable water supply is provided from surface water sources (EPA, 2010e). The nearest offsite use of groundwater for potable water supply is located approximately 3.5 mi (5.6 km) west of the site, in New Castle County, Delaware (Arcadis, 2006). This water supply consists of two wells installed within the Mt. Laurel aquifer, serving 132 residents (DNREC, 2003).

2.2.3.3 Available Volume

Groundwater within the PRM Aquifer is an important resource for water supply in a region extending from Mercer and Middlesex counties in New Jersey to the north, and toward Maryland to the southwest. Groundwater withdrawal from the early part of the 20th century through the 1970s resulted in the development of large-scale cones of depression in the elevation of the piezometric surface and, therefore, the available water quantity within the aquifer (Walker, 1983). Large scale withdrawals of water from the aquifer are known to influence water availability at significant lateral distances from pumping centers (Walker, 1983). In reaction to these observations, water management measures, including limitations on pumping, were instituted by the NJDEP (although not including the Salem and HCGS facility area). As of 2003, NJDEP-mandated decreases in water withdrawals had resulted in general recovery of water level elevations in both the Upper and Middle PRM aquifers in the Salem County area (DePaul et al., 2009).

2.2.3.4 Existing Quality

Annual REMP reports document regular sampling of groundwater as required by the NRC. In support of this SEIS, the annual REMP reports for 2006, 2007, and 2008 were reviewed (PSEG, 2007b; 2008a; 2009c). The program includes the collection and analysis of groundwater at one or two locations that may be affected by station operations. Although the facility has determined that there are no groundwater wells in locations that could be affected by station operations, they routinely collect a sample from one location, well 3E1 at a nearby farm, as a management audit sample. These samples, collected on a monthly basis, are analyzed for gamma emitters, gross alpha, gross beta, and tritium. In 2006 through 2008, no results were identified which would suggest potential impacts from facility operations.

In 2003, a release of tritium to groundwater from the Salem Unit 1 SFP was identified. The release was caused from the blockage of drains by mineral deposits. Response measures, including removal of the mineral deposits and installation of additional drains, were taken and the release was stopped (Arcadis, 2006).

A site investigation was initiated in 2003, and included the installation and sampling of 29 monitoring wells in the shallow and Vincentown aquifers (PSEG, 2004a). The tritium was released into groundwater inside of the cofferdam area that surrounds the Salem containment unit. Groundwater within the cofferdam area is able to flow outside of the cofferdam through a low spot in the top surface, which allowed the tritium plume to enter the flow system outside of the cofferdam. From that location, the plume followed a preferential flow path along the high permeability sand and gravel bed beneath the circulating water discharge pipe and, thus, toward the Delaware River. Tritium was detected in shallow groundwater at concentrations up to 15,000,000 picoCuries per liter (pCi/L). The extent of the impact was limited to within the PSEG property boundaries and no tritium was detected in the Vincentown aquifer, indicating that the release was limited to the shallow water-bearing aquifer (PSEG, 2009d). The release did not include any radionuclides other than tritium.

In 2004, PSEG developed a remedial action workplan, and a GRS was approved by NJDEP and became operational by September 2005. The GRS operates by withdrawing tritium-impacted groundwater from six pumping wells within the plume, and a mobile pumping unit that can be moved between other wells as needed to maximize withdrawal efficiency. The pumping system reverses the groundwater flow gradient and stops the migration of the plume toward the property boundaries. The tritium-impacted water removed from the groundwater is processed in the facility's NRLWDS. As part of this system, the groundwater is collected in tanks, sampled, and analyzed to identify the quantity of radioactivity and the isotopic breakdown. Upon verification that the groundwater meets NRC discharge requirements, it is released under controlled conditions to the Delaware River through the circulatory water system

(PSEG, 2009a). Operation of the groundwater extraction system is monitored by a network of 36 monitoring wells (PSEG, 2009e). This monitoring indicates that maximum tritium concentrations have dropped substantially, from a maximum of 15,000,000 pCi/L to below 100,000 pCi/L. Some concentrations still exceed the New Jersey Ground Water Quality Criterion for tritium of 20,000 pCi/L (PSEG, 2009e). However, groundwater that exceeds this criterion does not extend past the property boundaries (PSEG, 2009a).

To verify the status of the groundwater remediation program, Staff interviewed NJDEP staff during the site audit in March 2010. The NJDEP staff confirmed that both NJDEP and the New Jersey Geological Survey (NJGS) had been substantially involved in assisting PSEG in developing a response to the tritium release, and that NJDEP conducts ongoing confirmation sampling. Both NJDEP and NJGS review PSEG's Quarterly Remedial Action Progress Reports, including confirmation of the analytical results and verification of plume configurations based on those results. NJDEP staff confirmed that the GRS is operating in a satisfactory manner.

In response to an industry-wide initiative sponsored by the Nuclear Energy Institute (NEI), PSEG implemented a facility-wide radiological groundwater protection program (RGPP) at the Salem and HCGS facilities in 2006. The program, which is separate from the monitoring associated with the GRS, included the identification of station systems that could be sources of radionuclide releases, installation of monitoring wells near and downgradient of those systems and installation of wells upgradient and downgradient of the facility perimeter. The monitoring program consists of 13 monitoring wells at Salem (5 pre-existing and 8 new) and 13 wells at HCGS (all new). The results of the program are reported in the facility's annual Radiological Environmental Operating Reports. The wells are sampled on a semiannual basis and have detected no plant-related gamma-emitters. In the 2008 annual program, tritium was detected in 5 of the 13 wells at Salem, and 6 of the 13 wells at HCGS. All sample results were lower than 1,000 pCi/L, which is less than the 20,000 pCi/L EPA drinking water standard and New Jersey Ground Water Quality Criterion (PSEG, 2009c). These levels of detection are not high enough to trigger voluntary reporting that would be made under the guidelines of the NEI guidance (PSEG, 2009a).

During the site audit, PSEG provided information indicating that elevated tritium concentrations had been detected in six RGPP wells at the HCGS facility in November 2009. This included detection of tritium at concentrations up to 1,200 pCi/L in four wells, and at approximately 3,500 pCi/L in two wells (wells BH and BJ). The wells were all re-sampled in December 2009, and the tritium concentrations had dropped to levels of approximately 500 to 800 pCi/L, which still exceeded their levels prior to November 2009. The wells involved are located at the HCGS facility and are not related to the tritium plume being managed at Salem. PSEG has instituted a well inspection and assessment program to identify the source of the tritium, which is thought to be from either analytical error of rain-out of gaseous emissions in precipitation. Based on the locations of the wells and identification of cracked caps on some wells, it is possible that collection of rainwater run-on entered the wells, causing the increased concentrations. In response, PSEG has replaced all well caps with screw caps and is working with NJDEP and the Staff to implement a well inspection program.

During the site audit, PSEG also provided information on a small-scale diesel pump and treat remediation system being operated near Salem Unit 1 to address a leak of diesel fuel at that location. NJDEP is also involved in the operation of that system, and NJDEP staff confirmed that the remediation system is operating in a satisfactory manner.

2.2.4 Surface Water Resources

2.2.4.1 Description

The Salem and HCGS facilities are located on Artificial Island, a man-made island constructed on the New Jersey (eastern) shore of the Delaware River (PSEG, 2009a; 2009b). All surface water in Salem County drains to the Delaware River and Bay. Some streams flow directly to the river, while others join subwatersheds before reaching their destination. The tides of the Atlantic Ocean influence the entire length of the Delaware River in Salem County. Tidal marshes are located along the lower stretches of the Delaware River and are heavily influenced by the tides, flooding twice daily. Wetland areas, such as Mannington and Supawna Meadows, make up roughly 30 percent of the county. The southwestern portion of Salem County is predominately marshland, and to the north, tidal marshes are found in the western sections of the county at the mouths of river systems, including the Salem River and Oldmans Creek (Salem County, 2008).

The Division of Land Use Regulation (LUR) is managed by the NJDEP and seeks to preserve quality of life issues that affect water quality, wildlife habitat, flood protection, open space, and the tourism industry. Coastal waters and adjacent land are protected by several laws, including the Waterfront Development Law (N.J.S.A. 12:5-3), the Wetlands Act of 1970 (N.J.S.A. 13:9A), New Jersey Coastal Permit Program Rules (N.J.A.C. 7:7), Coastal Zone Management Rules (N.J.A.C. 7:7E), and the Coastal Area Facility Review Act (N.J.S.A. 13:19), which regulates almost all coastal development and includes the Kilcohook National Wildlife Refuge that is located in Salem County (NJDEP, 2010b).

The facilities are located at River Mile (RM) 51 on the Delaware River. At this location, the river is approximately 2.5 mi (4 km) wide. The facilities are located on the Lower Region portion of the river, which is designated by the DRBC as the area of the river subject to tidal influence, and between the Delaware Bay and Trenton, NJ (DRBC, 2008a). The Lower Region and the Delaware Bay together form the Estuary Region of the river, which is included as the Partnership for the Delaware Estuary within the EPA's National Estuary Program (EPA, 2010d).

Water use from the river at the facility location is regulated by both the DRBC and the State of New Jersey. The DRBC was established in 1961, through the Delaware River Basin Compact, as a joint Federal and State body to regulate and manage water resources within the basin. The DRBC acts to manage and regulate water resources in the basin by: (1) allocating and regulating water withdrawals and discharges; (2) resolving interstate, water-related disputes; (3) establishing water quality standards; (4) managing flow; and (5) watershed planning (DRBC, 1961).

As facilities that use water resources in the basin, Salem and HCGS water withdrawals are conducted under contract to the DRBC. The Salem facility uses surface water under a DRBC contract originally signed in 1977 (DRBC, 1977), and most recently revised and approved for a 25-year term in 2001 (DRBC, 2001). Surface water withdrawals by the HCGS facility were originally approved for two units in 1975, and then revised for a single unit in 1985 following PSEG's decision to build only one unit (DRBC, 1984a). The withdrawal rates are also regulated by NJDEP, under NJPDES Permit Nos. NJ0025411 (for HCGS) and NJ005622 (for Salem).

2.2.4.2 Affected Users

The Delaware River Basin is densely populated, and surface water resources within the river are used for a variety of purposes. Freshwater from the non-tidal portion of the river is used to supply municipal water throughout New York, Pennsylvania, and New Jersey, including the large metropolitan areas of Philadelphia and New York City. Approximately 75 percent of the length of the non-tidal Delaware River is designated as part of the National Wild and Scenic Rivers System. The river is economically important for commercial shipping, as it includes port facilities for petrochemical operations, military supplies, and raw materials and consumer products (DRBC, 2010).

In the tidal portion of the river, water is accessed for use in industrial operations, including power plant cooling systems. A summary of DRBC-approved water users on the tidal portion of the river from 2005 lists 22 industrial facilities and 14 power plants in Pennsylvania, New Jersey, and Delaware (DRBC, 2005). Of these facilities, Salem is by far the highest volume water user in the basin, with a reported water withdrawal volume of 1,067,892 million gallons (4.042 billion m^3) in 2005 (DRBC, 2005). This volume exceeds the combined total withdrawal for all other industrial, power, and public water supply purposes in the tidal portion of the river. The withdrawal volume for HCGS in 2005 was much lower, at 19,561 million gallons (74 million m^3).

2.2.4.3 Water Quality Regulation

To regulate water quality in the basin, the DRBC has established water quality standards, referred to as Stream Quality Objectives, to protect human health and aquatic life objectives. To account for differing environmental setting and water uses along the length of the river basin, the DRBC has established Water Quality Management (WQM) Zones, and has established separate Stream Quality Objectives for each zone. The Salem and HCGS facilities are located within Zone 5, which extends from RM 48.2 to RM 78.8.

The DRBC Stream Quality Objectives are used by the NJDEP to establish effluent discharge limits for discharges within the basin. The EPA granted the State of New Jersey the authority to issue NPDES permits, and such a permit implies water quality certification under the Federal Clean Water Act (CWA) Section 401. The water quality and temperature of the discharges for both the Salem and HCGS discharges are regulated by NJDEP under NJPDES Permit Nos. NJ0025411 (for HCGS) and NJ005622 (for Salem). In addition, industrial facilities in New Jersey are required, under the New Jersey Administrative Code (NJAC) Title 7:1E – 5.3, to provide notification to NJDEP whenever any hazardous substance, as defined in NJAC 7:1E Appendix A is released.

2.2.4.4 Salem Nuclear Generating Station NJPDES Requirements

The current NJPDES Permit No. NJ005622 for the Salem facility was issued with an effective date of August 1, 2001, and an expiration date of July 31, 2006 (NJDEP, 2001a). The permit requires that a renewal application be prepared at least 180 days in advance of the expiration date. Correspondence provided with the applicant's ER indicates that a renewal application was filed on January 31, 2006. During the site audit, NJDEP staff confirmed that the application was still undergoing review.

The Salem NJPDES permit regulates water withdrawals and discharges associated with non-radiological industrial wastewater, including intake and discharge of once-through cooling water. The once-through cooling water, service water, non-radiological liquid waste, radiological liquid waste, and other effluents are discharged through the cooling water system intake. The specific discharge locations, and their associated reporting requirements and discharge limits, are presented in Table 2-2.

Stormwater discharge is not monitored through the Salem NJPDES permit. Stormwater is collected and discharged through outfall discharge serial numbers (DSNs) 489A (south), 488 (west), and 487/487B (north). The NJPDES permit requires that stormwater discharges be managed under an approved Stormwater Pollution Prevention Plan (SWPPP) and, therefore, does not specify discharge limits. The same SWPPP is also applicable to stormwater discharges from the HCGS facility. The plan includes a listing of potential sources of pollutants and associated best management practices (NJDEP, 2003).

Industrial wastewater from Salem is regulated at nine specific locations, designated outfall DSNs 048C, 481A, 482A, 483A, 484A, 485A, 486A, 487B, and 489A. Outfall DSN 048C is the discharge system for the NRLWDS, and also receives stormwater from DSN 487B. For DSN 048C, the permit establishes reporting requirements for discharge volume (in millions of gallons per day), and compliance limits for total suspended solids, ammonia, petroleum hydrocarbons, and total organic carbon (NJDEP, 2001a).

Outfall DSNs 481A, 482A, 483A, 484A, 485A, and 486A are the discharge systems for cooling water, service water, and the radiological liquid waste disposal system. Outfall DSNs 481A, 482A, and 483A are associated with Salem Unit 1, while outfall DSNs 484A, 485A, and 486A are associated with Salem Unit 2. The permit establishes similar, but separate, requirements for each of these six outfalls. For each, the permit requires reporting of the discharge volume (in MGD), the pH of the intake, and the temperature of the discharge. The permit also establishes compliance limits for the discharge from each outfall for pH and chlorine-produced oxidants (NJDEP, 2001a).

Outfall DSN 487B is the discharge system for the #3 skim tank. The permit establishes reporting requirements for discharge volume (in MGD) and compliance limits for pH, total suspended solids, temperature of effluent, petroleum hydrocarbons, and total organic carbon (NJDEP, 2001a).

Table 2-2. NJPDES Permit Requirements for Salem Nuclear Generating Station

Discharge	Description	Required Reporting	Permit Limits
DSN 048C	Input is NRLWDS and Outfall DSN 487B Discharges to outfall DSNs 481A, 482A, 484A, and 485A	Effluent flow volume	None
		Total suspended solids	50 mg/L monthly average 100 mg/L daily maximum
		Ammonia (Total as N)	35 mg/L monthly average 70 mg/L daily maximum
		Petroleum hydrocarbons	10 mg/L monthly average 15 mg/L daily maximum
		Total organic carbon	Report monthly average 50 mg/L daily maximum
DSNs 481A, 482A, 483A, 484A, 485A, and 486A (the same requirements for each)	Input is cooling water, service water, and DSN 048C Outfall is six separate discharge pipes	Effluent flow volume	None
		Effluent pH	6.0 daily minimum 9.0 daily maximum
		Intake pH	None
		Chlorine-produced oxidants	0.3 mg/L monthly average 0.2 and 0.5 mg/L daily maximum
		Temperature	None
DSN 487B	#3 skim tank, and stormwater from north portion	Effluent flow	None
		pH	6.0 daily minimum 9.0 daily maximum
		Total suspended solids	100 mg/L daily maximum
		Temperature	43.3°C daily maximum
		Petroleum hydrocarbons	15 mg/L daily maximum
		Total organic carbon	50 mg/L daily maximum
Discharge	**Description**	**Required Reporting**	**Permit Limits**
DSN 489A	Oil/water separator, turbine sumps, and stormwater from south portion	Effluent flow	None
		pH	6.0 daily minimum 9.0 daily maximum
		Total suspended solids	30 mg/L monthly average 100 mg/L daily maximum
		Petroleum hydrocarbons	10 mg/L monthly average 15 mg/L daily maximum
		Total organic carbon	50 mg/L daily maximum
DSN Outfall FACA	Combined for discharges 481A, 482A, and 483A	Net temperature (year round)	15.3°C daily maximum
		Gross temperature (June to September)	46.1°C daily maximum
		Gross temperature (October to May)	43.3°C daily maximum
DSN Outfall FACB	Combined for discharges 484A, 485A, and 486A	Net temperature (year round)	15.3°C daily maximum
		Gross temperature (June to September)	46.1°C daily maximum
		Gross temperature (October to May)	43.3°C daily maximum

Discharge	Description	Required Reporting	Permit Limits
DSN Outfall FACC	Combined for discharges 481A, 482A, 483A, 484A, 485A, and 486A	Influent flow Effluent thermal discharge	3,024 MGD monthly average 30,600 MBTU/hr daily maximum

MBTU/hr = million British thermal units per hour
Source: NJDEP, 2001a

Outfall DSN 489A is the discharge system for the oil/water separator. The permit establishes reporting requirements for discharge volume (in MGD) and compliance limits for pH, total suspended solids, petroleum hydrocarbons, and total organic carbon (NJDEP, 2001a).

In addition to the reporting requirements and contaminant limits for these individual outfalls, the permit establishes temperature limits for Salem Unit 1 as a whole, Salem Unit 2 as a whole, and the Salem facility as a whole. Outfall FACA is the combined discharge from outfalls 481A, 482A, and 483A to represent the overall thermal discharge from Salem Unit 1. For outfall FACA, the permit establishes an effluent net temperature difference of 15.3 °C (27.5°F), a gross temperature of 43.3 °C (110°F) from October to May, and a gross temperature of 46.1 °C (115°F)from June to September (NJDEP, 2001a).

Similarly, outfall FACB is the combined discharge from outfall DSNs 484A, 485A, and 486A to represent the overall thermal discharge from Salem Unit 2. The temperature limits for outfall FACB are the same as those established for outfall FACA (NJDEP, 2001a).

Outfall FACC is the combined results from outfall DSNs 481A through 486A, representing the overall thermal discharge and flow volume for the Salem facility as a whole. The permit establishes an overall intake volume of 3,024 MGD (11.4 million m^3/day) on a monthly average basis, and an effluent thermal discharge limit of 30,600 million British thermal units (BTUs) per hour as a daily maximum (NJDEP, 2001a).

In addition to the outfall-specific reporting requirements and discharge limits, the Salem NJPDES permit includes a variety of general requirements (NJDEP, 2001a). These include requirements for the following:

- additives that may be used, where they may be used, and procedures for proposing changes to additives
- toxicity testing of discharges and, depending on results, toxicity reduction measures
- implementation and operations of intake screens and fish return systems
- wetland restoration and enhancement through the estuary enhancement program
- implementation of a biological monitoring program
- installation of fish ladders at offsite locations
- performance of studies of intake protection technologies
- implementation of entrainment and impingement monitoring
- conduct of special studies, including intake hydrodynamics and enhancements to entrainment and impingement sampling

- funding of construction of offshore reefs
- compliance with DRBC regulations, NRC regulations, and the NOAA Fisheries Biological opinion

In the permit, the NJDEP reserves the right to re-open the requirements for intake protection technologies (NJDEP, 2001a).

2.2.4.5 Hope Creek Generating Station NJPDES Requirements

The current NJPDES Permit No. NJ0025411 for the HCGS facility was issued in early 2003, with an effective date of March 1, 2003, and an expiration date of February 29, 2008 (NJDEP, 2003). The permit requires that a renewal application be prepared at least 180 days in advance of the expiration date. Correspondence provided with the applicant's ER indicates that a renewal application was filed on August 30, 2007. During the site audit, NJDEP staff confirmed that the application was still undergoing review.

The HCGS NJPDES permit regulates water withdrawals and discharges associated with both stormwater and industrial wastewater, including discharges of cooling tower blowdown (NJDEP, 2003). The cooling tower blowdown and other effluents are discharged through an underwater pipe located on the bank of the river, 1,500 ft (457 m) upstream of the SWS intake. The specific discharge locations, and their associated reporting requirements and discharge limits, are presented in Table 2-3.

Stormwater discharge is not monitored through the HCGS NJPDES permit. Stormwater is collected and discharged through outfall DSNs 463A, 464A, and 465A. These outfalls were specifically regulated, and had associated reporting requirements, in the HCGS NJPDES permit through 2005. However, the revision of the permit in January 2005 modified the requirements for stormwater, and the permit now requires that stormwater discharges be managed under an approved SWPPP and, therefore, does not specify discharge limits. The same SWPPP is also applicable to stormwater discharges from the Salem facility. The plan includes a listing of potential sources of pollutants and associated best management practices (NJDEP, 2003).

Industrial wastewater is regulated at five locations, designated DSNs 461A, 461C, 462B, 516A (oil/water separator), and SL1A (sewage treatment plant [STP]). Discharge DSN 461A is the discharge for the cooling water blowdown, and the permit established reporting and compliance limits for intake and discharge volume (in MGD), pH, chlorine-produced oxidants, intake and discharge temperature, total organic carbon, and heat content in millions of BTUs per hour, in both summer and winter (NJDEP, 2003).

Discharge DSN 461C is a discharge for the oil/water separator system and has established reporting and compliance limits for discharge volume, total suspended solids, total recoverable petroleum hydrocarbons, and total organic carbon (NJDEP, 2003).

Table 2-3. NJPDES Permit Requirements for Hope Creek Generating Station

Discharge	Description	Required Reporting	Permit Limits
DSN 461A	Input is cooling water blowdown and DSN 461C Outfall is discharge pipe	Effluent flow	None
		Intake flow	None
		Effluent pH	6.0 daily minimum 9.0 daily maximum
		Chlorine-produced oxidants	0.2 mg/L monthly average 0.5 mg/L daily maximum
		Effluent gross temperature	36.2oC daily maximum
		Intake temperature	None
		Total organic carbon (effluent gross, effluent net, and intake)	None
		Heat content (June to August)	534 MBTU/hr daily maximum
		Heat content (September to May)	662 MBTU/hr daily maximum
DSN 461C	Input is low volume oily waste from oil/water separator Outfall is to DSN 461A	Effluent flow	None
		Total suspended solids	30 mg/L monthly average 100 mg/L daily maximum
		Total recoverable petroleum Hydrocarbons	10 mg/L monthly average 15 mg/L daily maximum
		Total organic carbon	50 mg/L daily maximum
DSN 462B	Sewage treatment plant effluent, discharges to 461A	Effluent flow	None
		Total suspended solids	30 mg/L monthly average 45 mg/L weekly average 83% removal daily minimum
		Biological oxygen demand (BOD)	8 kg/day monthly average 30 mg/L monthly average 45 mg/L weekly average 87.5 percent removal daily minimum
		Oil and grease	10 mg/L monthly average 15 mg/L daily maximum
		Fecal coliform	200 /100 ml monthly geometric 400 /100 ml weekly geometric average
		6 separate metal and inorganic contaminants (cyanide, nickel, zinc, cadmium, chromium, and copper)	None
S16A	Oil/water separator residuals from 461C	24 separate metal and inorganic contaminants	None
		24 separate organic contaminants	None
		Volumes and types of sludge produced and disposed	None

Discharge	Description	Required Reporting	Permit Limits
SL1A	STP system residuals from 462B	17 separate metal and inorganic contaminants	None
		Volumes and types of sludge produced and disposed	None

Source: NJDEP, 2005c

Discharge DSN 462B is the discharge for the onsite sewage treatment plant. The permit includes limits for effluent flow volume, total suspended solids, oil and grease, fecal coliform, and six inorganic contaminants (NJDEP, 2005c).

Discharge 516A is the discharge from the oil/water separator system. This discharge has reporting requirements established for 48 inorganic and organic contaminants, for the volume of sludge produced, and for the manner in which the sludge is disposed (NJDEP, 2003).

Discharge SL1A is the discharge from the STP system. This discharge has reporting requirements established for 17 inorganic contaminants, as well as sludge volume and disposal information (NJDEP, 2003).

In addition to the outfall-specific reporting requirements and discharge limits, the HCGS NJPDES permit includes a variety of general requirements. These include requirements for additives that may be used, where they may be used, and procedures for proposing changes to additives; and compliance with DRBC regulations and NRC regulations (NJDEP, 2003).

In the permit, the NJDEP reserves the right to revoke the alternate temperature provision for outfall DSN 461A if the NJDEP determines that the cooling tower is not being properly operated and maintained (NJDEP, 2003).

Spill Reporting under NJAC 7:1E

As discussed above, industrial facilities in New Jersey are required to provide notification to NJDEP whenever any hazardous substance, as defined in NJAC 7:1E Appendix A, is released. The list of hazardous substance in NJAC 7:1E Appendix A includes almost 2,000 substances that are commonly used at industrial facilities, including many chemicals that Salem and HCGS are specifically permitted to use in accordance with their NJPDES permits. This includes chemicals which are added to the steam systems for corrosion protection, including ammonium hydroxide and hydrazine. In compliance with NJAC 7:1E – 5.3, the facilities occasionally report releases of these chemicals, including hydrazine, ammonium hydroxide, and sodium hypochlorite, to NJDEP, and those reports are publicly available. In two recent instances, the facilities have been subject to enforcement action associated with these releases. In September 2005, the facilities paid a penalty of $7,500 associated with a release of 5,000 gallons (19 m^3) of boiler feed water containing 7 parts per million (ppm) hydrazine and 20 ppm ammonia. In April 2008, they paid a penalty of $15,000 associated with the May 10, 2006 release of 5,000 gallons (19 m^3) of water containing hydrazine and ammonium hydroxide, and with a separate release of sodium hypochlorite. A separate penalty of $8,250 was paid in February 2007, associated with the same May 10, 2006 release (NJDEP, 2010c).

2.2.5 Aquatic Resources – Delaware Estuary

2.2.5.1 Estuary Characteristics

Salem and HCGS are located at the south end of Artificial Island on the New Jersey shore of the Delaware Estuary, about 52 RM (84 river km) north of the mouth of the Delaware Bay (Figure 2-5). The estuary is the source of the cooling water for both facilities and receives their effluents. The Delaware Estuary supports an abundance of aquatic resources in a variety of habitats. Open water habitats include salt water, tidally-influenced water of variable salinities, and tidal freshwater areas. Moving south from the Delaware River to the mouth of the bay, there is a continual transition from fresh to salt water. Additional habitat types occur along the edges of the estuary in brackish and freshwater marshes. The bottom of the estuary provides many different benthic habitats, with their characteristics dictated by salinity, tides, water velocity, and substrate type. Sediments in the estuary near Artificial Island are primarily mud, muddy sand, and sandy mud (PSEG, 2006c).

At Artificial Island, the estuary is tidal with a net flow to the south and a width of approximately 16,000 ft (5,000 m) (Figure 2-1). The USACE maintains a dredged navigation channel near the center of the estuary and about 6,600 ft (2,000 m) west of the shoreline at Salem and HCGS. The navigation channel is about 40 ft (12 m) deep and 1,300 ft (400 m) wide. On the New Jersey side of the channel, water depths in the open estuary at mean low water are fairly uniform at about 20 ft (6 m). Predominant tides in the area are semi-diurnal, with a period of 12.4 hours and a mean tidal range of 5.5 ft (1.7 m). The maximum tidal currents occur in the channel, and currents flow more slowly over the shallower areas (NRC, 1984; Najarian Associates, 2004).

Salinity is an important determinant of biotic distribution in estuaries, and salinity near the Salem and HCGS facilities depends on river flow. The NRC (1984) reported that average salinity in this area during periods of low flow ranged from 5 to 18 parts per thousand (ppt) and during periods of higher flow, ranged from 0 to 5 ppt. Najarian Associates (2004) and PSEG Services Corporation (2005b) characterized salinity at the plant as ranging between 0 and 20 ppt and, in the summer during periods of low flow, as typically exceeding 6 ppt. Based on temperature and conductivity data collected by the USGS at Reedy Island, just north of Artificial Island, Najarian Associates (2004) calculated salinity from 1991 through 2002. According to Figure B6 in the Najarian Associates 2004 report, the median salinity was approximately 5 ppt and salinity exceeded 12 ppt in only two years, exceeded 13 ppt in only one year, and never exceeded 15 ppt during the 11 year period. Based on these observations, the Staff assumes that salinity in the vicinity of Salem and HCGS typically ranges from 0 to 5 ppt during periods of low flow (usually, but not always, in the summer) and from 5 to 12 ppt during periods of high flow (Table 2-4). Within these larger patterns, salinity at any specific location also varies with the tides (NRC, 2007).

Table 2-4. Salinities in the Delaware Estuary in the Vicinity of Salem Nuclear Generating Station and Hope Creek Generating Station

Condition	Salinity Range (ppt)
Low Flow	0-5
High Flow	5-12

Source: NRC, 2007

Monthly average surface water temperatures in the Delaware Estuary vary with season. Between 1977 and 1982, water temperatures ranged from -0.9°C (30°F) in February 1982 to 30.5°C (86.9°F) in August 1980. Although the estuary in this reach is generally well mixed, it can occasionally stratify, with surface temperatures 1° to 2°C (2° to 4°F) higher than bottom temperatures and salinity increasing as much as 2 ppt per meter of water depth (NRC, 1984).

Cowardin et al. (1979) classified estuaries into five categories based on salinity, varying from fresh (zero ppt) to hyperhaline (greater than 40 ppt). They further subdivide the brackish category (0.5 to 30 ppt) into three subsections: oligohaline (0.5 to 5 ppt), mesohaline (5 to 18 ppt), and polyhaline (18 to 30 ppt). These categories describe zones within the estuary. The estuary reach adjacent to Artificial Island is at the interface of the oligohaline and mesohaline zones; thus, it is oligohaline during high flow and mesohaline during low flow conditions. Based on water clarity categories of good, fair, or poor, the EPA (1998) classified the water clarity in this area of the estuary as generally fair (meaning that a wader in waist-deep water would not be able to see his feet). The EPA classified the water clarity directly upstream and downstream of this reach as poor (meaning that a diver would not be able to see his hand at arm's length). EPA (1998) classified most estuarine waters in the Mid-Atlantic as having good water clarity and stated that lower water clarity typically is due to phytoplankton blooms and suspended sediments and detritus (organic particles and debris from the beakdown of vegetation).

Delaware Bay is a complex estuary, with many individual species playing different roles in the system. Additionally, most estuarine species have complex lifecycles, and are present in the bay at different stages, so many species play several ecological roles throughout their lifecycles. Changes in the abundance of these species can have far reaching effects, both within and without the bay, including major trends in commercial fisheries. Major assemblages of organisms within the estuarine community include plankton, benthic invertebrates, and fish.

2.2.5.2 Plankton

Plankton are organisms that are moved throughout the water column by tides and currents. They are relatively unable to control their own movements (Moisan et al., 2007). Plankton can be primary producers (phytoplankton) or consumers (zooplankton and microbes).

Phytoplankton

Phytoplankton are microscopic, single-celled algae that are responsible for the majority of primary production in the water column. Primary production is typically limited to the upper 2 m (7 ft) of the water column due to light limitation from high turbidity (NRC, 1984). Water quality parameters such as salinity, temperature, and nutrient availability regulate species composition, abundance, and distribution. Seasonal changes in these parameters cause fluctuations in the density of plankton populations (Versar, 1991). Species composition also varies with water quality parameters. In the highly variable, tidally influenced zone, species with a high tolerance for widely fluctuating environments are found. Species composition also fluctuates seasonally (DRBC, 2008b).

Phytoplankton were sampled in the late 1960s and early 1970s as part of the pre-operational ecological investigations for Salem performed by Ichthyological Associates (PSEG, 1983). In 1978, NJDEP agreed that Salem operation had no effect on phytoplankton populations, and phytoplankton studies related to the operation of Salem Units 1 and 2 were discontinued (PSEG, 1984). Versar (1991) conducted a major literature survey for the Delaware Estuary Program to assess the various biological resources of the estuary and possible trends in their abundance or health. This study found that phytoplankton formed the basis of the primary production in the estuary. More recently, Monaco and Ulanowicz (1997) established that pelagic phytoplankton in the Delaware Bay are responsible for most of the primary production. Sutton et al (1996) determined that phytoplankton in the lower bay (polyhaline zone) where the water is less turbid account for most of the primary production in the system. The Delaware Estuary contains several hundred phytoplankton species, a few of which are highly abundant (Sutton et al., 1996). *Skeletonema potamos* and various cyanobacteria and green algae are numerically dominant in the oligohaline zone.

NJDEP currently surveys phytoplankton in the Delaware estuary. These surveys monitor harmful algal blooms by collecting samples for chlorophyll analysis. The occurrence of blooms is highly variable between years, but blooms most often occur in the spring (NJDEP, 2005b). Algal blooms can have large consequences for the entire estuary because they can contain flagellates that may make fish and shellfish inedible, and they can deplete the oxygen in the water column so severely that large fish kills can result. The EPA also monitors algal blooms using helicopter surveys (NJDEP, 2005a).

Zooplankton

Zooplankton are heterotrophic plankton that consume phytoplankton, other types of zooplankton, and detritus (Moisan et al., 2007). They serve as a vital link between the micro algae, detritus, and larger organisms in the Delaware Estuary. Zooplankton are very small, have limited mobility, and provide a source of food for many other organisms, including filter feeders, larvae of fish and invertebrates, and larger zooplankton. They are dependent on phytoplankton, detritus, or smaller zooplankton for food. In turn, they are either eaten by larger organisms or contribute to the energy web by being decomposed by the detritivores after they settle to the substrate. Zooplankton show seasonal and spatial variability in abundance and species composition (PSEG, 1983). Their distribution can be affected by factors such as currents, salinity, temperature, and light intensity (NRC, 1984).

Some zooplankton spend their entire life cycle in the water column and others spend only part of their life cycle in the water column. Among the former are invertebrates such as shrimp, mysids, amphipods, copepods, ctenophores (comb jellies), jellyfish, and rotifers. Among the animals that spend a only portion of their life cycle as plankton are larval fish and invertebrates that have a planktonic stage before their development into adult forms. The planktonic stage provides for these organisms an important dispersal mechanism, ensuring that larvae arrive in as many appropriate habitats as possible (Sutton et al., 1996). Studies in the Salem pre-operational phase found many such zooplankton in large numbers, including the larval stages of the estuarine mud crab (*Rhithropanopeus harrisii*), fiddler crab (*Uca minax*), grass shrimp (*Palaemonetes pugio*), and copepods (PSEG, 1983).

Zooplankton were sampled by Ichthyological Associates as part of the pre-operational ecological studies for Salem Units 1 and 2. Studies related to plant operations in the early to mid 1970s found that two types of crustaceans, opossum shrimp and amphipods of the genus *Gammarus*, constituted the numerical majority of the taxa collected. Due to the abundance of these two taxa, they were selected by NJDEP and NRC for future ecological studies related to Salem operations. They also are important as prey items for many of the fishes in the estuary. As a result, general studies of the zooplankton in the estuary were discontinued by PSEG in favor of an approach more focused on individual species (PSEG, 1984). Studies reviewed in Sutton et al (1996) did not show a major change in the zooplankton assemblage since the early 1960s. Copepods generally are the most abundant organisms and are a major prey resource for larval and adult fish in the Delaware Estuary (Sutton et al., 1996).

Since many of the fish species found in the Delaware Estuary are managed either Federally or by individual States, there have been extensive studies of ichthyoplankton (larval fish and eggs). Additionally, fish have been monitored by PSEG and the States of New Jersey and Delaware since before the operation of Salem Units 1 and 2. Initial ichthyoplankton studies were general surveys. Later studies focused on the 11 target species established during the NPDES permitting process. These studies included impingement and entrainment studies and general sampling consisting of plankton tows and beach seines (PSEG, 1984). Versar (1991) reviewed several studies with respect to ichthyoplankton. This review included both the power plant studies and more general surveys focused on managed fish species. The review revealed that ichthyoplankton of the tidal freshwater region (corresponding to the oligohaline region) had a high abundance of the alosid fishes, including the American shad (*Alosa sapidissima*), hickory shad (*A. mediocris*), alewife (*A. pseudoharengus*), and blueback herring (*A. aestivalis*), as well as other anadromous species. Due to alosid lifecycles, both eggs and larvae have seasonal peaks in abundance and distribution that vary with the species. The bay anchovy (*Anchoa mitchilli*) is abundant in the transitional region (corresponding to the mesohaline region) in which Artificial Island is located. Other common ichthyoplankton species in the Delaware Estuary include the naked goby (*Gobiosoma bosc*), blueback herring, alewife, Atlantic menhaden (*Brevoortia tyrannus*), weakfish (*Cynoscion regalis*), and Atlantic silverside (*Menidia menidia*). The number of species was highest in the spring and summer months, and bay anchovy always constituted a large portion of the ichthyoplankton samples (Versar, 1991). The lifecycles, habitats, and other characteristics of fish species identified among the ichthyoplankton are described in Section 2.2.5.4.

2.2.5.3 Benthic Invertebrates

Benthic invertebrates (or benthos) are organisms that live within (infauna) or on (epifauna) the substrates at the bottom of the water column, including groups such as worms, mollusks, crustaceans, and microorganisms (CAML, 2008). Parabenthos are organisms that spend some time in or on the substrate but can also be found in the water column, including crabs, copepods, and mysids (Versar, 1991). The species composition, distribution, and abundance of the benthic invertebrate community are affected by physical conditions, such as salinity, temperature, water velocity, and substrate type, and by interactions between individuals and species. Substrates within the Delaware Estuary include mud, sand, clay, cobble, shell, rock, and various combinations of these; those near Salem and HCGS are mostly fine-grained silts and clays with small areas of sand (USACE, 1992).

The benthic invertebrate community of the estuary performs many ecological functions. Some benthic species or groups of species form habitats by building reefs (such as oysters and some polychaete worms) or by stabilizing or destabilizing soft substrates (such as some bivalves, amphipods, and polychaetes). Some benthic organisms are filter feeders that clean the overlying water (such as oysters, other bivalves, and some polychaetes), and others consume detritus. While the benthic community itself contains many trophic levels, it also provides a trophic base for fish and shellfish (such as crabs) valued by humans.

A review of benthic data for the Delaware Estuary was included in a report for the Delaware Estuary Program (Versar, 1991). Benthic data have been collected in the estuary since the early 1800s. Most of the earlier reports were surveys describing species; however, large amounts of quantitative data were collected in the 1970s. Generally, benthic invertebrate species distributions were found to be limited by salinity and substrate type (Versar, 1991). Additionally, localized poor water quality can have a major effect on species composition. Species found in the lower bay are limited by salinity gradients; estuarine species, such as the razor clam (Ensis directus) and the polychaete Heteromastus filiformis, are found throughout the entire bay; and freshwater and oligohaline species, such as the clam Gemma gemma, occur in lower salinity waters in the upper bay. Pre-operational studies by Ichthyological Associates also concluded that species composition varied seasonally, reflecting higher diversity and abundance during periods of higher salinity. The authors postulated that this was a result of both recruitment dynamics and immigration from the lower bay (PSEG, 1983).

The benthos of the tidal fresh portion (oligohaline) of the estuary includes tubificid worms, chironomid larvae, sphaerid clams, and unionid mussels. These assemblages are greatly influenced by anthropogenic impacts to the water quality in the area due to proximity of pollutant sources on the river. Highly tolerant species are found here, often with only one extremely dominant species. In the transition zone (mesohaline) oligochaetes and amphipods generally are numerically dominant. The bay region (polyhaline) has abundant bivalves and polychaetes (Versar, 1991). As reported in the applicant’s initial environmental report (PSEG, 1983), pre-operational studies for Salem Units 1 and 2 found mostly euryhaline species in the vicinity of the facility, including polychaetes, oligochates, and isopods (NRC, 1984).

Species composition and abundance of benthic organisms are often used as indicators of ecosystem health. Generally, the greater the diversity of species and the more abundant those species are, the healthier the system is considered. EPA collected benthic samples in the Delaware Estuary between 1990 and 1993 in an effort to assess the health of the system. As a result of this sampling effort, EPA determined that 93 percent of the tidal river between the Chesapeake and Delaware Canal and Trenton, NJ was either degraded or severely degraded. South of this area, EPA classified only 2 percent of the benthic invertebrate community as impaired, and none of the area was considered severely impaired (Delaware Estuary Program, 1995). More recently, EPA released a report describing the Delaware-Maryland-Virginia coastal bays as impacted over one-fourth of their total area. In the Delaware Bay itself, EPA considered the upper portion as severely impacted, the transition area as impacted, and the lower bay as mostly in good condition. The report described a large central area of the bay as impacted, possibly due to scouring from high currents or eutrophication resulting in high organic carbon levels in the sediments (EPA, 1998).

PSEG and its consultants conducted studies during the 1984 NPDES 316(b) permitting process (PSEG, 1984). They collected over 1,000 grab samples in the Delaware Estuary and identified a total of 57 taxa in 8 phyla. The most abundant species were the same as those found in previous studies. General densities of benthic organisms ranged between 17,000 per square meter (m^2; 183,000 per ft^2) and 25,000 per m^2 (269,000 per ft^2). As a result of the PSEG studies, NJDEP determined that benthic invertebrates would not be substantially affected by plant operations, and these organisms were no longer sampled as part of the monitoring effort (PSEG, 1984).

Mysids are a key biological resource in Delaware Bay because they are highly abundant and are prey for many other species, especially fish. They also are important predators of other invertebrates. Opossum shrimp are found in water with a salinity of 4 ppt or higher (mesohaline and polyhaline regions), most often in deeper areas. They migrate vertically into the water column at night and settle on the sediments during the day. Sand shrimp are more common in shallower waters and play the same ecological role as opossum shrimp. Amphipods are numerous in the transition region and are primarily represented by the genus Gammarus. These crustaceans also form a link between the smaller plankton and the larger fish species in this part of the estuary (Versar, 1991).

The benthos of the Delaware estuary also include mollusks and large crustaceans such as the blue crab (*Callinectes sapidus*) and horseshoe crab (*Limulus polyphemus*). These species can be difficult to sample with the equipment typically used for benthos sampling, sediment grab samplers (PSEG, 1984). PSEG monitoring survey efforts often caught blue crabs in the bottom trawl samples. Opossum shrimp and Gammarus spp. also are difficult to sample because they often inhabit vegetation in shallow marsh areas. These species were selected as target species during PSEG's early ecological studies with respect to the operation of Salem Units 1 and 2, but NJDEP and PSEG later determined that they were unaffected by the facility and they were no longer specifically monitored (PSEG, 1999).

Several benthic invertebrate species that have been given special attention by Federal, regional, or State organizations. For example, the blue crab has been extensively monitored at Salem as an important species, the horseshoe crab has been the focus of several restoration efforts within Delaware Bay due to its general decline and the fact that the bay is considered a major nursery and spawning area for the species, and both the horseshoe crab and the oyster were noted as important species by NMFS (NMFS, 2010a). These three species are discussed below.

Blue Crab

The blue crab is an important ecological, cultural, commercial, and recreational resource in the Delaware Bay (Hill et al., 1989). Blue crabs mate in low-salinity portions of estuaries during the summer, usually from May through October (ASMFC, 2004). Males can mate several times, but females mate only once (ASMFC, 2004). Once the female has been fertilized, she migrates to higher salinity regions to complete the spawning process. The fertilized eggs are extruded over several months and remain attached to the abdomen of the female. The eggs hatch and are released after 1 to 2 weeks, initiating a series of larval transitions. In the first larval stage, the zoea, the larvae are planktonic filter feeders and develop in the higher-salinity waters outside of the estuary. These larvae molt seven to eight times in 31 to 49 days before progressing to the next stage, the megalops, which are more like crabs, with pincers and jointed legs (Hill et al., 1989). After 6 to 20 days, the megalops stage molts into the first crab stage, resembling an adult crab. Over a period of 1 year, these juveniles migrate up the estuary into lower-salinity regions until they have reached the adult stage (Hill et al., 1989). Initially, sea grass beds are an important habitat, but crabs then make extensive use of marsh areas as nurseries (ASMFC, 2004). Natural mortality rates for the blue crab are hard to define as they vary non-linearly with life stage and environmental parameters. The maximum age reached by blue crabs has been estimated to be 8 years (ASMFC, 2004).

The blue crab is an omnivore, feeding on many other commercially important species, such as oysters and clams. Young blue crabs also are prey for other harvested species, especially those that use the estuary as a nursery area (Hill et al., 1989). Blue crabs are important in energy transfer within estuarine systems (ASMFC, 2004). They play different roles in the ecosystem depending on their life stage. Zoea larvae consume other zooplankton as well as phytoplankton. Megalops larvae consume fish larvae, small shellfish, aquatic plants, and each other. Post-larval stages consume detritus, carcasses, fish, crabs, and mollusks. Crab eggs are eaten by fish. Larval stages are eaten by other planktivores, including fish, jellyfish, and shellfish. Juvenile crabs are consumed by shore birds, wading birds, and fish. Adult crabs are consumed by mammals, birds, and large fish, including the striped bass (*Morone saxatitlis)*, American eel (*Anguilla rostrata*), and sandbar shark (*Carcharhinus plumbeus*) (Hill et al., 1989).

Blue crab population estimates are difficult, as recruitment is highly variable and dependent on temperature, dissolved oxygen, rainfall, oceanographic conditions, parasitism, and contaminant and predation levels (Hill et al., 1989; ASMFC, 2004). Landings of blue crabs on the east coast were in decline in the early 2000s, prompting a symposium led by the ASMFC in an attempt to assess the status of the fishery and to assist in developing sustainable landing limits. Participants in the symposium theorized that declines in blue crab populations could be a result of attempts to increase populations of other fisheries species that prey upon crabs (ASMFC, 2004).

Horseshoe Crab

The horseshoe crab is an evolutionarily primitive species that has remained relatively unchanged for 350 million years. It is not a true crab but is more closely related to spiders and other arthropods (FWS, 2006). The largest spawning population in the world inhabits the Delaware Bay. They migrate offshore during the winter months and return to shore in spring to spawn on beaches (ASMFC, 2008a). Spawning peaks in May and June, and crabs spawn repeatedly during the season (ASMFC, 2010a). Spawning occurs during high spring tides on sandy beaches with low wave action (ASMFC, 2008a). The female will partially burrow into the sand and deposit several thousand eggs. Eggs hatch in 3 to 4 weeks, and the larvae (which resemble the adult crabs without tails) will enter the water about 1 month later (FWS, 2006). They spend their first 6 days swimming in shallow water, and then settle to the bottom (FWS, 2006; ASMFC, 1998a). Juveniles will spend their first 2 year on intertidal sand flats. Older juveniles and adults inhabit subtidal habitats (ASMFC, 2010a). Molting continues after the juvenile stage, with each molt increasing the crab's size by up to 25 percent. After about 17 molts, or 9 to 12 years, the crabs are sexually mature (ASMFC, 2008a). Crabs can live up to 10 additional years after the last molt (ASMFC, 2010a). Horseshoe crabs exhibit limited beach fidelity, usually returning to their native beaches to spawn (FWS, 2003). However, crabs tagged in the Delaware Bay have been recaptured in New Jersey, Delaware, Maryland, and Virginia (ASMFC, 2008b).

Horseshoe crabs play a major ecological role in the migration patterns of shore birds from the Arctic to the southern Atlantic. Many bird species eat horseshoe crab eggs during their seasonal migrations on the Atlantic flyway (ASMFC, 2008a; FWS, 2006). Juvenile and adult horseshoe crabs eat mostly mollusks, such as clams and mussels, but also arthropods, annelids, and nemerteans. Larvae consume small polychaetes and nematodes (ASMFC, 1998a). In addition to providing a rich food source for birds, eggs and larvae are consumed by fish, crabs, gastropods, and loggerhead sea turtles (*Caretta caretta*) (ASMFC, 1998a). Seagulls often eat overturned adults on the beach (FWS, 2003).

Commercial uses for horseshoe crabs include applications in the fishing, biomedical, and livestock and fertilizer industries. Fisherman use horseshoe crabs as bait in the American eel and conch (*Busycon carica* and *B. canaliculatum*) fisheries. The biomedical industry uses their blood to detect contaminated medicine. This fishery captures, bleeds and releases the crabs (FWS 2003). At the turn of the 20th century, between 1.5 and 4 million horseshoe crabs were harvested annually for use by the livestock and fertilizer industries. Variations and reductions in harvests since that time are partially due to management and partially due to a decrease in demand. Stock status is currently unknown due to lack of commercial fishing data. Evidence from trawl surveys suggests that the population is growing in Delaware Bay. Harvests have been reduced in Delaware, but are increasing in Massachusetts and New York (ASMFC, 2008a). The management plan for the horseshoe crab provides limits on harvet seasons for male and female crabs, and for total hauls (ASMFC, 2008b).

Threats to horseshoe crab habitat include coastal erosion, development (particularly shoreline stabilization structures such as bulkheads, groins, seawalls, and revetments), sea level rise/land subsidence, channel dredging, contaminants, and oil spills in spawning areas. Habitats of concern include nearshore shallow water and intertidal sand flats, and beach spawning areas (ASMFC, 2010a).

American Oyster

The American oyster is also known as the eastern oyster and the Atlantic oyster. Oysters inhabit the Delaware Bay from the mouth of the bay to Bombay Hook on the Delaware side and to just south of Artificial Island on the New Jersey side (USACE, 2007). There are three physiological races recognized coast wide, each spawning at different temperatures. The oysters in the Delaware Bay are part of the population that spawns at 20 °C (68 °F). Spawning occurs in the summer months, with several events per season. During spawning events, males release their sperm and a pheromone into the water column and the females respond by releasing their eggs. Larvae remain in the water column for 2 to 3 weeks, dispersing with the water currents. Larvae pass through several morphological changes before settling, preferably on other oyster shells. Adult oysters are sessile and found in beds or reefs in dense masses. They often are the only large organism in the bed and can change water currents enough to affect the sediment deposition rate of the local environment. They are dioecious, but are capable of changing sex, with more oysters becoming female as they age. Growth is affected by environmental variables, such as temperature, salinity, intertidal exposure, turbidity, and food availability (Sellers and Stanley, 1984).

Oysters are tolerant of a wide array of environmental variables, as they have evolved to live in estuaries, which experience high and low temperatures, high and low salinities, submersion and exposure, and clear to muddy water. Optimal temperatures for adults are between 20°C and 30°C (68°F and 86°F). Salinities higher than 7.5 ppt are required for spawning, but adults will tolerate salinities between 5 and 30 ppt. Because oysters are filter feeders, water velocity is highly important. The water above a bed must be recharged 72 times every 24 hours for maximum feeding. Tidal flows of greater than 5 to 8.5 fps (152 to 259 centimeters per second [cm/sec]) provide for optimal growth (Sellers and Stanley, 1984).

Oyster larvae feed on plankton. Adults are stationary filter feeders, feeding on plankton as well as detritus and other particulate matter. They can filter up to 1.5 liters of water an hour, making them an important ecological resource. Due to their reef building abilities, they are also important because they create three-dimensional habitats, which can be home to over 300 other species. A wide variety of other filter feeders eat oyster larvae. Predators of adult oysters include gastropod oysterdrills (*Urosalpinx cinerea* and *Eupleura caudata*), the whelk *Busycon canaliculatum,* the starfish *Asterias forbesi*, the boring sponge (*Cliona* sp.), the flatworm *Stylochus ellipticus*, and crabs. Competitors for resources include slipper limpets (*Crepidula* sp.), jingle shells (*Anomia* sp.), barnacles, and the mussel *Brachiodontes exustus* (Sellers and Stanley, 1984).

The oyster is a commercially important species that has been harvested in Delaware Bay since the early 1800s (Delaware Estuary Program, 2010). By the mid 1850s, oyster fisherman had begun transplanting oysters from the naturally occurring seed beds of New Jersey to other areas in the bay for growth, due to concern over the smaller size of oysters being harvested. The natural seed beds are now protected outside of the leasing system, as these are the sources of the oysters transplanted to other beds. In the early 1900s, one to two million bushels were harvested from the bay annually, concurrent with the use of the new oyster dredge. Production remained relatively stable until the mid 1950s when disease decimated the population. Currently, the oyster harvest remains limited due mainly to diseases such as MSX ("multinucleated sphere unknown," later classified as *Haplosporidium nelson)* and Dermo (caused by the southern oyster parasite, *Perkinsus marinus*). Oysters now are directly harvested from the seed beds (Delaware Estuary Program, 2010).

Delaware, New Jersey, and the USACE currently are undertaking a joint effort to reestablish oyster beds and an oyster fishery in Delaware Bay. The majority of these efforts are focused on increasing recruitment and sustaining a population by shell and bed planting and seeding. Since 2001, despite management, oyster abundance has continued to decline due to below average recruitment. Recruitment enhancement is deemed important to stabilize stock abundance, to permit continuation and expansion of the oyster industry, to guarantee increased abundance that produces the shell necessary to maintain the bed, and to minimize the control of oyster population dynamics by disease. These goals will allow the oyster to play its ecological role as a filterer that enhances general water quality (USACE, 2007).

2.2.5.4 Fish

The Delaware Bay, Estuary, and River make up an ecologically and hydrologically complex system that supports many fish species. Most estuarine fish species have complex life cycles and are present in the estuary at various life stages; thus, they may play several ecological roles during their lives. Changes in the abundance of these species can have far-reaching effects, both within the bay and beyond, including effects on commercial fisheries. Given the complexity of the fish community of this system, the description below is based on species considered to be of particular importance for a variety of reasons.

Representative Species

To determine the impacts of operation from Salem and HCGS on the aquatic environment of the Delaware Estuary, monitoring has been performed in the estuary annually since 1977. The 1977 permitting rule for Section 316(b) of the CWA included a provision to select representative species (RS) to focus such investigations (the terms target species or representative important species have also been used) (PSEG, 1984; 1999). RS were selected based on several criteria: susceptibility to impingement and entrainment at the facility, importance to the ecological community, recreational or commercial value, and threatened or endangered status. PSEG currently monitors 12 species as RS: blueback herring (*Alosa aestivalis*), alewife (*Alosa pseudoharengus*), American shad (*Alosa sapidissima*), bay anchovy (*Anchoa mitchilli*), Atlantic menhaden (*Brevoortia tyrannus*), weakfish (*Cynoscion regalis*), spot (*Leiostomus xanthurus*), Atlantic silverside (*Menidia menidia*), Atlantic croaker (*Micropogonias undulatus*), white perch (Morone americana), striped bass (*Morone saxatilis*), and bluefish (*Pomatomus saltatrix*). These species are described below.

Blueback Herring and Alewife

The blueback herring and alewife can be difficult to differentiate and are collectively known and managed as “river herring.” The NMFS currently classifies both species as species of concern (NMFS, 2009).

The entire length of the Delaware River and portions of Delaware Bay are confirmed spawning runs for river herring (NJDEP, 2005d). River herring are anadromous, migrating inshore to spawn in freshwater rivers and streams in a variety of habitats. They are reported to return to their natal rivers, suggesting a need for management more focused on specific populations as opposed to establishing fishery-wide limits. Spawning migration begins in spring, with the alewife arriving inshore approximately one month before the blueback herring (NMFS, 2009). The adults of both species return to the ocean after spawning (ASMFC, 2009a).

Blueback herring can reach 16 inches (41 cm) long and have an average life span of 8 years. Males usually mature at 3 to 4 years of age, females at 5 years. Young of the year and juveniles of less than 2 inches (5 cm) are found in fresh and brackish estuarine nursery areas. They then migrate offshore to complete their growth. The juveniles use many habitats in the estuaries, including submerged aquatic vegetation, rice fields, swamps, and small tributaries outside the tidal zone (NMFS, 2009). Blueback herring prefer swiftly flowing water for spawning in their northern range.

Alewife reach maturity at approximately 4 years and can live 10 years, reaching up to 15 inches (38 cm) long (NMFS, 2009). They spawn over gravel, sand, detritus, and submerged aquatic vegetation in slow-moving water. Spawning is more likely to occur at night, and a single female may spawn with 25 males simultaneously. The eggs initially stick to the bottom, but they soon become pelagic and hatch within 2 to 25 days. The yolk sac is absorbed within 5 days and the larvae may remain in the spawning areas or migrate downstream to more brackish waters. Juveniles inhabit the brackish areas in estuaries, near their spawning location. As they develop and the temperature drops, they migrate toward the ocean, completing this process in the beginning of the winter months (NMFS, 2009).

While at sea, many predators eat river herring, including marine mammals, sharks, tuna, and mackerel. While in the estuaries, American eel, striped bass, largemouth bass, mammals, and birds consume them. The blueback herring and alewife minimize interspecific competition using several mechanisms, including the timing of spawning, juvenile feeding strategies and diets, and ocean emigration timing (ASMFC, 2009a). Blueback juveniles feed on benthic organisms and copepods, cladocerans, and larval dipterans at or just below the water surface (ASMFC, 2009a). While offshore, blueback herring feed on plankton, including ctenophores, copepods, amphipods, mysids, shrimp, and small fish (NMFS, 2009). During the spawning migration (unlike the alewife, which does not feed), the blueback herring feeds on invertebrates and fish eggs (ASMFC, 2009a). Juveniles are opportunistic feeders on a variety of invertebrates (ASMFC, 2009a). Alewife are schooling, pelagic omnivores while offshore, feeding mainly on zooplankton but also small fishes and their eggs and larvae (NMFS, 2009). Alewife not only migrate seasonally to spawn in response to temperatures but also migrate daily in response to zooplankton availability (NMFS, 2009). Adult alewife are eaten by many other fish. Alewife are also important as hosts to parasitic larvae of freshwater mussels, some species of which are threatened or endangered (ASMFC, 2009a). Both species are ecologically important due to their trophic position in both estuarine and marine habitats. As planktivores, they link zooplankton to piscivores, providing a vital energy transfer (Bozeman and VanDen Avyle, 1989).

River herring are directly consumed by humans and also are ingredients in fish meal, fish oil, pet and farm animal food, and bait. The eggs (roe) are canned for human consumption. The ASMFC manages the river herring fishery (ASMFC, 2009a). River herring also are often taken as bycatch in other fisheries (NMFS, 2009). The river herring fishery has been active in the United States for 350 years. Alewife landings peaked in the 1950s and the 1970s, then abruptly declined (NMFS, 2009). Blueback herring landing data are limited, but a severe decline was observed in the early 2000s. In addition to the commercial industry, there is an extensive recreational fishery. Blueback herring are exhibiting signs of overfishing in several of the estuary systems on the east coast, including the Delaware River (ASMFC, 2009a). River herring population declines have been attributed to overfishing and the loss of historic spawning habitat all along the east coast of the United States (NMFS, 2009). Reasons for habitat loss include dam construction, stream bank erosion, pollution, and siltation (ASMFC, 2009a). New Jersey currently has a small commercial bait fishery for river herring. Delaware also has a small river herring fishery associated with the white perch fishery. Neither State has specific regulations for river herring, but pending legislation in Delaware could eliminate the fishery in that State (ASMFC, 2009a).

American Shad

The American shad has been a commercially and culturally important species on the east coast of the United States since colonial times. The entire length of the Delaware River is a confirmed spawning run for the American shad. There is no confirmed information available on Delaware Bay itself, although shad would have to migrate through the bay to get to the river (NJDEP, 2005d). American shad adults are highly abundant in Delaware Bay, potentially confirming the use of the estuary as part of the spawning run (ASMFC, 1998b).

The American shad is a schooling, anadromous fish that migrates to freshwater to spawn in winter, spring, or summer, with the timing depending on water temperature. Mature shad can spawn up to six times over their lifetimes of 5 to 7 year. Preferred spawning substrates include sand, silt, muck, gravel, and boulders. Water velocity must be rapid enough to keep the eggs off the bottom. Eggs are spawned in areas that will allow them to hatch before drifting downstream into saline waters. At 4 weeks, the larvae become juveniles and spend their first summer in the freshwater systems (Mackenzie et al., 1985). The juveniles migrate toward the ocean in the fall months, cued by water temperature changes. In the Delaware River, this happens when the water reaches 20°C (68°F), usually in October and November. The juveniles will remain in the estuary until they are 1 year old (ASMFC, 1998b), then they migrate into the ocean. Juveniles remain in the ocean until they are mature, approximately 3 to 5 years for males and 4 to 6 years for females. Adults are likely to return to their natal rivers to spawn (MacKenzie et al., 1985).

Ecologically, the American shad plays an important role in the coastal estuary systems, providing food for some species and preying on others. It also transfers nutrients and energy from the marine system to freshwater areas because many shad die after they spawn (ASMFC, 1998b). Young American shad in the river systems feed in the water column on a variety of invertebrates. While at sea, they feed on invertebrates, fish eggs, and small fish (MacKenzie et al. 1985; ASMFC, 1998b). During the spawning run, shad consume mayflies and small fish.

Many species prey on shad while they are small, including striped bass, American eels, and birds. Seals, porpoises, sharks, bluefin tuna (Thunnus thynnus), and kingfish (Scomberomorus regahni) consume larger shad (Weiss-Glanz et al., 1986). Much of the American shad's life cycle is dictated by changes in ambient temperature. The peak of the spawning run and the ocean emigration happen when the water temperature is approximately 20°C (68°F). Deformities develop if eggs encounter temperatures above 22°C (72°F) and they do not hatch above 29°C (84°F). Juveniles actively avoid rises in temperature of 4°C (39°F) (MacKenzie et al., 1985).

Historically, huge numbers of American shad were harvested during their annual spring spawning runs. The Atlantic catch in 1896 was 50 million lbs (22,700 metric tons [MT]) (MacKenzie et al., 1985). By the end of the 19th century, only 17.6 million lbs (8,000 MT were caught, representing a severe decline in the American shad stock, and the fishery began fishing in the waters of the lower bays. Several States, including Maryland, closed the American shad fishery by 1985 (MacKenzie et al., 1985). The ASMFC currently manages the American shad fishery. The ASMFC stock assessment (2007a) showed American shad stocks are continuing to depete severley and are not recovering, with Atlantic harvests of approximately 550 tons (500 MT). The shad coastal intercept fishery in the Atlantic has been closed since 2005; additionally there is a 10 fish limit for the recreational inshore fishery. The reasons for their decline include dams, habitat loss, pollution, and overfishing (ASMFC, 2007a). A report published by the ASMFC (1998a) theorized that increased predation by the striped bass is also a factor in the decline of shad abundance (ASMFC, 1998b).

<u>Bay Anchovy</u>

The bay anchovy is an abundant forage fish in Delaware Bay. It is a small, schooling, euryhaline fish that grows to approximately 4 inches (10 cm) and can live for several years (Morton, 1989; SMS, 2008). It lives in waters ranging from fresh to hypersaline over almost any bottom type, including sand, mud, and submerged aquatic vegetation (Morton, 1989; Newberger and Houde, 1995). The bay anchovy spawns almost all year, typically in waters of less than 65 ft (20 m) deep. In the Middle Atlantic region, spawning occurs in estuaries in water of at least 12°C (54°F) and over 10 ppt salinity. The eggs are pelagic and hatch after about 24 hours. Newly hatched fish move upstream into lower-salinity areas to feed, eventually migrating to the lower estuary in the fall (Morton, 1989).

The bay anchovy is highly important both ecologically and commercially due to its abundance and widespread distribution (Morton, 1989). It plays a large role in the food webs that support many commercial and sport fisheries by converting zooplankton biomass into food for piscivores (Morton, 1989; Newberger and Houde, 1995). Young bay anchovies feed mainly on copepods, and adults consume mysids, small crustaceans, mollusks, and larval fish. Copepods are the primary food source of bay anchovies in Delaware Bay. Adult bay anchovies are tolerant of a range of temperatures and salinities and move to deeper water for the winter (Morton, 1989). There is no bay anchovy fishery, so they are not directly economically important. However, they support many other commercial fisheries as they are often the most abundant fish in coastal waters (Morton, 1989). Several authors count them as the most important link in the food web, as they are a primary forage item for many other fish, birds, and mammals (Morton, 1989; SMS, 2008; Newberger and Houde, 1995). Juvenile fish and gelatinous predators such as sea nettles and ctenophores consume bay anchovy eggs. Bay anchovy often account for over half the fish, eggs, or larvae caught in research trawls (SMS, 2008). Striped bass are heavily dependent on bay anchovies as larvae, juveniles, and adults, especially since the menhaden and river herring populations have declined in recent years (CBF, 2010).

Atlantic Menhaden

The Atlantic menhaden is a small schooling fish inhabiting the Atlantic coast from Nova Scotia to northern Florida in estuarine and nearshore coastal waters. It migrates seasonally, spending early spring through early winter in estuaries and nearshore waters, with the larger and older fish moving farther north during summer (ASMFC, 2005a). Spawning occurs offshore in fall and early winter between New Jersey and North Carolina (ASMFC, 2005a). The eggs are pelagic and hatch in 1 to 2 days. Once the yolk sac is absorbed at 4 days old, larvae begin to feed on plankton. Larvae enter estuary nursery areas after 1 to 3 months, between October and June in the Mid-Atlantic. Prejuvenile fish use the shallow, low salinity areas in estuaries as nurseries, preferring vegetated areas in fresh tidal marshes and swamps, where they become juveniles (Rogers and Van Den Ayvle, 1989). Juveniles spend approximately 1 year in the estuarine nurseries before joining the adult migratory population in late fall (ASMFC, 2005a). Larvae that entered the nursery areas late in the year may remain until the next fall. Once juveniles metamorphose to adults, they switch from individual capture to a filter feeding strategy. Fish are mature at age 2 or 3 and will then begin the spawning cycle (Rogers and Van Den Ayvle, 1989). Atlantic menhaden can live up to 8 years, but fish older than 6 years are rare (ASMFC, 2001).

Due to its high abundance and trophic positioning in the nearshore and estuarine ecosystems, the Atlantic menhaden is ecologically vital along the Atlantic coast (Rogers and Van Den Ayvle, 1989). It is a filter feeder that strains plankton from the water column and provides a trophic link between primary producers and the larger predatory species in nearshore waters (ASMFC, 2005a). It also transfers energy in and out of estuary systems and on and off the coastal shelf (Rogers and Van Den Avyle, 1989). It is especially important in this regard, as most marine fish species cannot use plankton as a food source (ASMFC, 2001). Rogers and Van Den Avyle (1989) hypothesized that due to its abundance and migratory movements, the Atlantic menhaden may change the assemblage structure of plankton in the water column. Larvae in the estuaries feed preferentially upon copepods and copepodites and may eat detritus as well. Young fish and adults filter feed on anything larger than 7 to 9 micrometers, including zooplankton, large phytoplankton, and chain diatoms (Rogers and Van Den Avyle, 1989). The Atlantic menhaden provides a food source for many larger fish (ASMFC, 2001; Rogers and Van Den Avyle, 1989). Its filter-feeding habits also have lead to a variety of physiological characteristics, such as high lipid content, which enables their survival during periods of low prey availability (Rogers and Van Den Avyle, 1989).

The Atlantic menhaden has been an important commercial fish along the Atlantic coast since colonial times. It has been fished since the early 1800s, and landings increased over time as new technologies developed (ASMFC, 2005a). The ASMFC manages the fishery. Currently, the reduction industry uses Atlantic menhaden for fish meal and oil, and both commercial and recreational fisheries use them as bait. Atlantic menhaden populations suffered in the 1960s when they were severely overfished, but they recovered in the 1970s. A stock assessment completed in 2003 declared that the Atlantic menhaden were not overfished, and a review in 2004 resulted in a decision not to require an assessment in 2006 (ASMFC, 2005a).

Weakfish

The weakfish inhabits the Atlantic coast from Nova Scotia to southern Florida, but is more common between New York and North Carolina (ASMFC, 2009b). Its growth varies geographically, with northern populations becoming much larger and living longer than the more southern populations. Within the Delaware Bay, the oldest females (age 9 years) were an average of 28 inches (710 mm) long, and the oldest males (6 years) were an average of 27 inches (686 mm) long (Mercer, 1989). Spring warming induces inshore migration from offshore wintering areas and spawning (ASMFC, 2009b). Spawning occurs in estuaries and nearshore areas between May and July in the New York Bight (Delaware Bay to New York) (Mercer, 1989). The weakfish is a batch spawner that continuously produces eggs during the spawning season, allowing more than one spawning event per female (ASMFC, 2002). Larval weakfish migrate into estuaries, bays, sounds, and rivers to nursery habitats, where they remain until they are 1 year old (ASMFC, 2009b; Mercer, 1989). Eggs are pelagic and hatch between 36 and 40 hours after fertilization. Larvae become demersal soon after this. Juvenile weakfish use the deeper waters of estuaries, tidal rivers, and bays extensively but do not often inhabit the shallower areas closer to shore. Within Delaware Bay, juvenile weakfish migrate toward lower salinities in the summer, higher salinities in the fall, and offshore for the winter months. Adults migrate inshore seasonally to spawn in large bays or the nearshore ocean. As temperatures cool for the winter, weakfish migrate to ocean wintering areas, the most important of which is the continental shelf between the Chesapeake Bay and North Carolina (Mercer, 1989).

The weakfish plays an important ecological role as both predator and prey in the estuarine and nearshore food webs (Mercer, 1989). Adults feed on peneid and mysid shrimps and a variety of other fishes. Younger weakfish consume mostly mysids and other zooplankton and invertebrates (Mercer, 1989; ASMFC, 2002). Weakfish are tolerant of a relatively wide variety of temperatures and salinities. In Delaware Bay, weakfish have been collected in temperatures between approximately 62.6°F and 82.4°F (17°C and 28°C) and salinities of 0 to 32 ppt (Mercer, 1989).

The weakfish is part of a mixed stock fishery that has been economically vital since the early 1800s (ASMFC, 2009b). It was historically highly abundant in Delaware Bay. It topped commercial landings in the State of Delaware until the 1990s and was consistently within the top five species in recreational landings (DNREC, 2006a). Weakfish biomass has declined significantly in recent years, with non-fishing pressures such as increased natural mortality, predation, competition, and environmental variables hypothesized as the cause for the decline (ASMFC, 2009b). Commercial landings have fluctuated since the beginning of the fishery, without apparent trend or sufficient explanation (ASMFC, 2009b; Mercer, 1989). Landings along the Atlantic coast peaked in the 1970s then declined throughout the 1980s and early 1990s. Management measures increased stock and commercial harvest until 1998, when the fishery declined again, this time continuously until 2008 (ASMFC, 2009b). Between 1995 and 2004, commercial landings in Delaware dropped by 82 percent and the recreational harvest dropped by 98 percent, reflecting a coast-wide drop of 78 percent (DNREC, 2006a). The results of the 2009 stock assessment defined the fishery as depleted, but not overfished, with natural sources of mortality listed as the cause of the low biomass levels. The ASMFC is currently developing an amendment to the management plan to address the decline (ASMFC, 2009b).

Spot

The range of spot along the Atlantic coast stretches from Maine to Florida. They are most abundant from the Chesapeake Bay to North Carolina (ASMFC, 2008c). During fall and summer, they are highly abundant in estuarine and near-shore areas from Delaware Bay to Georgia (Phillips et al., 1989). Spot migrate seasonally, spawning offshore in fall and winter at 2 to 3 years of age and spending the spring months in estuaries (ASMFC, 2008c). Spawning occurs offshore over the continental shelf from October to March. The eggs are pelagic and hatch after approximately 48 hours, producing buoyant larvae that become more demersal and migrating from the mid-depths during the day to the surface at night. The larvae move slowly toward shore, entering the post-larval stages when they reach nearshore areas and developing into juveniles when they reach the inlets (Phillips et al., 1989). Juveniles move into the low-salinity coastal estuaries, where they grow before moving into higher-salinity areas as they mature (ASMFC, 2008c). Seagrass beds and tidal creeks are important nursery habitats for spot, which often make up 80 to 90 percent of the total number of fish found in these habitats. Juveniles remain in the nursery areas for approximately a year, migrating back to the ocean in September or October (Phillips et al., 1989). Spot are tolerant of a wide range of environmental conditions; they inhabit water temperatures between 46.4 and 87.8°F (8 and 31°C) and salinities between 0 and 61 ppt (Phillips et al., 1989).

Due to their large numbers and use of a variety of habitats throughout their lifetimes, spot are an ecologically important species as both prey and predators. Spot may significantly reduce zooplankton biomass during their migration to the ocean. Juvenile and young spot eat benthic invertebrates. Adult spot are also benthic feeders, scooping up sediments and consuming large numbers of polychaetes, copepods, decapods, nematodes, and diatoms. Spot are important prey for fish such as spotted seatrout and striped bass and for birds such as cormorants. Spot make up a major portion of the fish biomass and numbers in estuarine waters of the Mid-Atlantic Region (Phillips et al., 1989).

Commercial landings of spot fluctuate widely because spot are a short-lived species (4 to 6 years) and most landings are composed of a single age class (ASMFC, 2008c). Commercial landings varied between 3.8 and 14.5 million lbs (1.7 and 6.6 million kg) between 1950 and 2005 (Austin et al., 2006). In addition, spot are a large component of the bycatch in other fisheries, including the south Atlantic shrimp trawl fishery (ASMFC, 2008c). Spot also are a very popular recreational species, with recreational landings sometimes surpassing commercial landings (Austin et al., 2006).

Atlantic Silverside

The Atlantic silverside inhabits salt marshes, estuaries, and tidal creeks along the Atlantic coast from Nova Scotia to Florida. It can be the most abundant fish in these habitats. Juveniles and adults inhabit intertidal creeks, marshes, and shore areas in bays and estuaries during spring, summer, and fall. During winter in the Mid-Atlantic Region, Atlantic silversides often migrate to deeper water within the bays or offshore (Fay et al., 1983a). Spawning occurs in the intertidal zones of estuaries between March and July in the Mid-Atlantic Region. Most Atlantic silversides die after their first spawning season, though they may spawn between 5 and 20 times in one season (NYNHP, 2009). Atlantic silverside spawning is a complex behavior in which fish swim parallel to the shore until the appropriate tidal level is reached, then the school rapidly turns shoreward to spawn in the shallows in areas where eggs may attach to vegetative substrates.

Eggs are demersal and adhesive, sticking to eel grass, cordgrass, and filamentous algae. Eggs hatch after 3 to 27 days, depending on temperature. The sex of an individual fish is determined by water temperature during the larval stage – colder temperatures produce more females and warmer temperatures produce more males. Larvae usually inhabit shallow, low salinity (8 to 9 ppt) water in estuaries and are most often found at the surface (Fay et al., 1989a). Eggs and larvae tolerate a wide degree of environmental conditions. Juveniles and adults appear to prefer temperatures between 64.4°F and 77°F (18°C and 25°C). The optimum salinity for hatching and early development is 30 ppt, but juveniles and adults tolerate a wide range of salinities (0 ppt to 38 ppt) (Fay et al., 1983a).

Ecologically, the Atlantic silverside is an important forage fish and plays a large role in the aquatic food web and in linking terrestrial production to aquatic systems. Due to their short life span and high winter mortality (up to 99 percent), they play a vital part in the export of nutrients to the near and offshore ecosystem. Little is known about the larval diet. Juvenile and adult fish are opportunistic omnivores and eat invertebrates, fish eggs, algae, and detritus. They feed in large schools over gravel and sand bars, open beaches, tidal creeks, river mouths, and tidally-flooded zones of marsh vegetation. They are prey for many species of commercially and recreationally important fish, crabs, and shorebirds (Fay et al., 1983a). There is no direct commercial or recreational fishery for this species, although many recreational fishers net these minnows for use as bait (Fay et al., 1983a).

Atlantic Croaker

The Atlantic croaker is a migratory species that appears to move inshore in the warmer months and southward in winter, although its movements have not been well defined (ASMFC, 2007b). It ranges from Cape Cod to Argentina and is uncommon north of New Jersey. Atlantic croaker are estuarine dependant at all life stages, especially as postlarvae and juveniles (Lassuy, 1983). Spawning occurs at 1 to 2 years of age in nearshore and offshore habitats between July and December (ASMFC, 2007b). Atlantic croaker can live for up to 12 years, and will spawn more than once in a season. Eggs are pelagic and are found in waters of varying salinities. Larvae have been found from the continental shelf to inner estuaries. Recruitment to the nursery habitats in the estuaries depends largely on currents and tides and appears to have seasonal peaks depending on latitude. Peak recruitment in the Delaware Estuary occurs in August through October. Ages at recruitment may vary from 2 months to 10 months. Larvae complete their development into juveniles in brackish, shallow habitats. Juveniles slowly migrate downstream, preferring stable salinity regimes in deeper water, and eventually enter the ocean in late fall as adults. They prefer mud bottoms with detritus and grass beds that provide a stable food source, but they are considered generalists (ASMFC, 2005b). Adult croaker are usually found in estuaries in spring and summer and offshore for the winter; their distribution is related to temperature and depth. They prefer muddy and sandy substrates that can support plant growth, but have also been found over oyster reefs. They are euryhaline, depending on the season, and are also sensitive to low oxygen levels. Atlantic croaker are bottom feeders that eat benthic invertebrates and fish. Larvae tend to consume large amounts of zooplankton, and juveniles feed on detritus (ASMFC, 2005b).

The Atlantic croaker is an important commercial and recreational fish on the Atlantic coast and the most abundant bottom-dwelling fish in this region. It has been harvested as part of a mixed stock fishery since the 1880s. Commercial landings appear to be cyclical, with catches ranging between 2 million lbs and 30 million lbs (0.9 million kg and 13.6 million kg). This may be due to variable annual recruitment, which appears to be dependent on natural environmental variables. Recreational landings have been increasing. The 2003 stock assessment determined that the Atlantic croaker was not overfished in the Mid-Atlantic Region (ASMFC, 2007b). A 2005 amendment to the management plan established fishing mortality and spawning stock biomass targets and thresholds for this species. There are no recreational or commercial management measures in this amendment, but some states have adopted internal management measures for the Atlantic croaker fishery (ASMFC, 2005b).

White Perch

The white perch is a member of the bass family that fills a vital trophic niche as both predator and prey to many species. It is a commercially and recreationally important species inhabiting coastal waters from Nova Scotia to South Carolina, with its highest abundance in New Jersey, Delaware, Maryland, and Virginia (Stanley and Danie, 1983). The white perch is a schooling fish that can grow up to 10 inches (25 cm) long in freshwater, 15 inches (38 cm) long in brackish water, and can live up to 10 years (PFBC, 2010; MDNR, 2008). It spawns in a wide variety of habitats, such as rivers, streams, estuaries, lakes, and marshes, usually in freshwater. Water speed and turbidity are not important in choosing a spawning location. Rising water temperature induces spawning in April through May in freshwater and in May through July in estuaries (Stanley and Danie, 1983). Marine and estuarine populations migrate to freshwater areas to spawn and, thus, are anadromous (PFBC, 2010). A single female spawns with several males. The eggs attach to the bottom immediately. Hatchlings remain in the spawning area for up to 13 days, then they drift downstream or with estuarine currents and become more demersal as they grow. Larvae can tolerate up to 5 ppt salinity, and adults can tolerate full seawater. Juveniles often inhabit upper estuarine nurseries, where they may stay for a year, preferring habitats with silt, mud, or plant substrates. Older juveniles move to offshore beach and shoal areas during the day, but return to the more protected nursery areas at night (Stanley and Danie, 1983).

Ecologically, the white perch plays several important roles in its lifecycle. It is omnivorous and will feed on both plankton and benthic species, but it concentrates on fish after it is fully grown. Freshwater populations feed on aquatic insects, crustaceans, fishes, and detritus (Stanley and Danie, 1983). Estuarine populations consume fish (such as alewife, gizzard shad, and smelt), fish eggs, and invertebrates (Stanley and Danie, 1983; PFBC, 2010). White perch provide food for Atlantic salmon, brook trout, chain pickerel, smallmouth bass, largemouth bass, and other piscivorous fish and terrestrial vertebrates (Stanley and Danie, 1983).

The largest commercial landings of white perch occurred at the turn of the 20th century. Catch levels then decreased, rising sporadically to reflect large year classes. White perch are a popular recreational fish in freshwater and estuaries. They are often the most abundant species caught recreationally in the northern Atlantic states (Stanley and Danie, 1983).

Striped Bass

Striped bass inhabit the Atlantic coast from the St. Lawrence River in Canada to northern Florida. They are highly abundant in both the Delaware Bay and Chesapeake Bay. Females can grow up to 65 lbs (29.4 kg) and live for 29 years, whereas males over 12 years old are uncommon (Fay et al., 1983b). Striped bass migrate along the coast seasonally and are anadromous, spawning in rivers and estuaries after reaching an age of 2 years (males) to 4 years (females) (ASMFC, 2008d). There are known riverine and estuarine spawning areas in the upper Delaware and Chesapeake bays. Spawning occurs in April through June in the Mid-Atlantic Region, with some of the most important spawning areas found in the upper Chesapeake Bay and the Chesapeake-Delaware Canal (Fay et al., 1983b). In the Delaware River, the main spawning grounds are located between Wilmington, DE, and Marcus Hook, PA (Delaware Division of Fish and Wildlife, 2010b). The eggs are pelagic and both eggs and larvae tend to remain in the spawning area throughout the early developmental stages. Most juveniles also remain in the estuaries where they were spawned until they reach adult size, tending to move downstream after the first year. On the Atlantic coast, some adults leave the estuaries and join seasonal migrations to the north in the warmer months, while others remain in the estuaries. Some of these adults will also migrate into coastal estuaries to overwinter. Reproduction is highly variable, with several poorly successful seasons between each strong year class. Variability in adult and juvenile behavior and the unpredictable importance of strong year classes makes management of the fishery challenging. There are four different stocks identified along the Atlantic coast, including the Roanoke River-Albemarle Sound, Chesapeake Bay, Delaware River, and Hudson River stocks (Fay et al., 1983b).

Striped bass are tolerant of a wide variety of environmental variables but require specific conditions for successful reproduction. Higher water flows and colder winters may produce successful year classes. Eggs tolerate temperatures of between 57.2°F and 73.4°F (14°C and 23 °C), salinities of 0 to 10 ppt, dissolved oxygen of 1.5 to 5.0 mg/L, turbidity of 0 to 500 mg/L, pH of 6.6 to 9.0, and a current velocity of 1.4 to 197 inches/sec (30.5 to 500 cm/sec). Larvae are slightly more tolerant of variables outside these ranges, and juveniles are even more tolerant (Fay et al., 1983b). Young and juveniles tend to inhabit sandy bottoms in shallow water, but can also inhabit areas over gravel, mud, and rock. Adults use a wide variety of bottom types, such as rock, gravel, sand, and submerged aquatic vegetation (ASMFC, 2010b). Larvae and juveniles consume invertebrates,fish eggs, and small fish. Young striped bass eat invertebrates and small fish. Adults are mainly piscivorous, consuming schooling bait fish as well as invertebrates (Fay et al., 1983b; DNREC, 2006b). Young striped bass provide food for weakfish, bluefish, white perch, and other large fishes; a variety of predators eat larvae and eggs. Adult striped bass probably compete with weakfish and bluefish, and juveniles are likely to compete with white perch in the nursery areas (Fay et al., 1983b). Striped bass do not feed while on spawning runs (DNREC, 2006b).

The striped bass is historically one of the most important fishery species along the Atlantic coast from Maine to North Carolina, with recreational landings exceeding commercial landings (ASMFC, 2003; 2008d). Its population has recovered since a sharp decline from its peak in the 1970s (ASMFC, 2008d). The 2007 stock assessment declared the fishery recovered, fully exploited, and not overfished. This recovery is considered one of the greatest successes in fisheries management (ASMFC, 2008d). The recovery of the striped bass fishery may be the cause of a decline in weakfish abundance (DNREC, 2006b).

Bluefish

The bluefish is a migratory schooling fish that inhabits estuaries and the oceans over the continental shelf in tropical and temperate waters globally. It occurs in the Atlantic from Nova Scotia to northern Mexico. Adults migrate north during summer between Cape Hatteras and New England and spend winter in the south near Florida in the Gulf Stream. Bluefish spawn in the open ocean (Pottern et al., 1989). There is a single spawning event that begins in the south in the late winter and continues northward into the summer as the fish migrate (ASMFC, 1998c). Eggs are pelagic and larvae drift with the offshore currents until coastal waters become warmer (Pottern et al., 1989; ASMFC, 1998c). Larvae transform to a pelagic juvenile stage in 18 to 25 days (NOAA, 2006). Spring-spawned juveniles then migrate into bays and estuaries at 1 to 2 months old, where they complete their development before joining the adult population in the fall (Pottern et al., 1989). Summer-spawned juveniles enter the estuaries for only a short time before migrating south for the winter (ASMFC, 1998c). Some juveniles will spend a second summer in the estuaries (Pottern et al., 1989). Bluefish can live for up to 12 years and reach lengths of 39 inches (91.4 cm) and weights of 31 lbs (14 kg) (ASMFC, 2006).

Due to its large size and numbers, the bluefish probably plays a large role in the community structure of forage species along the Atlantic coast. Larval bluefish consume large quantities of zooplankton, mostly copepods, in the open ocean (Pottern et al., 1989; NOAA, 2006). Juveniles in the estuaries eat small shrimp and fish. Adult bluefish are mostly piscivorous but also eat invertebrates. (Pottern et al., 1989). Bluefish are highly sensitive to temperature, preferring an optimum range of 64 °F to 68 °F (18 °C to 20 °C). Temperatures above or below this range can induce rapid swimming, loss of interest in food, loss of equilibrium, and changes in schooling and diurnal behaviors. They are found in estuaries at 10 ppt and waters of up to 38 ppt in the ocean (Pottern et al., 1989).

The bluefish has been a highly important recreational fish species since the 1800s. It is harvested for human consumption but there is no commercial bluefish industry. Slightly less than half the recreational catch is in inland bays and estuaries (Pottern et al., 1989). A bluefish management plan was developed in 1990 due to the continuous decline in landings since the early 1980s (ASMFC, 2006; 1998c). Recent numbers have been rising in response to the management plan amendment developed in 1998 (ASMFC, 2006).

Species with Essential Fish Habitat (EFH)

In addition to the 12 species monitored by PSEG and discussed above, there are 14 species that have designated EFH in the upper portion of the Delaware Estuary in the vicinity of Salem and HCGS. EFH is defined as “those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity” (16 U.S.C. 1802(10); 50 CFR 600.10). This definition includes all developmental stages of the particular fishes in question. Thus, EFH for a given species can vary by life stage.

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) was reauthorized in 1996 and amended to focus on the importance of habitat protection for healthy fisheries (16 USC 1801 et seq.). The MSA amendments, known as the Sustainable Fisheries Act, required the eight regional fishery management councils to describe and identify EFH in their regions, to identify actions to conserve and enhance their EFH, and to minimize the adverse effects of fishing on EFH. The act strengthened the authorities of the governing agencies to protect and conserve the habitats of marine, estuarine, and anadromous fish, crustaceans, and mollusks (NEFMC, 1999). EFH was defined by Congress as those waters and substrates necessary for spawning, breeding, feeding, or growth to maturity (MSA, 16 USC 1801 et seq.). The National Marine Fisheries Service (NMFS) designates EFH. The consultation requirements of Section 305(b) of the MSA provide that Federal agencies consult with NMFS on all actions or proposed actions authorized, funded, or undertaken by the agency that may adversely affect EFH.

EFH is an essential component in the development of Fishery Management Plans to assess the effects of habitat loss or degradation on fishery stocks and to take actions to mitigate such damage. Many managed species are mobile and migrate seasonally, so some species are managed coast-wide, others are managed by more than one fishery management council, and still others are managed for the entire coast by a single council. In Delaware Bay, various fisheries species are managed by the Atlantic States Marine Fisheries Commission (ASMFC), the New England Fisheries Management Council (NEMFC), the Mid-Atlantic Fishery Management Council (MAFMC), and the South Atlantic Fishery Management Council (SAFMC). Several species are regulated by the states of New Jersey and Delaware as well, in some cases with more rigid restrictions than those of the regional councils.

Salem and HCGS are located near the interface of the salinity zones classified by NMFS as tidal freshwater and mixing salinity zones. The area of the Delaware Estuary adjacent to Artificial Island is designated by NMFS as EFH for various life stages of several species of fish. The Staff considered all the designated EFH that could occur in the vicinity of Salem and HCGS based on geographic coordinates; some species and life stages with EFH requirements that are outside of the conditions that normally occur in the local area were eliminated from further consideration.

NMFS identifies EFH on their website for the overall Delaware Bay (NOAA, 2010e) and for smaller squares within the estuary defined by 10 minutes (') of latitude by 10' of longitude. NMFS provides tables of species and life stages that have designated EFH within the 10' by 10' squares. The 10' by 10' square that includes Salem and HCGS is defined by the following coordinates:

North: 39° 30.0'N South: 39° 20.0'N

East: 75° 30.0'W West: 75° 40.0'W

The following description of the general location and New Jersey shoreline within this square confirms that it includes Artificial Island and the Salem and HCGS facilities (NOAA, 2010e):

> Atlantic Ocean waters within the square within the Delaware River, within the mixing water salinity zone of the Delaware Bay affecting both the New Jersey and Delaware coasts. On the New Jersey side, these waters affect: from Hope Creek on the south, north past Stoney Point, and Salem Nuclear Power Plant on Artificial Island, to the tip of Artificial Island as well as affecting Baker Shoal.

NMFS identified 14 fish species with EFH in the Delaware Estuary in the vicinity of Salem and HCGS (NMFS, 2010a). These species and their life stages with EFH in this area are identified in Table 2-5. Some of the species were eliminated from further consideration due to salinity requirements of the species; the salinity requirements of these eliminated species and life stages are provided in Table 2-6. Salinities in the vicinity of Artificial Island are described above in Section 2.2.5.1 and summarized in Table 2-4. For each of these EFH species, the Staff compared the range of salinities in the vicinity of Salem and HCGS with the salinity requirements of the potentially affected life stages (Table 2-6). The salinity requirements of many of these EFH species and life stages were found to be higher than salinity ranges in the vicinity of Salem and HCGS or to overlap these salinity ranges only during periods of low flow (Table 2-6). This comparison allowed the list of species with EFH that potentially could be affected by Salem or HCGS to be further refined. If the salinity requirements of an EFH species life stage were not met in the vicinity of the Salem and HCGS facilities, the EFH for that species and life stage was eliminated from further consideration because its potential to be affected by the proposed action would be negligible. As a result, four species were identified that have potentially affected EFH for one or more life stages in the vicinity of Salem and HCGS (Table 2-7): winter flounder (Pleuronectes americanus), windowpane flounder (Scophthalmus aquosus), summer flounder (Paralichthys dentatus), and Atlantic butterfish (Peprilus triacanthus). Descriptions of these four species are included below.

Table 2-5. Designated Essential Fish Habitat by species and life stage in NMFS' 10 ' x 10 ' square of latitude and longitude in the Delaware Estuary that includes Salem Nuclear Generating Station and Hope Creek Generating Station

Scientific Name	Common Name	Eggs	Larvae	Juveniles	Adults
Urophycis chuss	Red hake				
Pleuronectes americanus	Winter flounder	X	X	X	X
Scophthalmus aquosus	Windowpane flounder	X	X	X	X
Pomotomus saltatrix	Bluefish			X	X
Paralichthys dentatus	Summer flounder			X	X
Peprilus triacanthus	Atlantic butterfish			X	
Stenotomus chrysops	Scup	n/a	n/a	X	
Centropristes striatus	Black sea bass	n/a		X	
Scomberomorus cavalla	King mackerel	X	X	X	X
Scomberomorus maculatus	Spanish mackerel	X	X	X	X
Rachycentron canadum	Cobia	X	X	X	X
Leucoraja eglantaria	Clearnose skate			X	X
Leucoraja erinacea	Little skate			X	X
Leucoraja ocellata	Winter skate			X	X

X indicates designated EFH within this area. Blank indicates no designated EFH in this area. n/a indicates that the species does not have this life stage or has no EFH designation for this life stage.

Sources: NOAA, 2010e; NOAA, 2010f

Table 2-6. Potential Essential Fish Habitat species eliminated from further consideration due to salinity requirements

Species, Life Stage	EFH Salinity Requirement (ppt) [a]	Site Salinity[e] Matches Requirement
Windowpane, juvenile	5.5-36	low flow only
Windowpane, adult	5.5-36	low flow only
Windowpane, spawner	5.5-36	low flow only
Bluefish, juvenile	23-36	no
Bluefish, adult	>25	no
Scup, juvenile	>15	no
Black sea bass, juvenile	>18	no
King mackerel	>30	no
Spanish mackerel	>30	no
Cobia	>25	no
Clearnose skate, juvenile	probably >22 [b]	no
Clearnose skate, adult	probably >22 [b]	no
Little skate, juvenile	mostly 25-30 [c]	no
Little skate, adult	probably >20 [c]	no
Winter skate, juvenile	probably >20 [d]	no
Winter skate, adult	probably >20[d]	no

(a) Salinity data from NOAA table "Summary of Essential Fish Habitat (EFH) and General Habitat Parameters for Federally Managed Species" unless otherwise noted.
(b) NOAA Technical Memorandum NMFS-NE-174 (NOAA, 2003a).
(c) NOAA Technical Memorandum NMFS-NE-175 (NOAA, 2003b).
(d) NOAA Technical Memorandum NMFS-NE-179 (NOAA, 2003c).
(e) Salinities in Delaware Estuary in vicinity of Salem/HCGS: high flow 0-5 ppt, low flow 5-12 ppt.

Table 2-7. Fish Species and Life Stages with Potentially Affected Essential Fish Habitat in the Vicinity of Salem Nuclear Generating Station and Hope Creek Generating Station

Species	Eggs	Larvae	Juveniles	Adults
Winter flounder	X	X	X	X
Windowpane flounder	X	X	X	X
Summer flounder			X	X
Atlantic butterfish			X	

Source: NRC, 2007

Winter Flounder

There are two major populations of winter flounder in the Atlantic: one inhabits estuarine and coastal waters from Newfoundland to Georgia, the other lives offshore on Georges Bank and Nantucket Shoal (Buckley, 1989). In the Mid-Atlantic, winter flounder are most common between the Gulf of Saint Lawrence and Chesapeake Bay (Grimes et al., 1989). In the Delaware Bay region, winter flounder spawn in coastal waters in February and March. Spawning occurs at depths of 7 to 260 ft (2 to 79 m) over sandy substrates in inshore coves and inlets at salinities of 31 to 32.5 ppt (Buckley, 1989; NOAA, 1999a). Sexual maturity is dependent on size rather than age, with southern individuals (age 2 or 3 years) reaching spawning size more rapidly than northern fish (age 6 or 7 years). The eggs are demersal, stick to the substrate, and are most often found at salinities between 10 and 30 ppt (Buckley, 1989). Larvae initially are planktonic but become increasingly benthic as they develop (NOAA, 1999a). Juveniles and adults are completely benthic, with juveniles preferring a sandy or silty substrate in estuarine areas (Buckley, 1989). Juveniles move seaward as they grow, remaining in estuaries for the first year (Buckley, 1989; Grimes et al., 1989). Water temperature appears to dictate adult movements; south of Cape Cod, winter flounder spend the colder months in inshore and estuarine waters and move farther offshore in the warmer months (Buckley, 1989). Winter flounder can live for up to 15 years and may reach 23 inches (58 cm) in length (NOAA, 1999a). Winter flounder tolerate salinities of 5 to 35 ppt and prefer waters temperatures of 32 °F to 77 °F (0 °C to 25 °C). Higher temperatures for extended periods can cause mortality (Buckley, 1989).

Winter flounder larvae feed on small invertebrates, invertebrate eggs, and phytoplankton (Buckley, 1989; NOAA, 1999a). Adults feed on benthic invertebrates such as polychaetes, cnidarians, mollusks, and hydrozoans. Adults and juveniles are an important food source for predatory fish such as the striped bass (Morone saxatilis), bluefish (Pomatomus saltatrix), goosefish (Lophius americanus), spiny dogfish (Squalus acanthias), and other flounders, and birds such as the great cormorant (Phalacrocorax carbo), great blue heron (Ardea herodias), and osprey (Pandion haliaetus) (Buckley, 1989).

Winter flounder are highly abundant in estuarine and coastal waters and, therefore, are one of the most important species of the commercial and recreational fisheries on the Atlantic coast (Buckley, 1989). The NEFMC and ASMFC manage the winter flounder fishery as part of the groundfish fishery, which comprises 15 demersal species (NEFMC, 2010). Winter flounder also are very popular recreational fish, with the recreational catch sometimes exceeding the commercial catch (Buckley, 1989). Biomass in the New England Mid-Atlantic winter flounder stock declined from 1981 to 1992, and the fishery was declared overexploited. As of 1999, biomass remains significantly lower than prior to overexploitation (NOAA, 1999a). As part of the management program, EFH has been established for the winter flounder along the Atlantic coast. The Delaware Bay's mixing and saline waters are EFH for all parts of the winter flounder lifecycle, including eggs, larvae, juveniles, adults, and spawning adults (NEFMC, 1998a).

Windowpane Flounder

Windowpane flounder inhabit estuaries, coastal waters, and oceans over the continental shelf along the Atlantic coast from the Gulf of Saint Lawrence to Florida. They are most abundant in bays and estuaries south of Cape Cod in shallow waters, over sand, sand and silt, or mud substrates (NOAA, 1999b). They spawn from April to December, and in the Mid-Atlantic Region spawning peaks in May and September (NOAA, 1999b; Morse and Able, 1995). The eggs are pelagic and buoyant and hatch in approximately 8 days. Larvae begin life as plankton, but soon settle to the bottom (at 0.39 to 0.78 inches [10 to 20 mm] in length) and become demersal. This settling occurs in estuaries and over the continental shelf for spring-spawned fish, which inhabit the polyhaline portions of the estuary throughout the summer. Fall-spawned fish settle mostly on the shelf. Juveniles migrate to coastal waters from the estuaries as they grow larger during autumn, and they overwinter in deeper waters. Adults remain offshore throughout the year and are highly abundant off southern New Jersey. Sexual maturity is reached between 3 and 4 years of age, and length generally does not exceed 18 inches (46 cm) (NOAA, 1999b).

Juvenile and adult windowpane flounder have similar food sources, including small crustaceans and fish larvae (NOAA, 1999b). Adult windowpane tolerate a wide range of temperatures and salinities, from 23 °F to 80.2 °F (0 °C to 26.8 °C), and 5.5 ppt to 36 ppt. Adults and juveniles are abundant in the mixing and saline zones of Delaware Bay (NOAA, 1999b), and these zones as well as the inland bays are EFH for all life stages of the windowpane flounder, including eggs, larvae, juveniles, adults, and spawning adults (NEFMC, 1998b). The windowpane flounder is managed by the NEFMC under the multispecies groundfish plan (NEFMC, 2010). The fishery does not directly target windowpane, but groundfish trawls take them as bycatch (NOAA, 1999b; Morse and Able, 1995).

<u>Summer Flounder</u>

The summer flounder is a demersal fish inhabiting coastal waters over sandy substrates from Nova Scotia to Florida, but it is most abundant between Cape Cod and Cape Fear (ASMFC, 2008e). It lives in bays and estuaries in spring, summer, and autumn, and migrates offshore for the winter (NEFSC, 2006a). Migrating adults tend to return to the same bay or estuary every year (NOAA, 1999c). Spawning occurs in autumn and early winter as the fish are migrating over the continental shelf (NEFSC, 2006a; NOAA, 1999c). Eggs are pelagic and buoyant, as are the early stages of larvae (NOAA, 1999c). Larvae move inshore between October and May, where they develop in estuaries and bays (NEFSC, 2006a; ASMFC, 2008e). Larvae become demersal as soon as the right eye migrates to the top of the head, then they bury themselves in the substrate while they are in the inshore nursery areas. Within the estuaries, marsh creeks, seagrass beds, mud flats, and open bay areas are important habitats for juveniles. Some juveniles stay in the estuary habitat until their second year, while others migrate offshore for the winter. Juveniles inhabit the deeper parts of the Delaware Bay throughout the winter (NOAA, 1999c). Sexual maturity is reached by age 2 years, females may live up to 20 years and reach 26 lbs (12 kg) in weight, but males generally live for only 10 years (NEFSC, 2006a).

Tidal movements of juveniles may be due to the desire to stay within a desired set of environmental variables, including temperature, salinity, and dissolved oxygen. Larvae and juveniles live in waters with temperatures between 32 and 73 °F (0 and 23 °C) and usually inhabit the higher-salinity portions of estuaries. Newly recruited juveniles live over a variety of substrates, including mud, sand, shell hash, eelgrass beds, and oyster bars, but as they grow, they are more often over sand. Larvae feed on invertebrates and small fish, with benthic prey items becoming increasingly important with age. Adult summer flounder most often live over substrates of sand, coarse sand, or shell fragments and may occur in marsh creeks and seagrass beds. Their diet consists of varioius invertebrates and fish. Large predators, such as sharks, rays, and goosefish, consume adult summer flounder (NOAA, 1999c).

The summer flounder is a highly important commercial and recreational species along the Atlantic coast. Both the ASMFC and the MAFMC manage the fishery under the summer flounder, scup, and black sea bass fishery management plan. The recreational harvest makes up a sizeable portion of the total and is occasionally larger than the commercial harvest. In 1999, the summer flounder stock was considered overexploited, but as of 2005, the stock was considered not overfished (NOAA, 1999c; NEFSC, 2006a). In 2009, the ASMFC increased total allowable landings. Although the stock is currently considered not overfished, it has not reached rebuilt status (ASMFC, 2008e).

The Delaware Bay is important as a habitat for adults and as a nursery for juveniles, and NMFS has designated EFH for summer flounder larvae, juveniles, and adults in the Delaware Bay (NOAA, 2010g). Summer flounder adults and juveniles are present in the Delaware Bay in salinity zones of 0.5 ppt to above 25 ppt (CCMA, 2005), which includes the vicinity of Salem and HCGS.

<u>Atlantic Butterfish</u>

The Atlantic butterfish is a pelagic schooling fish that is ecologically important as a forage fish for many larger fishes, marine mammals, and birds. Its range includes the Atlantic coast from Newfoundland to Florida, but it is most abundant from the Gulf of Maine to Cape Hatteras (NEFSC, 2006b; NOAA, 1999d). Butterfish migrate seasonally in response to changes in water temperature. During 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). Butterfish inhabit bays, estuaries, and coastal waters up to 200 mi (322 km) offshore during the summer. Butterfish spawn offshore and in large bays and estuaries from June through August. They are broadcast spawners that spawn at night in the upper part of the water column in water of 15°C (59°F) or more. Eggs are pelagic and buoyant (NOAA, 1999d). Butterfish eggs and larvae are found in water with depths ranging from the shore to 6,000 ft (1828 m) and temperatures between 9°C (48°F) and 19°C (66°F). Juvenile and adult butterfish are found in waters from 33 to 1,200 ft (10 to 366 m) deep and at temperatures ranging from 3°C (37°F) to 28°C (82°F) (NMFS 2010b). Butterfish reach sexual maturity by age 1, rarely live more than 3 years, and normally reach a weight of up to 1.1 lbs (0.5 kg) (NEFSC, 2006b). Adult butterfish prey on small fish, squid, crustaceans, and other invertebrates and in turn are preyed upon by many species of fish and squid. In summer, butterfish can be found over the entire continental shelf, including sheltered bays and estuaries, to a depth of 656 ft (200 m) over substrates of sand, rock, or mud (Cross et al., 1999).

The Atlantic butterfish is an important commercial fish species that is also bycatch in other fisheries (NEFSC, 2004; 2006b). The fishery has been in operation since the late 1800s (NOAA, 1999d). U.S. commercial landings peaked in 1984 and a record low catch occurred in 2005 (NEFSC, 2006b). The MAFMC manages the Atlantic butterfish under the Atlantic mackerel, squid, and butterfish fishery management plan (NEFSC, 2006b). Due to a lack of data, it has not been established if overfishing is currently occurring, but during the last stock assessment in 1993, it was established that biomass was at medium levels, the catch was not excessive, and recruitment was high (NEFSC, 2004). EFH for Atlantic butterfish juveniles may exist in the vicinity of Salem and HCGS. Inshore EFH for the butterfish includes the mixing or saline zones of estuaries where butterfish eggs, larvae, juveniles, and adults are common or abundant on the Atlantic coast, from Passamaquoddy Bay in Maine to the James River in Virginia (NMFS 2010b).

2.2.6 Terrestrial Resources

This section describes the terrestrial resources in the immediate vicinity of the Salem and HCGS facilities on Artificial Island and within the transmission line ROWs connecting these facilities to the regional power grid. For this assessment, terrestrial resources were considered to include plants and animals of uplands as well as wetlands of Artificial Island and bodies of freshwater located on Artificial Island or the ROWs.

2.2.6.1 Artificial Island

The project site is within the Middle Atlantic coastal plain of the eastern temperate forest ecoregion. This ecoregion, which runs along the eastern seaboard from Delaware to the South Carolina/Georgia border, is characterized by low, flat plains with many marshes, swamps, and estuaries (EPA, 2007). As discussed in Section 2.2.1, Land Use, Artificial Island, on which the Salem and HCGS facilities are situated, is a man-made island approximately 3 mi (4.8 km) long and 5 mi (8 km) wide that was created by the deposition of dredge spoil material atop a natural sandbar. All terrestrial resources on the island have become established since creation of the island approximately 100 years ago. Consequently, Artificial Island contains poor quality soils and very few trees. Approximately 65 percent of the island is undeveloped and dominated by tidal marsh, which extends from the higher areas along the river eastward to the marshes of the former natural shoreline adjacent to the eastern boundary of Artificial Island. Terrestrial, non-wetland habitats of the island, which are limited and occur primarily on the periphery of the developed portions of PSEG property, consist principally of areas covered by grasses and other herbs with scrub/shrubs and planted trees. Almost all of the undeveloped portions of the island consist of estuarine emergent wetlands (tidal), with scattered occurrences of freshwater wetlands. Small, isolated, freshwater impoundments are also present, particularly along the northwest shoreline.

The Salem and HCGS facilities were constructed on adjacent portions of the PSEG property, which occupies the southwest corner of Artificial Island. The PSEG property is low and flat with elevations rising to about 18 ft (5.5 m) above the level of the river at the highest point. Developed areas covered by facilities and pavement occupy over 70 percent of the 740 ac (300 ha) PSEG site (approximately 525 ac [212 ha]). Maintained areas of grass, including two baseball fields, cover about 12 ac (5 ha) of the site interior. The remaining 27 percent of the

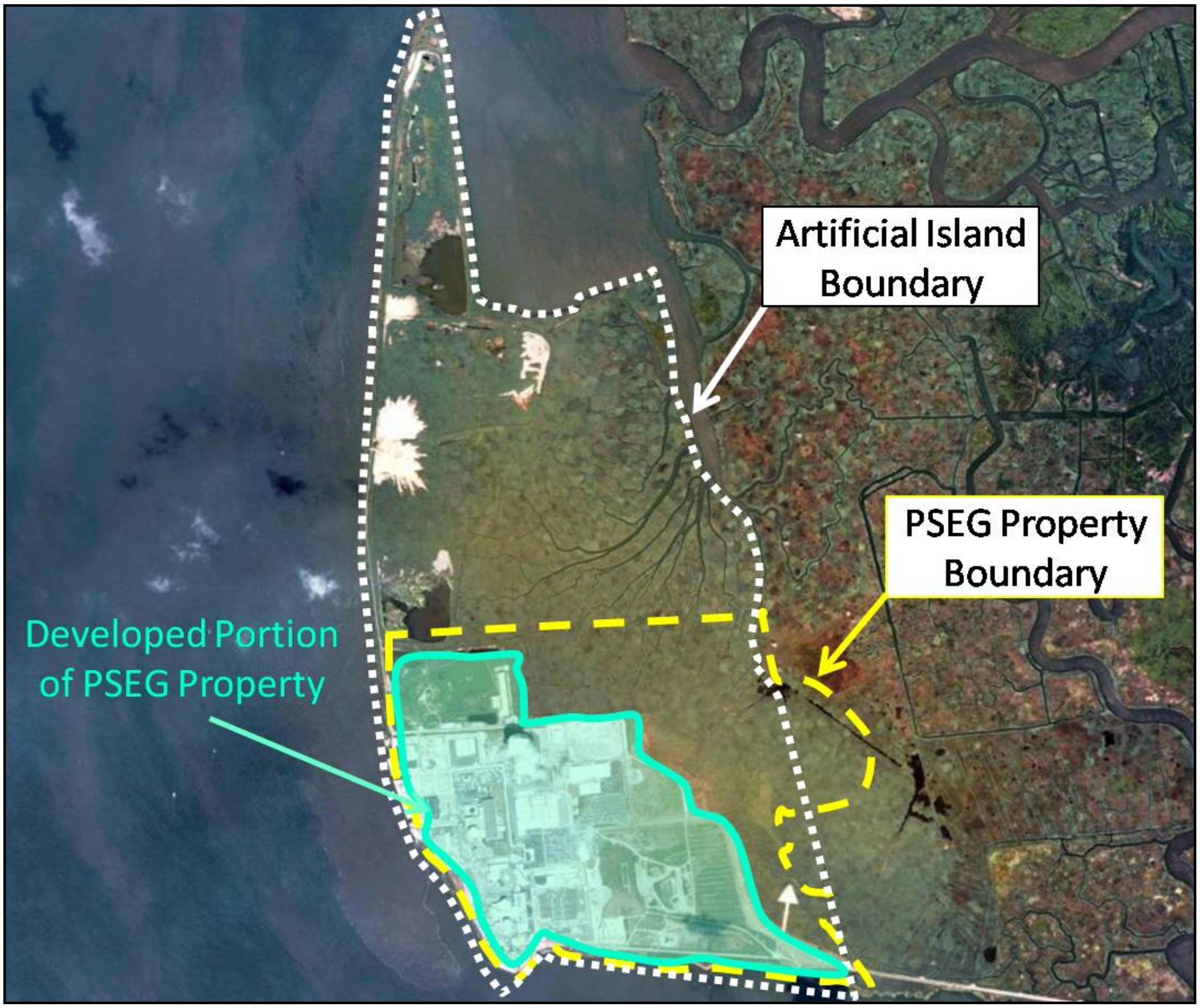
1


Figure 2-11. Aerial Photo Showing the Boundaries of Artificial Island (dotted), PSEG Property (dashed), and Developed Areas (solid).

PSEG property (approximately 200 ac [81 ha]) consists primarily of tidal marsh dominated by the common reed (*Phragmites australis*) and several cordgrass species (*Spartina* spp.) (PSEG, 2009b).

The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) classifies all land on the project site as Urban, while the soils on the remainder of Artificial Island are Udorthents consisting of dredged fine material (NRCS, 2010). The National Wetlands Inventory (NWI) identifies a non-tidal inland marsh/swamp area on the periphery of the project site adjacent to Hope Creek Road and two small, man-made freshwater ponds immediately north of the Hope Creek reactor. NWI classifies the rest of Artificial Island as estuarine emergent marsh, with the exception of the northernmost 1 mi (1.6 km) of the island, which is contains freshwater emergent wetlands and freshwater ponds (FWS, 2010c).

The tidal marsh vegetation of the site periphery and adjacent areas is dominated by common reed, but other plants present include big cordgrass (*Spartina cynosuroides*), salt marsh cordgrass (*S. alterniflora*), saltmeadow cordgrass (*S. patens*), and saltmarsh bulrush (*Scirpus robustus*) (PSEG, 2009b). Fragments of this marsh community exist along the eastern edge of the PSEG property. The non-estuarine vegetation on the undeveloped areas within the facilities consists mainly of small areas of turf grasses and planted shrubs and trees around buildings, parking lots, and roads.

Tidal marshes in this region are commonly used by many migrant and resident birds because they provide habitat for breeding, foraging, and resting (PSEG, 2004b). A total of 44 avian species, including many shorebirds, wading birds, and waterfowl associated with open water and emergent marsh areas of the estuary were observed within a 4-mi (6-km) radius of the Salem site during preconstruction surveys conducted in 1972 (AEC, 1973). Several avian species were observed on the project site, itself, including the red-winged blackbird (*Agelaius phoeniceus*), common grackle (*Quiscalus quiscula*), northern harrier (*Circus cyaneus*), song sparrow (*Melospiza melodia*), and yellowthroat (*Geothlypis trichas*) (AEC, 1973). HCGS construction studies reported the occurrence of 178 bird species within 10 mi (16 km) of the project site, approximately half of which were recorded within tidal marsh and the open water of the Delaware River and roughly 45 of the 178 total observed species were classified as permanent resident species (PSEG, 1983). Osprey (*Pandion haliaetus*) have used Artificial Island transmission line towers and other suitable high perches on and near the site since the construction of the plants (PSEG, 1983; NRC, 1984; NJDFW, 2009b). Resident songbirds, such as the marsh wren (*Cistothorus palustris*), and migratory songbirds, such as the swamp sparrow (*Melospiza georgiana*), use the nearby Alloway Creek Estuary Enhancement Program restoration site for breeding (PSEG, 2004b).

Mammals such as the eastern cottontail (*Sylvilagus floridanus*), the Norway rat (*Rattus norvegicus*), the house mouse (*Mus musculus*), and raccoon (*Procyon lotor*) were observed on and in the vicinity of the Salem and HCGS sites during preconstruction surveys (AEC, 1973). Other mammals likely to occur in the vicinity of the two facilities include the white-tailed deer (*Odocoileus virginianus*), eastern gray squirrel (Sciurus carolinensis), red fox (Vulpes fulva), gray fox (Urocyon cinereoargenteus), muskrat (*Ondatra zibethica*), opossum (*Didelphis marsupialis*), and striped skunk (*Mephitis mephitis*).

Twenty-six reptile species were observed during HCGS preconstruction surveys PSEG, 1983). Three species, the snapping turtle (*Chelydra serpentina*), northern water snake (*Natrix sipedon*), and eastern mud turtle (*Kinosternon subrubrum*), prefer freshwater habitats but also occur in brackish marsh. The northern diamondback terrapin (*Malaclemys terrapin*), inhabits saltwater and brackish habitats and occurs in tidal marsh adjacent to the project site. Other common reptiles likely to inhabit the area include the spotted turtle (Clemmys guttata), eastern box turtle (Terrapene carolina), eastern painted turtle (Chrysemys picta), and eastern garter snake (Thamnophis sirtalis) (PSEG, 1983). Amphibians likely to occur in the upland and/or freshwater wetland habitats of the island include the New Jersey chorus frog (*Pseudoacris triseriata kalmi*), southern leopard frog (*Rana utricularia*), and Fowler's toad (*Bufo woodhousii fowleri*) (NJDEP, 2001b).

Two Wildlife Management Areas (WMAs) managed by the New Jersey Division of Fish and Wildlife are located near Salem and HCGS:

- Abbotts Meadow WMA encompasses approximately 1,000 ac (405 ha) and is about 4 mi (6.4 km) northeast of HCGS.
- Mad Horse Creek State WMA encompasses roughly 9,500 acres (3,844 ha), of which the northernmost portion is less than 1 mi (1.6 km) northeast of the PSEG property boundary. The southern portion of this WMA includes Stowe Creek, which is designated as an Important Bird Area (IBA) in New Jersey. Stowe Creek IBA provides breeding habitat for several pairs of bald eagles (*Haliaeetus leucocephalus*), which are State-listed as endangered, and the adjacent tidal wetlands support large populations of the northern harrier (Circus cyaneus), which also is State-listed as endangered, as well as many other birds dependent on salt marsh/wetland habitats (NAS, 2010).

Alloway Creek Wetland Restoration Site is a restoration area less than 3 mi (5 km) northeast of HCGS and Salem that is owned and maintained by PSEG. Over 1,600 ac (647 ha) of wetlands and uplands of the 3,096 ac (1,253 ha) Alloway Creek Wetland Restoration Site were restored by PSEG between 1996 and 1999 to increase fish habitat and reduce invasive species, such as *Phragmites australis* from spreading (PSEG 2009c). The site includes two nature trails, several observation platforms, a boardwalk to the beach, and a wildlife viewing blind.

The Supawna Meadows National Wildlife Refuge (NWR), part of the Cape May NWR Complex, is located approximately 7 mi (11 km) north of the HCGS and Salem sites and, like Artificial Island, consists primarily of brackish tidal marshes (FWS, 2010d). Supawna Meadows NWR is adjacent to the Delaware River and estuary and is recognized as a wetland of international importance and an international shorebird reserve that provides important feeding and resting grounds for migratory shorebirds and waterfowl (FWS, 2010d). Black ducks (Anas rubripes), mallards (Anas platyrhynchos), and northern pintails (Anas acuta) winter in the refuge, and sandpipers (Actitis hypoleucos) and other shorebirds use the marshes and beaches as a feeding area during summer months (FWS, 2010d).

2.2.6.2 Transmission Line Right-of-Ways

Section 2.2.1 describes the existing power transmission system that distributes electricity from Salem and HCGS to the regional power grid. There are four 500-kV transmission lines within three ROWs that extend beyond the PSEG property on Artificial Island. Two ROWs extend northeast approximately 40 mi (64 km) to the New Freedom substation south of Philadelphia.

The other ROW extends north then west approximately 25 mi (40 km), crossing the Delaware River to end at the Keeney substation in Delaware (Figure 2-8).

In total, the three ROWs for the Salem and HCGS power transmission system occupy approximately 4,376 ac (1,771 ha) and pass through a variety of habitat types, including marshes and other wetlands, agricultural or forested land, and some urban and residential areas (PSEG, 2009a). The major land cover types crossed by these ROWs are cultivated land (23 percent), palustrine forested wetland (19 percent), deciduous forest (13 percent), scrub/shrub (12 percent), and estuarine emergent wetland (11 percent). Other types, such as pasture/hay, urban/developed, and water, collectively cover less than 22 percent of the land crossed by these ROWs (PSEG 2010). As the three ROWs exit the PSEG property, they cross estuarine tidal marsh to the east and north of Artificial Island.

The initial segments of the New Freedom North and New Freedom South ROWs traverse approximately 3 mi (5 km) of estuarine emergent marsh east of the PSEG property boundary. This tidal marsh is part of the northern portion of the Mad Horse Creek State WMA. The middle segments of the New Freedom North and New Freedom South ROWs, extend a distance of approximately 30 mi (48 km) and cross a mixture of mainly agricultural and forested lands.

The Keeney ROW turns north after exiting HCGS and traverses approximately 5 mi (8 km) of emergent marsh and swamp paralleling the New Jersey shore of the Delaware Estuary before crossing 8 mi (13 km) of agricultural, sparsely forested, and rural residential lands. The Keeney ROW then continues west across the Delaware River approximately 3 mi (5 km) to the Red Lion substation. From the substation, the Red Lion-Keeney portion of the line within the Keeney ROW remains exclusively within Delaware and crosses primarily highly developed, residential land.

Animals likely to occur within the Salem and HCGS transmission line ROWs are similar to those described in Section 2.2.6.1 as occurring on the Salem and HCGS sites. Generally, species that prefer open fields, agricultural areas, marshes, and forest edges are the most likely to inhabit transmission line ROWs.

Before their termination at the New Freedom substation, the New Freedom ROWs traverse the New Jersey Pinelands National Reserve (PNR) for the last one-quarter of their length (NPS, 2006a). The New Freedom North and New Freedom South ROWs cross a total of approximately 10 mi (16 km) and 17 mi (27 km) of the PNR, respectively. The PNR contains the New Jersey Pinelands, also known as the Pine Barrens, which is a heavily forested area of the southern New Jersey Coastal Plain that supports a unique and diverse assemblage of unusual species, including orchids and carnivorous plants; low, dense forests of oak and pine; a 12-ac (5-ha) stand of pygmy pitch pines; and scattered bogs and marshes (NJPC, 2010). The United Nations Educational, Scientific, and Cultural Organization (UNESCO) designated the Pinelands a U.S. Biosphere Reserve in 1988. Biosphere Reserves are areas of terrestrial and coastal ecosystems with three complementary roles: conservation; sustainable development; and logistical support for research, monitoring, and education (UNESCO, 2010). The PNR's future development is guided by the Pinelands Comprehensive Management Plan, which is implemented by the New Jersey Pinelands Commission.

The two New Freedom ROWs also cross the Great Egg Harbor River, a designated National Scenic and Recreational River located within the PNR. This 129-mi (208-km) river system (including 17 tributaries) starts in suburban towns near Berlin, NJ and meanders southeast for approximately 60 mi (97 km) and gradually widens as tributaries enter, until it terminates at the Atlantic Ocean.

PSEG vegetation management practices provide guidance to ensure that all vegetation under HCGS and Salem transmission lines is regularly inspected and maintained to avoid vegetation-caused outages to transmission systems in accordance with regulations of the New Jersey Board of Public Utilities (NJ-BPU, 2009) and standards of the North American Electric Reliability Council (NERC, 2006). If removal of woody vegetation is necessary within ROWs, PSEG coordinates its removal with the New Jersey BPU. In addition, PSEG follows protocol to prevent impacts to wetlands and threatened and endangered species as outlined in their vegetative management guidelines (PSEG, 2010c). As part of their protective measures, PSEG conducts annual surveys for threatened and endangered species in its ROWs (PSEG, 2010c).

The New Jersey Pinelands Commission regulates the maintenance of the ROW portions within the PNR. The commission's Comprehensive Management Plan directs the creation and maintenance of early successional habitats within ROWs that represent characteristic Pinelands communities (Lathrop and Bunnell, 2009).

2.2.7 Threatened and Endangered Species

This discussion of threatened and endangered species is organized based on the principal ecosystems in which such species may occur in the vicinity of the Salem and HCGS facilities and the associated transmission line ROWs. Thus, Section 2.2.7.1 discusses aquatic species that may occur in adjacent areas of the Delaware Estuary, and Section 2.2.7.2 discusses terrestrial species that may occur on Artificial Island or the three ROWs, as well as freshwater aquatic species that may occur in the relatively small streams and wetlands within these terrestrial areas.

2.2.7.1 Aquatic Species of the Delaware Estuary

There are five aquatic species with a Federal listing status of threatened or endangered that have the potential to occur in the Delaware Estuary in the vicinity of the Salem and HCGS facilities. These species include four sea turtles and one fish (Table 2-8). In addition, there is one fish species that is a Federal candidate for listing (NMFS, 2010b; FWS, 2010a). These six species also have a State listing status of threatened or endangered in New Jersey and/or Delaware (DNREC, 2008).These species are discussed below.

Table 2-8. Threatened and Endangered Aquatic Species of the Delaware Estuary

Scientific Name	Common Name	Status[(a)]		
		Federal	New Jersey	Delaware
Reptiles				
Caretta caretta	Loggerhead sea turtle	T	E	E
Chelonia mydas	Green sea turtle	T	T	E
Lepidochelys kempii	Kemp's ridley sea turtle	E	E	E
Dermochelys coriacea	Leatherback sea turtle	E	E	E
Fish				

Scientific Name	Common Name	Status(a)		
		Federal	New Jersey	Delaware
Acipenser brevirostrum	Shortnose sturgeon	E	E	-
A. oxyrinchus oxyrinchus	Atlantic sturgeon	C	-	E

(a) E = Endangered; T = Threatened; C = Candidate

Loggerhead, Green, Kemp's Ridley, and Leatherback Sea Turtles

The four species of sea turtles identified by NMFS as potentially occurring in the Delaware Estuary are the threatened loggerhead (*Caretta caretta*) and green (*Chelonia mydas*) and the endangered Kemp's ridley (*Lepidochelys kempii*) and leatherback (*Dermochelys coriacea*). Kemp's ridley, loggerhead, and green sea turtles have been documented in the Delaware Estuary at or near the Salem and HCGS facilities; the leatherback sea turtle is less likely to occur in the vicinity (NMFS, 2010b).

Kemp's ridley, loggerhead, and green sea turtles have a similar appearance, though they differ in maximum size and coloration. The Kemp's ridley is the smallest species of sea turtle; adults average approximately 100 pounds (lbs; 45 kilograms [kg]) with a carapace length of 24 to 28 inches (61 to 71 centimeters [cm]) and a shell color that varies from gray in young individuals to olive green in adults. The loggerhead is the next largest of these three species; adults average about 250 lbs (113 kg) with a carapace length of 36 inches (91 cm) and a reddish brown shell color. The green is the largest of the three; adults average 300 to 350 lbs (136 to 159 kg) with a length of more than 3 ft (1 m) and brown coloration (its name comes from its greenish colored fat). The leatherback is the largest species of sea turtle and the largest living reptile; adults can weigh up to about 2,000 lbs (907 kg) with a length of 6.5 ft (2 m). The leatherback is the only sea turtle that lacks a hard, bony shell. Instead, its carapace is approximately 1.5 inches (4 cm) thick with seven longitudinal ridges and consists of loosely connected dermal bones covered by leathery connective tissue (NMFS, 2010c).

The Kemp's ridley has a carnivorous diet that includes fish, jellyfish, and mollusks. The loggerhead has an omnivorous diet that includes fish, jellyfish, mollusks, crustaceans, and aquatic plants. The green has a herbivorous diet of aquatic plants, mainly seagrasses and algae, that is unique among sea turtles. The leatherback has a carnivorous diet of soft-bodied, pelagic prey such as jellyfish and salps. All four of these sea turtle species nest on sandy beaches; none nest on the Delaware Estuary (NMFS, 2010c).

Major threats to these sea turtles include the destruction of beach nesting habitats and incidental mortality from commercial fishing activities. Sea turtles are killed by many fishing methods, including longline, bottom, and mid-water trawling; dredges; gillnets; and pots/traps. The required use of turtle exclusion devices has reduced bycatch mortality. Additional sources of mortality due to human activities include boat strikes and entanglement in marine debris (NMFS and FWS, 2007a; 2007b; 2007c; NOAA, 2010i).

Shortnose Sturgeon

The shortnose sturgeon *(Acipenser brevirostrum)* is a primitive fish, similar in appearance to other sturgeon (NOAA, 2010j), and has not evolved significantly for the past 120 million years (NEFSC, 2006). This species was not specifically targeted as a commercial fishery species, but has been taken as bycatch in the Atlantic sturgeon (*A.oxyrinchus oxyrinchus*) and shad fisheries. As they were not easily distinguished from Atlantic sturgeon, early data is unavailable for this species (NMFS, 1998). Furthermore, since the 1950s, when the Atlantic sturgeon fishery declined, shortnose sturgeon data has been almost completely lacking. Due to this lack of data, the U.S. Fish and Wildlife Service (FWS) believed that the species had been extirpated from most of its range; reasons noted for the decline included pollution and overfishing. Later research indicated that the construction of dams and industrial growth along the larger rivers on the Atlantic coast in the late 1800s also contributed to their decline due to loss of habitat.

Shortnose sturgeon can live from 30 years (males) to 67 years (females), grow up to 4.7 ft (143 cm) long, and reach a weight of 51 lbs (23 kg). Age at sexual maturity varies within their range from north to south, with individuals in the Delaware Bay area reaching maturity at 3 to 5 years for males and approximately 6 years for females (NOAA, 2010j). Shortnose sturgeon are demersal and feed predominantly on benthic invertebrates (NMFS, 1998).

The shortnose sturgeon is found along the Atlantic coast from Canada to Florida in habitats that include fast-flowing rivers, estuaries, and, in some locations, offshore marine areas over the continental slope. They are anadromous, spawning in coastal rivers and later migrating into estuaries and nearshore environments during non-spawning periods. They do not appear to make long-distance offshore migrations like other anadromous fishes (NOAA, 2010j). Migration into freshwater to spawn occurs between late winter and early summer, depending on latitude (NEFSC, 2006). Spawning occurs in deep, rapidly flowing water over gravel, rubble, or boulder substrates, to which the demersal eggs adhere before hatching in 9 to 12 days (NMFS, 1998). Juveniles remain in freshwater or the fresher areas of estuaries for 3 to 5 years, then they move to more saline areas, including nearshore ocean waters (NEFSC, 2006). In the Delaware Bay drainage, shortnose sturgeon most often occur in the Delaware River and may be found occasionally in the nearshore ocean, but little is known of the distribution of juveniles in the Delaware Estuary. Their abundance is greatest in the river between Trenton, New Jersey, and Philadelphia, Pennsylvania. Adults overwinter in large groups between Trenton and Bordentown, New Jersey (USACE, 2009).

NMFS began a status review of the shortnose sturgeon in 2007 (NMFS, 2008) which is ongoing. Due to its distinct population segments, the status of the species varies depending on the river in question. NMFS (2008) estimated the size of the population in the Delaware River system as 12,047 adults based on surveys from 1999 through 2003. Current threats to the shortnose sturgeon vary among rivers. Generally, over the entire range, most threats include dams, pollution, and general industrial growth. Drought and climate change could aggravate the existing threats due to lowered water levels, which can reduce access to spawning areas, increase thermal injury, and concentrate pollutants. Additional threats include discharges, dredging or disposal of material into rivers, development activities involving estuaries or riverine mudflats and marshes, and mortality due to bycatch in the shad gillnet fishery. NMFS (2008) determined that the Delaware River population is most threatened by dredging operations and water quality issues.

Atlantic Sturgeon

Atlantic sturgeon supported a large commercial fishery by 1870, but the fishery crashed in approximately 100 years due to overfishing. The effects of overfishing were exacerbated by the fact that this species takes a very long time to reach sexual maturity. The ASMFC adopted a Fishery Management Plan in 1990 that implemented harvest quotas. The current status of the

Atlantic sturgeon stock is unknown due to little reliable data. In 1998, a coastwide stock assessment by ASMFC determined that biomass was much lower than it had been in the early 1900s (ASMFC, 2009c). This assessment resulted in an amendment to the Fishery Management Plan that instituted a coastwide moratorium on Atlantic sturgeon harvest that will remain in place until 2038 in an effort to accumulate 20 years worth of breeding stock. The Federal government similarly enacted a moratorium in 1999 prohibiting harvest in the exclusive economic zone offshore (ASMFC, 2009c). Concurrent with the coastwide stock assessment, NMFS decided that listing the Atlantic sturgeon as threatened or endangered was not warranted (ASMFC, 2009c).

NMFS initiated a second status review in 2005 and concluded that the stock should be broken into five distinct population segments: Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic stocks (ASMFC, 2009c). The Delaware River and Estuary are in the New York Bight segment. NMFS determined that three of these distinct population segments are likely (>50 percent chance) to become endangered in the next 20 years (New York Bight, Chesapeake Bay, and Carolina), and these three were recommended by NMFS for listing as threatened under the ESA. The other two population segments were determined by NMFS to have a moderate (<50 percent) chance of becoming endangered in the next 20 years and were not recommended for listing (ASMFC, 2009c; Greene et al., 2009). In October 2009, the Natural Resources Defense Council submitted a petition under the ESA to list the Atlantic sturgeon. NMFS announced in January 2010 that it agreed listing may be warranted and decided to request public comment to update the 2007 species status review before beginning a 12-month finding and determination on whether to propose listing (NOAA, 2010c).

ASMFC (2009c) lists threats to the Atlantic sturgeon that include bycatch mortality, poor water quality, dredging activities, and for some populations, habitat impediments (dams blocking access to spawning areas) and ship strikes. As of 2009, NMFS designates the Atlantic sturgeon over its entire range as a species of concern and a candidate species. Reasons for the listing include genetic diversity (distinct populations) and lack of adequate estimates of the size of most population segments (NOAA, 2009b).

Atlantic sturgeon inhabit the Atlantic coast in the ocean, large rivers, and estuaries from labrador to northern Florida. Populations have been extirpated from most coastal systems except for the Hudson River, the Delaware River, and some South Carolina systems (ASMFC 2010c).

Atlantic sturgeon are anadromous, migrating inshore to coastal estuaries and rivers to spawn in the spring. A single fish will spawn only every 2 to 6 years (ASMFC, 2009c). Females broadcast eggs in fast-flowing, deep water with hard bottoms (ASMFC, 2010c). Eggs are demersal and stick to the substrate after 20 min of dispersal time. Larvae are pelagic and swim in the water column before they become benthic juveniles within 4 weeks (Greene et al., 2009). Juveniles remain where they hatch for 1 to 6 years before migrating to the ocean to complete their growth (ASMFC, 2009c). Little is known about the distribution and timing of juveniles and their migration, but aggregations at the freshwater/saltwater interface suggest that these areas are nurseries (ASMFC, 2010c). At between 30 and 36 inches (76 to 91 cm) in length, juveniles move offshore (NOAA, 2009b). Data are lacking regarding adult and sub-adult distribution and habitats in the open ocean (ASMFC, 2010c). Atlantic sturgeon can live for up to 60 years and can reach 14 ft (4.3 m) and 800 lbs (363 kg). Females reach sexual maturity between 7 and 30 years of age and by males between 5 and 24 years (ASMFC, 2009c).

Atlantic sturgeon feed predominantly on benthic invertebrates, such as mussels, worms, and shrimps, as well as on small fish (ASMFC, 2009c). Juveniles consume annelid worms, isopods, amphipods, insect larvae, small bivalve mollusks, and mysids. Little is known of the adult and subadult feeding habits in the marine environment, but some studies have found that these life stages consume mollusks, polychaetes, gastropods, shrimps, amphipods, isopods, and small fish (ASMFC, 2009c).

The Delaware River and associated estuarine habitats may have historically supported the largest Atlantic sturgeon stock on the east coast. Juveniles once were caught as bycatch in numbers large enough to be a nuisance in the American shad fishery. Over 180,000 females spawned annually in the Delaware River before 1890. Juveniles have more recently been captured in surveys near Trenton, New Jersey. Gill net surveys by the DNREC have captured juveniles frequently near Artificial Island. The DNREC also tracks mortality during the spawning season. In 2005 and 2006, 12 large adult fish carcasses were found with severe external injuries presumed to be caused by boat strikes (Greene et al., 2009).

2.2.7.2 Terrestrial and Freshwater Aquatic Species

There are five terrestrial species Federally listed as threatened or endangered that have recorded occurrences or the potential to occur either in Salem County, in which the Salem and HCGS facilities are located, or the counties crossed by the three ROWs (Gloucester and Camden Counties, New Jersey and New Castle County, Delaware). These species include the bog turtle (*Clemmys muhlenbergii*) and four plants (Table 2-9) (FWS, 2010a). Four of these species are also listed as endangered in New Jersey, and the bog turtle is listed as endangered in both New Jersey and Delaware (DNREC, 2008). In letters provided in accordance with the consultation requirements under Section 7 of the Endangered Species Act, FWS confirmed that no Federally-listed species under their jurisdiction are known to occur in the vicinity of the Salem and HCGS facilities (FWS, 2010b). However, two of the species Federally-listed as threatened, the bog turtle and swamp pink (*Helonias bullata*), were identified by the New Jersey Field Office of FWS (FWS, 2010b) as having known occurrences or other areas of potential habitat along the New Freedom North and New Freedom South transmission line ROWs. Because the bog turtle and swamp pink have the potential to occur within the transmission line ROWs, these species are discussed in more detail below.

Table 2-9. Listed Terrestrial and Freshwater Aquatic Species. *This table lists the status of Federally listed and/or State-listed as threatened, endangered, or special concern species that may occur on the HCGS or Salem sites or within the in-scope transmission line ROWs.*

Scientific Name	Common Name	Status			County(ies)	Habitat
		Federal[a]	New Jersey[b]	Delaware[c]		
Birds						
Accipiter cooperii	Cooper's hawk	-	T/T[d]	E-BR	Gloucester, Salem	Deciduous, coniferous, and mixed riparian or wetland forests
Ammodramus henslowii	Henslow's sparrow	-	E	E	Gloucester	Open fields with high, thick herbaceous vegetation; grassy fields between salt marsh and uplands
A. savannarum	grasshopper sparrow	-	T/S	SCC	Salem	Grasslands; pastures; agricultural lands
Bartramia longicauda	upland sandpiper	-	E	E	Gloucester, Salem	Open meadows and fallow fields often associated with pastures
Buteo lineatus	red-shouldered hawk	-	E/T	SCC	Gloucester	Deciduous, riparian, or mixed woodlands in old growth forests; hardwood swamps with standing water
Circus cyaneus	northern harrier	-	E/U	E-BR	Salem	Freshwater, brackish, and saline tidal marshes; emergent wetlands; fallow fields; grasslands; meadows
Cistothorus platensis	sedge wren	-	E	E	Salem	Wet meadows; freshwater marshes; bogs; drier portions of salt or brackish coastal marshes

Scientific Name	Common Name	Status			County(ies)	Habitat
		Federal[a]	New Jersey[b]	Delaware[c]		
Dolichonyx oryzivorus	bobolink	-	T/T	-	Salem	Hayfields, pastures, grassy meadows; coastal and freshwater marshes during migration
Falco peregrinus	peregrine falcon	-	E	SCC	Camden, Gloucester, Salem	Open areas near water
Haliaeetus leucocephalus	bald eagle	-	E	E	Gloucester, Salem	Forests near water or tidal areas
Melanerpes erythrocephalus	red-headed woodpecker	-	T/T	E	Camden, Gloucester, Salem	Upland and wetland open woods that contain dead or dying trees and sparse undergrowth
Pandion haliaetus	osprey	-	T/T	SCC	Gloucester, Salem	Dead trees or platforms near coastal/inland rivers, marshes, bays, inlets
Passerculus sandwichensis	savannah sparrow	-	T/T	-	Salem	Open habitats such as alfalfa fields, grasslands, meadows, fallow fields, and salt marsh edges
Podilymbus podiceps	pied-billed grebe	-	E/S	E-BR	Salem	Freshwater marshes associated with bogs, lakes, or slow-moving rivers
Pooecetes gramineus	vesper sparrow	-	E	-	Gloucester, Salem	Pastures, grasslands, cultivated fields, and other open areas
Strix varia	barred owl	-	T/T	SCC	Gloucester, Salem	Remote, contiguous, old growth wetland forests, including deciduous wetland forests; Atlantic white cedar swamps associated with stream corridors

Scientific Name	Common Name	Status			County(ies)	Habitat
		Federal[a]	New Jersey[b]	Delaware[c]		
Reptiles and Amphibians						
Ambystoma tigrinum	eastern tiger salamander	-	E	SCC	Gloucester, Salem	Uplands and wetlands containing breeding ponds, forests, and burrowing-appropriate soil types such as old fields, and deciduous or mixed woods
Clemmys muhlenbergii	bog turtle	T	E	E	Camden, Gloucester, Salem, New Castle	Open, wet, grassy pastures or bogs with soft, muddy bottoms
Crotalus horridus horridus	timber rattlesnake	-	E	-	Camden	Deciduous upland forests or pinelands habitats, often near cedar swamps and along streambanks
Hyla andersoni	pine barrens treefrog	-	E	-	Camden, Gloucester, Salem	Specialized acidic habitats such as Atlantic white cedar swamps and pitch pine lowlands with open canopies, dense shrub layers, and heavy ground cover
Pituophis melanoleucus	northern pine snake	-	T	-	Camden, Gloucester, Salem	Dry pine-oak forest types growing on infertile sandy soils
Invertebrates						
Callophrys irus	frosted elfin	-	T	SCC	Camden	Dry clearings and open areas, savannas, power-line ROWs, roadsides
Lampsilis cariosa	yellow lampmussel	-	T	E	Gloucester	Medium to large rivers, lakes and ponds
Leptodea ochracea	tidewater mucket	-	T	E	Camden, Gloucester	Freshwater water with tidal influence on the lower coastal plain, pristine rivers

Scientific Name	Common Name	Status			County(ies)	Habitat
		Federal[a]	New Jersey[b]	Delaware[c]		
Ligumia nasuta	eastern pond mussel	-	T	E	Camden, Gloucester	Lakes, ponds, streams and rivers of variable depths with muddy, sandy, or gravelly substrates
Lycaena hyllus	bronze copper		E	SCC	Salem	Brackish and freshwater marshes, bogs, fens, seepages, wet sedge meadows, riparian zones, wet grasslands, and drainage ditches
Pontia protodice	checkered white	-	T	-	Camden	Open areas, savannas, old fields, vacant lots, power-line ROWs, forest edges
Plants						
Aeschynomene virginica	sensitive joint vetch	T	E	-	Camden, Gloucester, Salem	Fresh to slightly salty (brackish) tidal marshes
Aplectrum hyemale	putty root	-	E	-	Gloucester	Moist, deciduous upland to swampy forests
Aristida lanosa	wooly three-awn grass	-	E	-	Camden, Salem	Dry fields, uplands, pink-oak woods, primarily in sandy soil
Asimina triloba	pawpaw	-	E	-	Gloucester	Shady, open-woods areas in wet, fertile bottomlands, or upland areas on rich soils
Aster radula	low rough aster	-	E	-	Camden, Gloucester, Salem	Wet meadows, open boggy woods, and along the edges; or openings in wet spruce or tamarack forests
Bouteloua curtipendula	side oats grama grass	-	E	-	Gloucester	Rocky, open slopes, woodlands, and forest openings

Scientific Name	Common Name	Status			County(ies)	Habitat
		Federal[(a)]	New Jersey[(b)]	Delaware[(c)]		
Cacalia atriplicifolia	pale Indian plantain	-	E	-	Camden, Gloucester	Dry, open woods, thickets, and rocky openings
Calystegia spithamaea	erect bindweed	-	E	-	Camden, Salem	Dry, open, sandy to rocky sites such as pitch pine/scrub oak barrens, sandy roadsides, riverbanks, and ROWs
Carex aquatilis	water sedge	-	E	-	Camden	Swamps; bogs, marshes; ponds; lakes; marshy meadows
C. bushii	Bush's sedge	-	E	-	Camden	Dry to mesic grasslands; forest margin[s]
C. limosa	mud sedge	-	E	-	Gloucester	Fens; sphagnum bogs; wet meadows; shorelines
C. polymorpha	variable sedge	-	E	-	Gloucester	Dry, sandy, open areas of scrub; forests; swampy woods; bank and marsh edge[s]
Castanea pumila	chinquapin	-	E	-	Gloucester, Salem	High ridges and slopes within mixed hardwood forests, dry pinelands, and ROWs
Cercis canadensis	redbud	-	E	-	Camden	Rich, moist wooded areas in the forest understory, streambanks, and abandoned farmland[s]
Chenopodium rubrum	red goosefoot	-	E	-	Camden	Moist, often salty soils along the coast

Scientific Name	Common Name	Status			County(ies)	Habitat
		Federal[a]	New Jersey[b]	Delaware[c]		
Cyperus lancastriensis	Lancaster flat sedge	-	E	-	Camden, Gloucester	Riverbanks, floodplains, and other disturbed, sunny or partly sunny places in mesic, or dry-mesic soils
C. polystachyos	coast flat sedge	-	E	-	Salem	Along shores; in ditches; swales between dunes
C. pseudovegetus	marsh flat sedge	-	E	-	Salem	Open mesic forests; stream edges; swamps; moist sandy areas; bottomland prairies
Diodia virginiana	larger buttonweed	-	E	-	Camden	Wet meadows; pond margins
Eleocharis melanocarpa	black-fruit spike-rush	-	E	-	Salem	Fresh, oligotrophic, often drying, sandy shores; ponds; ditches
E. equisetoides	knotted spike-rush	-	E	-	Gloucester	Fresh lakes; ponds; marshes; streams; cypress swamps
E. tortilis	twisted spike-rush	-	E	-	Gloucester	Bogs; ditches; seeps
Eriophorum tenellum	rough cotton-grass	-	E	-	Camden, Gloucester	Bogs and other wet, peaty substrates
Eupatorium capillifolium	dog fennel thoroughwort	-	E	-	Camden	Coastal meadows; fallow fields; flatwoods; marshes; disturbed habitat
E. resinosum	pine barren boneset	-	E	-	Camden, Gloucester	Tidal marshes; wetlands; open swamps; wet ditches; sandy acidic soils of grass-sedge bogs; pocosin-savannah ecotones

Scientific Name	Common Name	Status			County(ies)	Habitat
		Federal[a]	New Jersey[b]	Delaware[c]		
Euphorbia purpurea	Darlington's glade spurge	-	E	-	Salem	Rich, cool woods along seeps, streams, or swamps
Glyceria grandis	American manna grass	-	E	-	Camden	Grassy areas
Hemicarpha micrantha	small-flower halfchaff sedge	-	E	-	Camden	Emergent shorelines, but rarely freshwater tidal shores
Hottonia inflata	featherfoil	-	E	-	Salem	Quiet, shallow water of pools; streams; ditches
Hydrastis canadensis	golden seal	-	E	-	Camden	Mesic, deciduous forests, often on clayey soil
Hydrocotyle ranunculoides	floating marsh-pennywort	-	E	-	Salem	Ponds; marshes
Hypericum adpressum	Barton's St. John's-wort	-	E	-	Salem	Pond shore
Isotria meleoloides	small-whorled pogonia	T	-	-	-	Mixed deciduous forests in second- or third-growth successional stages, coniferous forests
Juncus caesariensis	New Jersey rush	-	E	-	Camden	Borders of wet woods; wet springy bogs; swamps
J. torreyi	Torrey's rush	-	E	-	Camden	Edge of sloughs; wet sandy shores; along slightly alkaline watercourses; swamps

Scientific Name	Common Name	Status			County(ies)	Habitat
		Federal[a]	New Jersey[b]	Delaware[c]		
Kuhnia eupatorioides	false boneset	-	E	-	Camden	Limestone edges of bluffs; rocky wooded slopes; rocky limestone talus
Lemna perpusilla	minute duckweed	-	E	-	Camden, Salem	Mesotrophic to eutrophic, quiet waters
Limosella subulata	awl-leaf mudwort	-	E	-	Camden	Freshwater marshes
Linum intercursum	sandplain flax	-	E	-	Camden, Salem	Open, dry, sandplain grasslands or moors; sand barrens; mown fields; ROWs
Luzula acuminate	hairy wood-rush	-	E	-	Gloucester, Salem	Grassy areas
Melanthium virginicum	Virginia bunchflower	-	E	-	Camden, Gloucester, Salem	Fens; bottomland prairies; mesic upland forests; mesic upland prairies; along streams and roadsides
Muhlenbergia capillaries	long-awn smoke grass	-	E	-	Gloucester	Sandy, pine openings; dry praires; and exposed ledges
Myriophyllum tenellum	slender water-milfoil	-	E	-	Camden	Sandy soil with water to 5 ft deep
M. pinnatum	cut-leaf water-milfoil	-	E	-	Salem	Floodplain marsh
Nelumbo lutea	American lotus	-	E	-	Camden, Salem	Mostly floodplains of major rivers in ponds, lakes, pools in swamps and marshes; backwaters of reservoirs
Onosmodium virginianum	Virginia false-gromwell	-	E	-	Camden, Gloucester, Salem	Sandy soils in dry open woods
Ophioglossum vulgatum pycnostichum	southern adder's tongue	-	E	-	Salem	Rich wooded slopes; shaded secondary woods; forested bottomlands; and floodplain woods
Penstemon laevigatus	smooth beardtongue	-	E	-	Gloucester	Rich woods; fields

Scientific Name	Common Name	Status			County(ies)	Habitat
		Federal[(a)]	New Jersey[(b)]	Delaware[(c)]		
Platanthera flava flava	southern rein orchid	-	E	-	Camden	Floodplain forests; white cedar, hardwood, and cypress swamps; riparian thickets; wet meadows
Polemonium reptans	Greek-valerian	-	E	-	Salem	Moist, stream banks; deciduous woods
Prunus angustifolia	chickasaw plum	-	E	-	Camden, Gloucester, Salem	Woodland edges; forest openings; open woodlands; savannahs; prairies; plains; meadows; pastures; roadsides
Pycnanthemum clinopodioides	basil mountain mint	-	E	-	Camden	Dry south or west facing slopes on rocky soils; open oak-hickory forests, woodlands, or savannas with exposed bedrock
P. torrei	Torrey's mountain mint	-	E	-	Gloucester	Open, dry areas including red cedar barrens, rocky summits, roadsides and trails, and dry upland woods
Quercus imbricaria	shingle oak	-	E	-	Gloucester	Rich bottomlands; dry to moist uplands
Q. lyrata	overcup oak	-	E	-	Salem	Lowlands; wet forests; streamside forests; periodically inundated areas
Rhododendron atlanticum	dwarf azalea	-	E	-	Salem	Moist, flat, pine woods; savannas
Rhynchospora globularis	coarse grass-like beaked-rush	-	E	-	Camden, Gloucester, Salem	Sandy and rocky stream banks; sink-hole ponds; upland prairies; open rocky and sandy areas
R. knieskernii	Knieskern's beaked-rush	T	E	-	Camden	Moist to wet pine barrens; borrow pits; sand pits
Sagittaria teres	slender arrowhead	-	E	-	Camden	Swamps of acid waters and sandy pool shores

Scientific Name	Common Name	Status			County(ies)	Habitat
		Federal[(a)]	New Jersey[(b)]	Delaware[(c)]		
Schwalbea americana	chaffseed	E	E	-	Camden	Acidic, sandy or peaty soils in open flatwoods; streamhead pocosins; pitch pine lowland forests; longleaf pine/oak sandhills; seepage bogs; palustrine pine savannahs ecotonal areas between peaty wetlands
Scirpus longii	Long's woolgrass	-	E	-	Camden	Marshes
Scutellaria leonardii	small skullcap	-	E	-	Salem	Fields; meadows; prairies
Spiranthes laciniata	lace-lip ladies' tresses	-	E	-	Gloucester	Coastal plain marshes; swamps; dry to damp roadsides; meadows; ditches; fields
Triadenum walteri	Walter's St. John's wort	-	E	-	Camden	Buttonbush swamps; swamps; thickets; streambanks
Utricularia biflora	two-flower bladderwort	-	E	-	Gloucester, Salem	Shores and shallows
Valerianella radiata	beaked cornsalad	-	E	-	Gloucester	Pastures; prairies; valleys; creek beds; wet meadows; roadsides
Verbena simplex	narrow-leaf vervain	-	E	-	Camden, Gloucester	Fields, meadows, and prairies
Vernonia glauca	broad-leaf ironweed	-	E	-	Gloucester, Salem	Dry fields; clearings; upland forests
Vulpia elliotea	squirrel-tail six-weeks grass	-	E	-	Camden, Gloucester, Salem	Grassy habitats
Wolffiella floridana	sword bogmat	-	E	-	Salem	Quiet waters
Xyris fimbriarta	fringed yellow-eyed grass	-	E	-	Camden	Low pine savanna; bogs; seeps; peats and mucks of pond shallows; sluggish shallow streams
Aeschynomene virginica	sensitive joint vetch	T	E	-	Camden, Gloucester, Salem	Fresh to slightly salty (brackish) tidal marshes
Aplectrum hyemale	putty root	-	E	-	Gloucester	Moist, deciduous upland to swampy forests

Scientific Name	Common Name	Status			County(ies)	Habitat
		Federal[a]	New Jersey[b]	Delaware[c]		
Aristida lanosa	wooly three-awn grass	-	E	-	Camden, Salem	Dry fields; uplands; pink-oak woods with sandy soil
Asimina triloba	pawpaw	-	E	-	Gloucester	Shady, open-woods areas in wet, fertile bottomlands; rich-soiled uplands
Aster radula	low rough aster	-	E	-	Camden, Gloucester, Salem	Wet meadows; open boggy woods; wet spruce or tamarack forest openings
Bouteloua curtipendula	side oats grama grass	-	E	-	Gloucester	Rocky, open slopes; woodlands; forest openings
Cacalia atriplicifolia	pale Indian plantain	-	E	-	Camden, Gloucester	Dry, open woods, thickets; rocky openings
Calystegia spithamaea	erect bindweed	-	E	-	Camden, Salem	Dry, open, sandy to rocky sites such as pitch pine/scrub oak barrens, sandy roadsides, riverbanks, and ROWs
Carex aquatilis	water sedge	-	E	-	Camden	Swamps; bogs; marshes; ponds; lakes; marshy meadows
C. bushii	Bush's sedge	-	E	-	Camden	Dry to mesic grasslands; forest margins
C. limosa	mud sedge	-	E	-	Gloucester	Fens; sphagnum bogs; wet meadows; and shorelines
C. polymorpha	variable sedge	-	E	-	Gloucester	Dry, sandy, open areas of scrub; forests; swampy woods; bank and marsh edges
Castanea pumila	chinquapin	-	E	-	Gloucester, Salem	High ridges and slopes within mixed hardwood forests, dry pinelands, and ROWs

Scientific Name	Common Name	Status			County(ies)	Habitat
		Federal[(a)]	New Jersey[(b)]	Delaware[(c)]		
Cercis canadensis	redbud	-	E	-	Camden	Rich, moist wooded areas in the forest understory; streambanks; abandoned farmlands
Chenopodium rubrum	red goosefoot	-	E	-	Camden	Moist, often salty soils along the coast
Cyperus lancastriensis	Lancaster flat sedge	-	E	-	Camden, Gloucester	Riverbanks; floodplains; disturbed, sunny or partly sunny places in mesic, or dry-mesic soils
C. polystachyos	coast flat sedge	-	E	-	Salem	Along shores; in ditches; swales between dunes
C. pseudovegetus	marsh flat sedge	-	E	-	Salem	Open mesic forests; stream edges; swamps; moist sandy areas; bottomland prairies
Diodia virginiana	larger buttonweed	-	E	-	Camden	Wet meadows; pond margins
Eleocharis melanocarpa	black-fruit spike-rush	-	E	-	Salem	Fresh, oligotrophic, often drying, sandy shores, ponds, and ditches

Sources: DNREC 2002; DNREC 2008; FWS 2009b; FWS 2009c; NJDEP 2008b; NJDEP 2008c

(a) E = Endangered; T = Threatened; C = Candidate; - = Not Listed

(b) E = Endangered; T = Threatened; - = Not Listed; S = Stable species (a species whose population is not undergoing any long-term increase/decrease within its natural cycle); U = Undetermined (a species about which there is not enough information available to determine the status). SC = Species Concern (a species showing evidence of decline, may become threatened)

(c) BR = Breeding Population only; E = Endangered; SCC = Species of Conservation Concern; - = Not Listed; Note that Delaware does not maintain a T&E species lists by county. Upon request, the DNREC provided PSEG the locations of species of greatest conservation need that occur within 0.5 mi (0.8 km) of the transmission corridor in New Castle County

(d) State status for birds separated by a slash (/) indicates a dual status. The first status refers to the breeding population in the state, and the second status refers to the migratory or winter population in the state.

Bog Turtle

The bog turtle (now also referred to as *Glyptemys muhlenbergii*) has two discontinuous populations. The northern population, which occurs in Connecticut, Delaware, Maryland, Massachusetts, New Jersey, New York, and Pennsylvania, was Federally listed as threatened in 1997 under the ESA (16 USC 1531 *et seq*.). The southern population was listed as threatened due to its similarity of appearance to the northern population. The bog turtle was Federally listed due to declines in abundance caused by loss, fragmentation, and degradation of early successional wet-meadow habitat, and by collection for the wildlife trade (FWS, 2001b). The northern population was listed as endangered by the state of New Jersey in 1974 (NJDFW, 2010a). In New Jersey, bog turtles occur in rural areas of the state, including Salem, Sussex, Warren, and Hunterdon Counties, and as of 2003 were found in over 200 individual wetlands (NJDFW, 2010b).

The bog turtle is one of the smallest turtles in North America. Its upper shell is 3 to 4 in. (7.6 to 10.2 cm) long and light brown to black in color, and each side of its black head has a distinctive patch of color that is red, orange, or yellow. Its life span is generally 20 to 30 years. In New Jersey, the bog turtle is active from April through October and hibernates the remainder of the year in densely vegetated areas near the edges of woody plants (FWS, 2004; NJDFW, 2010b).

The bog turtle is diurnal and semi-aquatic, foraging on land and in water for a diet of plants (seeds, berries, duckweed), animals (slugs, snails, and insects), and carrion (FWS, 2001b; 2004; NJDFW, 2004). Northern bog turtles primarily inhabit wetlands fed by groundwater or associated with the headwaters of streams and dominated by emergent vegetation. These habitats typically include wet meadows with open canopies and shallow, cool water that flows slowly (FWS, 2001b). Bog turtle habitats in New Jersey typically are characterized by native communities of low-lying grasses, sedges, mosses, and rushes; however, many of these areas are in need of restoration and management due to the encroachment of woody species and invasive species such as common reed (*Phragmites australis*), cattail, and Japanese stiltgrass (*Microstegium vimineum*) (NJDFW, 2010c). Livestock grazing maintains the early successional stage vegetation favorable for bog turtles (NJDFW, 2010a). Areas of potential habitat for the bog turtle occur along the New Freedom North and New Freedom South transmission line ROWs. However, the FWS (2010) have indicated that this species is not known to occur on or in the vicinity of the Salem or HCGS sites.

Swamp Pink

Swamp pink historically occurred between New York State and the southern Appalachian Mountains of Georgia. In the species current habitats of Georgia, North Carolina, South Carolina, Delaware, Maryland, New Jersey, New York, and Virginia, the largest concentrations are found in New Jersey (CPC, 2010). Swamp pink was Federally listed as a threatened species in 1988 due to population declines and threats to its habitat (FWS, 1991). It also was listed as endangered by the State of New Jersey in 1991 and currently is also designated as endangered in Delaware and six other states (CPC, 2010). New Jersey contains 70 percent of the known populations of swamp pink, most of which are on private lands. Swamp pink continues to be threatened by direct loss of habitat to development, and by development adjacent to populations, which can interfere with hydrology and reduce water quality (FWS, 2010e).

Swamp pink, a member of the lily family, has smooth evergreen leaves. It flowers in April and May. The flower stem is 1 to 3 ft (30 to 91 cm) tall with small leaves, and pink flowers are clustered (30 to 50 flowers) at the top of the stalk (FWS, 2010e). Fruits are trilobed, heart-shaped, and contain many seeds (Center for Plant Conservation, 2010; FWS, 1991). Swamp pink is not very successful at dispersing through seeds; rhizomes are the main source of new plants (FWS, 1991). Swamp pink has a highly clumped distribution where it occurs. Populations can vary from a few individuals to several thousand plants and could be considered colonies due to the the rhizomes connecting the plants (FWS, 1991).

Swamp pink is a wetland plant that usually grows on hummocks in soil that is saturated but not persistently flooded. It is thought to be limited to shady areas. Specific habitats include Atlantic white-cedar (*Chamaecypa tisthyoides*) swamps, swampy forested wetlands that border small streams, meadows, and spring seepage areas. It is most commonly found with other wetland plants such as red maple (*Acer rubrum*), sweet pepperbush (*Clethra alnifolia*), sweetbay magnolia (*Magnolia virginiana*), sphagnum moss (Sphagnum spp.), cinnamon fern (*Osmunda cinnamomea*), and skunk cabbage (*Symplocarpus foetidus*) (FWS, 2010e; CPC, 2010).

As of 1991, when a recovery plan for swamp pink was completed, New Jersey supported over half the known populations of the species, with 71 confirmed occurrences mostly on the coastal plain in pinelands fringe areas in the Delaware River drainage (FWS, 1991). In Delaware, 15 sites were confirmed in the coastal plain province in the counties of New Castle, Kent, and Sussex (FWS, 1991). In Delaware, one occurrence of swamp pink was recorded in New Castle County. Delaware does not have regulations specifically for protection of rare plant species (FWS, 2008). As of 2008 in New Jersey, Salem County had 20 confirmed occurrences of swamp pink, Gloucester County had 13, and Camden County had 28 (FWS, 2008). The swamp pink has potential habitat occur along the New Freedom North and New Freedom South transmission line ROWs. However, the FWS (2010) have indicated that this species is not known to occur on or in the vicinity of the Salem or HCGS sites.

2.2.8 Socioeconomic Factors

This section describes current socioeconomic factors that have the potential to be directly or indirectly affected by changes in operations at Salem and HCGS. Salem, HCGS, and the communities that support them can be described as dynamic socioeconomic systems. The communities provide the people, goods, and services required to operate Salem and HCGS. Salem and HCGS operations, in turn, create the demand and pay for the people, goods, and services in the form of wages, salaries, and benefits for jobs and dollar expenditures for goods and services. The measure of the communities' ability to support the demands of Salem and HCGS depends on their ability to respond to changing environmental, social, economic, and demographic conditions.

The socioeconomic region of influence (ROI) for Salem and HCGS is defined as the areas in which Salem and HGCS employees and their families reside, spend their income, and use their benefits, thereby affecting the economic conditions of the region. The Salem and HCGS ROI consists of a four-county region where approximately 85 percent of Salem and 82 percent of HCGS employees reside: Salem, Gloucester, and Cumberland counties in New Jersey and New

Castle County in Delaware. Salem and HCGS staff include shared corporate employees and matrixed workers (i.e., employees who work collaboratively between both facilities). The following sections describe the housing, public services, offsite land use, visual aesthetics and noise, population demography, and the economy in the ROI for Salem and HCGS.

Salem employs a permanent workforce of approximately 644 employees and the HCGS permanent workforce includes approximately 521 employees (PSEG, 2010d). Salem and HCGS share an additional 340 PSEG corporate and 109 matrixed employees. Approximately 85 percent of the Salem workforce, 82 percent of the HCGS workforce, and 79 percent of the PSEG corporate and matrixed employees live in Salem, Gloucester, and Cumberland counties in New Jersey and New Castle County in Delaware (Table 2-10). The remaining 15 percent of the Salem workforce are divided among 14 counties in New Jersey, Pennsylvania, and Maryland, as well as one county in Georgia, with numbers ranging from 1 to 42 employees per county. The remaining 18 percent of the HCGS workforce are divided among 16 counties in New Jersey, Pennsylvania, and Maryland, as well as one county in each of three States (Delaware, New York, and Washington), with numbers ranging from 1 to 38 employees per county. The remaining 21 percent of the corporate and matrixed employees reside in 13 counties in New Jersey, Pennsylvania, and Maryland, as well as one county in Delaware, one county in North Carolina, and the District of Columbia. Given the residential locations of Salem and HCGS employees, the most significant impacts of plant operations are likely to occur in Salem, Gloucester, and Cumberland counties in New Jersey and New Castle County in Delaware. Therefore, the socioeconomic impact analysis in this draft SEIS focuses on the impacts of Salem and HCGS on these four counties.

Table 2-10. Salem Nuclear Generating Station and Hope Creek Generating Station Employee Residence by County

County	Number of Salem Employees	Number of HCGS Employees	Number of Corporate and Matrixed Employees	Total Number of Employees	Percent of Total Workforce
Salem , NJ	253	198	189	640	39.7
Gloucester, NJ	100	74	68	242	15.0
Cumberland, NJ	73	51	35	159	9.8
New Castle, DE	123	106	64	293	18.2
Other	95	92	93	280	17.3
Total	**644**	**521**	**449**	**1,614**	**100**

Source: PSEG, 2010d

Refueling outages at Salem and HCGS generally occur at 18-month intervals for both stations. During refueling outages, site employment increases by as many as 600 workers at each station for approximately 23 days (PSEG, 2009a; 2009b). Most of these workers are assumed to be located in the same geographic areas as the permanent Salem and HCGS Staff.

2.2.8.1 Housing

Table 2-11 lists the total number of occupied and vacant housing units, vacancy rates, and median value in the four-county ROI. According to the 2000 census, there were nearly 373,600 housing units in the ROI, of which approximately 353,000 were occupied. The median value of owner-occupied units ranged from $91,200 in Cumberland County to $136,000 in New Castle County. The vacancy rate was highest in Salem County (7.1 percent) and Cumberland County (7.0 percent) and lower in New Castle County (5.3 percent) and Gloucester County (4.6 percent).

By 2008, the total number of housing units within the four-county ROI had grown by approximately 28,000 units to 401,673 housing units, while the total number of occupied units grew by 17,832 units to 370,922. The median house value increased approximately $101,600 between the 2000 census and the 3-year estimation period (2006 through 2008). As a result, the vacancy rate increased from 6 percent to 8 percent of total housing units.

Table 2-11. Housing in Cumberland, Gloucester, and Salem Counties, New Jersey, and New Castle County, Delaware

	Cumberland	Gloucester	Salem	New Castle	ROI
2000					
Total Housing Units	**52,863**	**95,054**	**26,158**	**199,521**	**373,596**
Occupied housing units	49,143	90,717	24,295	188,935	353,090
Vacant units	3,720	4,337	1,863	10,586	20,506
Vacancy rate (percent)	7	4.6	7.1	5.3	5.5
Median value (dollars)	91,200	120,100	105,200	136,000	113,125
2008[(a)]					
Total Housing Units	**55,261**	**106,641**	**27,463**	**212,308**	**401,673**
Occupied housing units	50,648	100,743	24,939	194,592	370,922
Vacant units	4,613	5,898	2,524	17,716	30,751
Vacancy rate (percent)	8.3	5.5	9.2	8.3	7.7
Median value (dollars)	171,600	238,200	197,100	252,000	214,725

(a) Housing values for the 2008 estimates are based on 2006–2008 American Community Survey 3-Year Estimates, U.S. Census Bureau.

Source: USCB, 2010a.

2.2.8.2 Public Services

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

Water Supply

Information for the major municipal water suppliers in the three New Jersey counties, including firm capacity and peak demand, is presented in Table 2-12. Population served and water source for each system is also provided. The primary source of potable water in Cumberland County is groundwater withdrawn from the Cohansey-Maurice watershed. In Gloucester County, the water is primarily groundwater obtained from the Lower Delaware watershed. The major suppliers in Salem County obtain their drinking water supply from surface water or groundwater from the Delaware Bay watershed.

Information for the major municipal water suppliers in New Castle County, DE, is provided in Table 2-13, including maximum capacity and average daily production, as well as population served and water source for each system. The majority of the potable water supply is surface water withdrawn from the Brandywine-Christina watershed.

1 **Table 2-12. Major Public Water Supply Systems in Cumberland, Gloucester, and Salem**
2 **Counties, New Jersey**

Water System	Population Served	Primary Water Source	Peak Daily Demand[(a)] (MGD)	Total Capacity (MGD)
Cumberland County				
City of Bridgeton	22,770	GW	4.05	3.35
City of Millville	27,500	GW	5.71	7.83
City of Vineland	33,000	GW	15.26	16.49
Gloucester County				
Borough of Clayton	7,155	GW	1.09	1.22
Deptford Township	26,000	SW (Purchased)	4.79	8.80
Borough of Glassboro	19,238	GW	4.29	6.31
Mantua Township	11,713	SW (Purchased)	2.19	2.74
Monroe Township	26,145	GW	6.22	7.15
Borough of Paulsboro	6,200	GW	1.25	1.80
Borough of Pitman	9,445	GW	0.96	1.59
Washington Township	48,000	GW	8.25	12.92
West Deptford Township	20,000	GW	4.26	7.03
Borough of Westville	6,000	GW	0.70	1.73
City of Woodbury	11,000	SW (Purchased)	1.76	4.32
Salem County				
Pennsville Township	13,500	GW	1.63	1.87
City of Salem	6,199	SW	1.66	4.27

MGD = million gallons per day; GW = groundwater; SW = surface water

(a) Current peak yearly demand plus committed peak yearly demand.

Sources: EPA, 2010c (population served and primary water source); NJDEP, 2009d (peak annual demand and available capacity)

3

4

Table 2-13. Major Public Water Supply Systems in New Castle County, Delaware

Water System	Population Served	Primary Water Source	Average Daily Production (MGD)	Maximum Capacity (MGD)
City of Middletown	16,000	GW	NA	NA
City of New Castle	6,000	GW	0.5	1.3
City of Newark	36,130	SW	4	6
City of Wilmington	140,000	SW	29	61

GW = groundwater; SW = surface water; NA = not available

Sources: EPA, 2010c (population served and primary water source); PSEG, 2009a and PSEG, 2009b (reported production and maximum capacity)

Education

Salem and HCGS are located in Lower Alloways Creek School District, which had an enrollment of approximately 223 students in pre-Kindergarten through 8th grade for the 2008–2009 school year. Salem County has 15 public school districts, with a total enrollment of 12,012 students. Cumberland County has a total of 15 school districts with 26,739 students enrolled in public schools in the county in 2008–2009. Gloucester County has 28 public school districts with a total 2008–2009 enrollment of 49,782 students (NJDOE, 2010). There are five public school districts in New Castle County, DE; total enrollment in the 2009–2010 school year is 66,679 students (DDE, 2010).

Transportation

Figures 2.1-1 and 2.1-2 show the Salem and HCGS location and highways within a 50-mi (80 km) radius and a 6-mi (10-km) radius of the facilities. At the larger regional scale, the major highways serving Salem and HCGS are Interstate 295 and the New Jersey Turnpike, located approximately 15 mi (24 km) north of the facilities. Interstate 295 crosses the Delaware River via the Delaware Memorial Bridge, providing access to Delaware and, via Interstate 95, to Pennsylvania.

Local road access to Salem and HCGS is from the northeast via Alloway Creek Neck Road, a two-lane road which leads directly to the facility access road. Alloway Creek Neck Road intersects County Route (CR) 658 approximately 4 mi (6.4 km) northeast of Salem and HCGS. CR 658 leads northward to the City of Salem, where it intersects New Jersey State Route 49, which is the major north-south route through western Salem County and connects local traffic to the Delaware Memorial Bridge to the north. Approximately 1 mi (1.6 km) east of its intersection with Alloway Creek Neck Road, CR 658 intersects with CR 623 (a north-south road) and CR 667 (an east-west road). Employees who live to the north, northeast, and northwest of Salem and HCGS, as well as those from Delaware and Pennsylvania, could travel south on State Route 49, connecting to CR 658 and from there to Alloway Creek Neck Road to reach the facilities. Employees from the south could travel north on CR 623, connecting to Alloway Creek Neck Road via CR 658. Employees living farther south or to the southeast could use State Route 49, connecting to Alloway Creek Neck Road via CR 667, and CR 658 or CR 623 (PSEG, 2009a; 2009b).

Traffic volumes in Salem County are highest on roadways in the northern and eastern parts of the county, where all of the annual average daily traffic counts greater than 10,000 were measured. The highest annual average daily traffic count in the county is 27,301 on Interstate 295 in the northeastern corner of the county. In western Salem County, in the vicinity of Salem and HCGS, annual average daily traffic counts range from 236 to 1,052, while within the City of Salem they range from 4,218 to 9,003. At the traffic count location closest to Salem and HCGS, located on CR 623, the annual average daily traffic count is 895 (NJDOT, 2009). Level of service data, which describe operational conditions on a roadway and their perception by motorists, are not collected by the State of New Jersey (PSEG, 2009a; PSEG, 2009b).

2.2.8.3 Offsite Land Use

This section describes offsite land use in the four-county ROI, including Salem, Gloucester, and Cumberland counties in New Jersey and New Castle County in Delaware, which is where the majority of Salem and HCGS employees reside. Salem and HCGS are located in western Salem County adjacent to the Delaware River, which is the border between New Jersey and Delaware.

Salem County, New Jersey

Salem County is rural in nature, consisting of more than 338 square miles (mi^2; 875 square kilometers [km^2]) of land with an estimated 66,141 residents, a 2.9 percent increase since 2000 (USCB, 2010a). Only 13 percent of the land area in the county is considered urban (in residential, commercial, or industrial use), with development concentrated in western Salem County along the Delaware River. The remaining 87 percent of the county is dedicated farmland under active cultivation (42 percent) or undeveloped natural areas, primarily tidal and freshwater wetlands (30 percent) and forests (12 percent) (Morris Land Conservancy, 2008). There are 199 farms for a total of 26,191 ac (10,600 ha), or 12 percent of the county, which have been preserved in Salem County under the New Jersey Farmland Preservation Program (SADC, 2009).

Two municipalities within Salem County, Lower Alloways Creek Township and the City of Salem, receive annual real estate tax payments from Salem and from HCGS. Over half of the land area in Lower Alloways Creek Township is wetlands (65 percent), 15 percent is used for agriculture, and 8 percent is urban. The City of Salem is largely urban (49 percent), with 24 percent of its area wetlands and 12 percent in agricultural use (Morris Land Conservancy, 2006).

Land use within Salem County is guided by the *Smart Growth Plan* (Rukenstein & Associates, 2004), which has the goal of concentrating development within a corridor along the Delaware River and Interstate 295/New Jersey Turnpike in the northwestern part of the county and encouraging agriculture and the preservation of open space in the central and eastern parts of the county. Land development is regulated by the municipalities within Salem County through the use of zoning and other ordinances.

Lower Alloways Creek Township has a master plan to guide development, which includes a land use plan (LACT, 1992). The plan encourages development in those areas of the township most capable of providing necessary services, continuation of agricultural use, and restriction on development in the conservation district (primarily wetlands). The land use plan includes an industrial district adjacent to Artificial Island. The master plan was updated in the *2005 Master*

Plan Reexamination Report (Alaimo Group, 2005), which looked at key issues and reaffirmed the importance of preserving farmland, open space, and environmental resources.

Cumberland County, New Jersey

Cumberland County, which is located to the south and east of Salem County, occupies about 489 mi^2 (1,300 km^2) of land along the Delaware Bay at the south end of New Jersey. In 2008, the county had an estimated population of 156,830 residents, which is a 7.1 percent increase since 2000 (USCB, 2010a). Over 60 percent of the land area in the county is forest (32 percent) or wetlands (30 percent). Approximately 19 percent is occupied by agriculture, mostly concentrated in the northwestern part of the county near Salem County. Only 12 percent of Cumberland County is considered urban (DVRPC, 2009). Under the New Jersey Farmland Preservation Program, 117 farms, including a total of 14,569 ac (5,900 ha) of farmland, have been preserved in Cumberland County (SADC, 2009).

Cumberland County has assembled a series of planning initiatives that together provide a strategic plan for the future of the county (Orth-Rodgers, 2002). A recently completed *Farmland Preservation Plan* for the county seeks to maintain its productive farmland in active use. The *Western/Southern Cumberland Region Strategic Plan* (issued as a draft in 2005) identifies 32 existing community centers in the county for concentration of future residential and commercial growth, and the county Master Plan, prepared in 1967, is in the process of being updated. The municipalities within Cumberland County regulate land development through zoning and other ordinances (DVRPC, 2009).

Gloucester County, New Jersey

Gloucester County is located northeast of Salem County. Gloucester County has approximately 325 mi^2 (840 km^2) of land and in 2008, had an estimated population of 287,860 residents, which represents a 12.6 percent increase since 2000 (USCB, 2010a). It is the fastest growing county in New Jersey (based on percent increase in population) and has the fastest growing municipality (Woolwich Township) on the East Coast (Gloucester County, 2010). Major land uses in the county are urban (26 percent) and agriculture (26 percent), with 30 percent of the county land area vacant and 10 percent wetlands (Gloucester County, 2009). There are 113 farms with a total of 9,527 ac (3,800 ha; 4 percent of the county land area) that have been preserved in Gloucester County under the New Jersey Farmland Preservation Program (SADC, 2009).

The County *Development Management Plan* and its various elements provide guidance for land use planning in Gloucester County. It encourages a growth pattern that will concentrate development rather than disperse it, enhancing existing urban areas and preserving natural resources. The Gloucester County *Northeast Region Strategic Plan* goals include taking advantage of infill opportunities to avoid sprawl into undeveloped areas and creating compact development that allows preservation of farms and open spaces. Land development is regulated by the municipalities within Gloucester County through zoning and other ordinances (GCPD, 2005).

New Castle County, Delaware

New Castle County, the northernmost county in the State of Delaware, is located east of Salem County across the Delaware River. The county encompasses slightly more than 426 mi^2 (1,100 km^2) and has an estimated resident population of 529,641, which is a 5.9 percent increase from 2000 to 2008. It is the most populous of the three counties in Delaware (USCB, 2010a). The three major land uses in New Castle County are agriculture (29 percent), residential (28 percent), and forests (15 percent) (New Castle County, 2007). In 2007, the county had a total of 347 farms (less than 14 percent of all farms in the State) located on approximately 67,000 ac (27,000 ha) of land. This reflects a decrease of 6 percent in land used for farming compared to 2000 (USDA, 2007).

The New Castle County *Comprehensive Development Plan* addresses county policies with regard to zoning, density, and open space preservation. It seeks to concentrate new growth, as well as redevelopment, in established communities in order to preserve limited resources. This is accomplished through the use of a future land use map. The plan proposes policies to encourage development in the northern part of the county with growth in the southern portion more centralized and compact (New Castle County, 2007).

2.2.8.4 Visual Aesthetics and Noise

Salem and HCGS are bordered by the Delaware River to the west and south and by a large expanse of wildlife management areas on the north, east, and southeast. The access road runs east to west along the shoreline of Artificial Island then continues east through the wetlands. The immediate area is flat in relief, consisting of open water and large expanses of tidal and freshwater marsh. Across the bay, in Delaware, the shoreline consists of State parks and wildlife areas with low profile marshy habitats and very few structures to interrupt the view. Beyond the parks and wetland areas are farmlands and then small to medium sized towns, in both Delaware and New Jersey.

The main vertical components of the Salem and HCGS building complex are the HCGS natural draft cooling tower (514-ft [157-m] tall), the most prominent feature on Artificial Island, and the three-domed reactor containment buildings (190 to 200-ft [58 to 61-m] tall). The structures are most visible from the Delaware River. Portions of the Salem and HCGS building complex can be seen from many miles away, in particular the cooling tower and the plume it produces. The complex can easily be seen from the marsh areas and the river itself, while in the more populated areas, it is often blocked by trees or houses and can only be seen from certain angles. The structures within the Salem and HCGS building complex are for the most part made of concrete and metal, with exposed non-concrete buildings and equipment painted light, generally neutral colors, such as brown and blue (AEC, 1973; PSEG, 1983). The overhead transmission lines leading away to the north, northeast, and east can also be seen from many directions as they cross over the low profile expanses of the marshes. Farther inland, portions of the transmission lines are visible, especially as they pass over roads and highways.

Sources of noise at Salem and HCGS include the cooling tower, transformers, turbines, circuit breakers, transmission lines and intermittent industrial noise from activities at the facilities. Noise studies were conducted prior to the operation of the Salem generating units. The transformers were each estimated to produce between 82 and 85 adjusted decibels (dBA) at 6 ft (1.8 m) away and the turbines were each estimated to produce 95 dBA at 3 ft (0.9 m) away. The combined noise from all sources was estimated at 36 dBA at the site boundary. The noise from the plant at the nearest residence, approximately 3.5 mi (5.6 km) from the Salem and HCGS facilities, was estimated to be approximately 27 dBA. The U. S. Department of housing and urban development (HUD) criterion guidelines for non-aircraft noise define 45 dBA as the maximum noise level for the “clearly acceptable” range. An ambient noise survey, within a radius of 5 mi (8 km), established that most of the existing sound levels were within New Jersey's limits for industrial operations, as measured at residential property boundaries (PSEG, 1983).

Given the industrial nature of these two stations, noise emissions are generally nothing more than an intermittent minor nuisance. Noise levels may sometimes exceed the 55 dBA level that the U.S. Environmental Protection Agency (EPA) uses as a threshold level to protect against excess noise during outdoor activities (EPA, 1974). However, according to the EPA this threshold does "not constitute a standard, specification, or regulation," but was intended to provide a basis for state and local governments establishing noise standards. To date, no noise complaints associated with operations at Salem and HCGS have been reported from neighboring communities.

2.2.8.5 Demography

According to the 2000 census, approximately 501,820 people lived within a 20-mi (32-km) radius of Salem and HCGS, which equates to a population density of 450 persons per mi^2. This density translates to a Category 4 (greater than or equal to 120 persons per mi^2 within 20 mi) using the generic environmental impact statement (GEIS) measure of sparseness. Approximately 5,201,842 people live within 50 mi (80 km) of Salem and HCGS, for a density of 771 persons per mi^2 (PSEG, 2009a; 2009b). Applying the GEIS proximity measures, this density is classified as Category 4 (greater than or equal to 190 persons per mi^2 within 50 mi [80 km]). Therefore, according to the sparseness and proximity matrix presented in the GEIS, a Category 4 value for sparseness and for proximity indicates that Salem and HCGS are located in a high population area.

Table 2-14 shows population projections and growth rates from 1970 to 2050 in Cumberland, Gloucester, and Salem counties in New Jersey and New Castle County in Delaware. All of the four counties experienced continuous growth during the period 1970 to 2000, except for Salem County, which saw a 1.5 percent decline in population between 1990 and 2000. Gloucester County experienced the greatest rate of growth during this period. Beyond 2000, county populations are expected to continue to grow in the next decades, with Gloucester County projected to experience the highest rate of growth.

Table 2-14. Population and Percent Growth in Cumberland, Gloucester, and Salem Counties, New Jersey, and New Castle County, Delaware from 1970 to 2000 and Projected for 2010 to 2050

Year	Cumberland County		Gloucester County		Salem County		New Castle County	
	Population	Percent Growth[a]	Population	Percent Growth[a]	Population	Percent Growth[a]	Population	Percent Growth[a]
1970	121,374	—	172,681	—	60,346	---	385,856	----
1980	132,866	9.5	199,917	15.8	64,676	7.2	398,115	3.2
1990	138,053	3.9	230,082	15.1	65,294	1.0	441,946	11.0
2000	146,438	6.1	254,673	10.7	64,285	-1.5	500,265	13.2
2008	**155,388**	**6.1**	**284,886**	**11.9**	**65,952**	**2.6**	**526,414**	**5.2**
2010	157,745	7.7	289,920	13.8	66,342	3.2	535,572	7.1
2020[b]	164,617	4.4	307,688	6.1	69,433	4.7	564,944	5.5
2030[b]	176,784	7.4	338,672	10.1	74,576	7.4	586,387	3.8
2040[c]	185,421	4.9	360,845	6.5	78,351	5.1	613,116	4.6
2050[c]	194,941	5.1	385,221	6.8	82,468	5.3	638,524	4.1

— = Not applicable

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

(b) The 2020 and 2030 population projections for Cumberland, Gloucester, and Salem counties are for 2018 and 2028, respectively.

(c) Calculated.

Sources: Population data for 1970 through 1990 (USCB, 1995a; 1995b); population data for 2000 (USCB, 2000d); Population estimates for 2008 (USCB, 2010a); New Jersey counties estimated population for 2009 (USCB, 2010b); New Castle County projected population for 2010 to 2040 (DPC, 2009); New Jersey counties projected population for 2018 and 2028 (CUPR, 2009).

The 2000 demographic profile of the four-county ROI is included in Table 2-15. Persons self-designated as minority individuals comprise approximately 30 percent of the total population. This minority population is composed largely of Black or African American residents.

Table 2-15. Demographic Profile of the Population in the Salem Nuclear Generating Station and Hope Creek Generating Station Region of Influence in 2000

	Cumberland, NJ	Gloucester, NJ	Salem, NJ	New Castle, DE	ROI
Total Population	**146,438**	**254,673**	**64,285**	**500,265**	**965,661**
Race, Not-Hispanic or Latino (percent of total population)					
White	58.4	85.7	79.6	70.7	73.4
Black or African American	19.2	8.9	14.4	19.9	16.5
American Indian and Alaska Native	0.7	0.2	0.3	0.2	0.3
Asian	0.9	1.5	0.6	2.6	1.9
Native Hawaiian and Other Pacific Islander	0.03	0.02	0.02	0.03	0.03
Some other race	0.1	0.1	0.1	0.1	0.1
Two or more races	1.63	1.1	1.1	1.2	1.2
Ethnicity					
Hispanic or Latino	27,823	6,583	2,498	26,293	63,197
Percent of total population	19.0	2.6	3.9	5.3	6.5
Minority Populations (including Hispanic or Latino ethnicity)					
Total minority population	60,928	36,411	13,114	146,505	256,958
Percent minority	41.6	14.3	20.4	29.3	26.6

Source: USCB, 2000d

According to the U.S. Census Bureau's 2006-2008 American Community Survey 3-Year Estimates, minority populations were estimated to have increased by approximately 61,000 persons and comprised 30.8 percent of the four-county ROI population (see Table 2–16). Most of this increase was due to an estimated influx of Hispanic or Latinos (over 25,000 persons), an increase in population of over 39.8 percent from 2000. The next largest increases in minority populations were Black or African American and Asian populations with increases of approximately 23,000 and 9,700 persons or 14.4 and 53 percent, respectively, from 2000.

Table 2-16. Demographic Profile of the Population in the Salem and HCGS Region of Influence, 2006-2008 Three-Year Estimate

	Cumberland, NJ	Gloucester, NJ	Salem, NJ	New Castle, DE	Region of Influence
Total Population	155,388	284,886	65,952	526,414	1,032,640
Race (percent of total population, Not-Hispanic or Latino)					
White	53.6	82.8	77.8	65.3	69.2
Black or African American	19.2	9.5	14.8	22.0	17.7
American Indian and Alaska Native	0.8	0.1	0.3	0.2	0.2
Asian	1.1	2.3	0.6	3.7	2.7
Native Hawaiian and Other Pacific Islander	0.01	0.03	0.00	0.02	0.02
Some other race	0.2	0.1	0.3	0.2	0.2
Two or more races	1.6	1.6	0.9	1.4	1.4
Ethnicity					
Hispanic or Latino	36,530	10,409	3,489	37,929	88,357
Percent of total population	23.5	3.7	5.3	7.2	8.6
Minority Populations (including Hispanic or Latino ethnicity)					
Total minority population	72,112	48,927	14,653	182,540	318,232
Percent minority	46.4	17.2	22.2	34.7	30.8

Source: U.S. Census Bureau, 2006–2008 American Community Survey (USCB, 2010a).

<u>Transient Population</u>

Within 50 mi (80 km) of Salem and HCGS, colleges and recreational opportunities attract daily and seasonal visitors who create demand for temporary housing and services. In 2000, in the four-county ROI, 0.5 percent of all housing units were considered temporary housing for seasonal, recreational, or occasional use. Table 2-17 provides information on seasonal housing for the counties located within the Salem and HCGS ROI (USCB, 2000b). In 2008, there were 49,498 students attending colleges and universities located within 50 mi (80 km) of Salem and HCGS (NCES, 2009).

Table 2-17. Seasonal Housing in the Salem Nuclear Generating Station and Hope Creek Generating Station Region of Influence in 2000

County	Number of Housing Units	Vacant Housing Units for Seasonal, Recreational, or Occasional Use	Percent
Cumberland	52,863	826	1.6
Gloucester	95,054	274	0.3
Salem	26,158	131	0.5
New Castle	199,521	707	0.4
ROI	373,596	1,938	0.5

Source: USCB, 2000c

Migrant Farm Workers

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

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

The 2007 Census of Agriculture collected information on migrant farm and temporary labor. Table 2-18 provides information on migrant farm workers and temporary (less than 150 days) farm labor within 50 mi (80 km) of Salem and HCGS. According to the 2007 Census of Agriculture, 15,764 farm workers were hired to work for less than 150 days and were employed on 1,747 farms within 50 mi (80 km) of Salem and HCGS. The county with the largest number of temporary farm workers (4,979 persons on 118 farms) was Atlantic County, NJ (USDA, 2007). Salem County had 804 temporary farm workers on 121 farms; Cumberland County had 1,857 temporary workers on 141 farms, and Gloucester County had 1,228 on 110 farms (USDA, 2007). New Castle County reported 320 temporary workers on 52 farms.

Farm operators were asked whether any hired workers were migrant workers, defined as a farm worker whose employment required travel that prevented the migrant worker from returning to their permanent place of residence the same day. A total of 453 farms in the region (within a 50-mi [80 km] radius of Salem and HCGS) reported hiring migrant workers. Chester County, PA reported the most farms (101) with hired migrant workers. Within the four-county ROI, a total of 164 farms were reported with hired migrant farm workers, including Cumberland County with 65 farms, followed by Gloucester County with 56 and Salem County with 33. New Castle County reported a total of 10 farms with hired migrant workers (USDA, 2007).

Table 2-18. Migrant Farm Worker and Temporary Farm Labor within 50 Miles of Salem Nuclear Generating Station and Hope Creek Generating Station

County[(a)]	Farm workers working less than 150 days	Farms hiring workers for less than 150 days	Farms reporting migrant farm labor	Farms with hired farm labor
Delaware:				
Kent	728	106	22	169
New Castle	320	52	10	81
County Subtotal	**1,048**	**158**	**32**	**250**
Maryland:				
Caroline	478	121	13	153
Cecil	546	87	5	128
Hartford	266	101	12	155
Kent	245	78	8	111
Queen Anne's	317	89	13	126
County Subtotal	**1,852**	**476**	**51**	**673**
New Jersey:				
Atlantic	4,979	118	74	163
Camden	470	43	17	52
Cape May	173	38	8	46
Cumberland	1,857	141	65	192
Gloucester	1,228	110	56	163
Salem	804	121	33	172
County Subtotal	**9,511**	**571**	**253**	**788**
Pennsylvania:				
Chester	2,687	403	101	580
Delaware	106	19	2	25
Montgomery	560	115	14	155
Philadelphia	-	5	-	5
County Subtotal	**3,353**	**542**	**117**	**765**
County Total	**15,764**	**1,747**	**453**	**2,746**

(a) Includes counties with approximately more than half their area within a 50-mi radius of Salem and HCGS.

Source: USDA, 2007

2.2.8.6 Economy

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

<u>Employment and Income</u>

Between 2000 and 2007, the civilian labor force in Salem County decreased 4.4 percent to 18,193. During the same time period, the civilian labor force in Gloucester County and

Cumberland County grew 18.5 percent and 5.8 percent, respectively, to the 2007 levels of 92,154 and 48,468. In New Castle County, DE, the civilian labor force increased slightly (0.9 percent) to 284,647 between 2000 and 2007 (USCB, 2010c).

In 2008, trade, transportation, and utilities represented the largest sector of employment in the three New Jersey counties, followed by education and health services in Salem and Gloucester counties and manufacturing in Cumberland County (NJDLWD, 2010a; 2010b; 2010c). The trade, transportation, and utilities sector employed the most people in New Castle County, DE, in 2008, followed closely by the professional and business services sector (DDL, 2009). A list of some of the major employers in Salem County is provided in Table 2-19. The largest employer in the county in 2006 was PSEG with over 1,300 employees.

Table 2-19. Major Employers in Salem County in 2007

Firm	Number of Employees
PSEG	1,300+[(a)]
E.I. duPont	1,250
Mannington Mills	826
Memorial Hospital of Salem County	600
Atlantic City Electric	426
R.E. Pierson Construction	400+
Anchor Glass	361
McLane NJ	352
Elmer Hospital	350
Wal-Mart	256
Berkowitz Glass	225
Siegfried (USA)	155

Source: Salem County, 2007

(a) PSEG (2010c) reports that Salem and HCGS employ approximately 1,165 employees and share an additional 340 PSEG corporate and 109 matrixed employees, for a total of 1,614 employees.

Income information for the four-county ROI is presented in Table 2-20. Median household incomes in Gloucester and New Castle counties were each above their respective State median household income averages, while Salem and Cumberland counties had median household incomes below the State of New Jersey average. Per capita incomes in Salem, Gloucester, and Cumberland counties were each below the State of New Jersey average, while the New Castle County per capita income was above the State of Delaware average. In Salem and Cumberland counties, 9.9 and 15.1 percent of the population, respectively, was living below the official poverty level, which is greater than the percentage for the State of New Jersey as a whole (8.7 percent). Only 7.5 percent of the Gloucester County population was living below the poverty level. In Delaware, 9.9 percent of the New Castle County population was living below the poverty level, while the State average was 10.4 percent. In addition, Cumberland County has the highest percentage of families living below the poverty level in the ROI.

Table 2-20. Income Information for the Salem Nuclear Generating Station and Hope Creek Generating Station Region of Influence, 2008

	Salem County	Gloucester County	Cumberland County	New Jersey	New Castle County	Delaware
Median household income (dollars)	61,204	72,316	49,944	69,674	62,628	57,270
Per capita income (dollars)	27,785	30,893	21,316	34,899	31,400	29,124
Persons below poverty level (percent)	9.9	7.5	15.1	8.7	9.9	10.4
Families below poverty level (percent)	5.9	5.7	12.6	6.3	6.1	7.1

Source: USCB, 2010a.

Unemployment

In 2008, the annual unemployment average in Salem, Gloucester, and Cumberland counties was 7.5, 6.4, and 9.6 percent, respectively, all of which were higher than the unemployment average of 6.0 percent for the State of New Jersey. Conversely, the annual unemployment average of 5.6 for New Castle County was lower than the State of Delaware average of 6.0 percent (USCB, 2010a).

Taxes

The owners of Salem and HCGS pay annual property taxes to Lower Alloways Creek Township. From 2003 through 2009, PSEG and Exelon paid between $1,191,870 and $1,511,301 annually in property taxes to Lower Alloways Creek Township (Table 2-21). During the same time period, these tax payments represented between 54.2 and 59.3 percent of the township's total annual property tax revenue. Each year, Lower Alloways Creek Township forwards this tax money to Salem County, which provides most services to township residents. The property taxes paid annually for Salem and HCGS during 2003 through 2009 represent approximately 2.5 to 3.5 percent of Salem County's total annual property tax revenue. As a result of the payment of property taxes for Salem and HCGS to Lower Alloways Creek Township, residents of the township do not pay local municipal property taxes on residences, local school taxes, or municipal open space taxes; they pay only Salem County taxes and county open space taxes (PSEG, 2009a; 2009b).

In addition, PSEG and Exelon pay annual property taxes to the City of Salem for the Energy and Environmental Resource Center, located in Salem. From 2003 through 2009, between $177,360 and $387,353 in annual property taxes for the Center were paid to the city (Table 2-22).

Table 2-21. Salem Nuclear Generating Station and Hope Creek Generating Station Property Tax Paid and Percentage of Lower Alloways Creek Township and Salem County Tax Revenues, 2003 to 2009

				Lower Alloways Creek Township				Salem County			
	Property Tax Paid by PSEG and/or Exelon (dollars)			Total Property Tax Revenue in Township (dollars)	PSEG and/or Exelon Property Tax as Percentage of Total Property Tax Revenue (percent)			Total Property Tax Revenue in County (dollars)	PSEG and/or Exelon Property Tax as Percentage of Total Property Tax Revenue (percent)		
Year	Salem	HCGS	Total		Salem	HCGS	Total		Salem	HCGS	Total
2003	748,537	464,677	1,213,214	2,099,185	35.7	22.1	57.8	34,697,781	2.2	1.3	3.5
2004	764,379	474,512	1,238,891	2,251,474	34.0	21.1	55.0	36,320,365	2.1	1.3	3.4
2005	783,644	485,624	1,269,268	2,325,378	33.7	20.9	54.6	40,562,971	1.9	1.2	3.1
2006	734,841	457,029	1,191,870	2,195,746	33.5	20.8	54.3	43,382,037	1.7	1.1	2.7
2007	772,543	480,476	1,253,019	2,310,262	33.4	20.8	54.2	46,667,551	1.7	1.0	2.7
2008	745,081	463,397	1,208,478	2,038,467	36.6	22.7	59.3	49,058,072	1.5	0.9	2.5
2009	931,785	579,516	1,511,301	2,644,636	35.2	21.9	57.1	51,636,999	1.8	1.1	2.9

Source: PSEG, 2009a; PSEG, 2009b; PSEG, 2010e

Table 2-22. Energy and Environmental Resource Center Property Tax Paid and Percentage of City of Salem Tax Revenues, 2003 to 2009

Year	Property Tax Paid by PSEG and/or Exelon (dollars)	Total Property Tax Revenue in City of Salem (dollars)	PSEG and/or Exelon Property Tax as Percentage of Total Property Tax Revenue in City of Salem (percent)
2003	177,360	5,092,527	3.5
2004	211,755	6,049,675	3.5
2005	220,822	6,294,613	3.5
2006	228,492	6,485,947	3.5
2007	318,910	7,389,319	4.3
2008	184,445	8,423,203	2.2
2009	387,353	8,313,289	4.7

Source: PSEG, 2009a; 2009b; 2010e

This represented between 2.2 and 4.7 percent of the city's total annual property tax revenue. Ownership of the Energy and Environmental Resource Center was transferred to PSEG Power in the fourth quarter of 2008; therefore, Exelon is no longer minority owner of the center.

In 1999, the State of New Jersey deregulated its utility industry (EIA, 2008). Any changes to the tax assessment for Salem or HCGS would already have occurred and are reflected in the tax payment information provided in Table 2-21. Potential future changes to Salem and HCGS property tax rates due to deregulation would be independent of license renewal.

The continued availability of Salem and HCGS and the associated tax base is an important feature in the ability of Salem County communities to continue to invest in infrastructure and to draw industry and new residents.

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 Salem/HCGS site and its immediate vicinity. The information presented was collected from area repositories, the New Jersey State Historic Preservation Office (SHPO), the New Jersey State Museum (NJSM), and the applicant's ER (PSEG, 2009a; 2009b).

2.2.9.1 Cultural Background

The prehistory of New Jersey includes five major temporal divisions based on technological advancements, the stylistic evolution of the lithic tool kit, and changes in subsistence strategies related to a changing environment and resource base. These divisions are as follows:

- The Paleo-Indian Period (circa 12,000–10,000 years before present [BP])
- The Archaic Period (circa 10,000–3,000 years BP)

- The Woodland Period (circa 3,000 BP–1600 AD)
- The Contact Period (circa 1600–1700 AD)
- Historic Period (circa 1700–1700 AD)

These periods are typically broken into shorter time intervals reflecting specific adaptations and stylistic trends and are briefly discussed below.

Paleo-Indian Period

The Paleo-Indian Period began after the Wisconsin glacier retreated from the region approximately 12,000 years ago, and represents the earliest known occupation in New Jersey. The Paleo-Indian people were hunter-gatherers whose subsistence strategy may have been dependent upon hunting large game animals over a wide region of tundra-like vegetation that gradually developed into open grasslands with scattered coniferous forests (Kraft, 1982). The settlement pattern during this period likely consisted of small, temporary camps (Kraft, 1982).

Few Paleo-Indian sites have been excavated in the Mid-Atlantic Region. Within New Jersey, Paleo-Indian sites, such as the Plenge site excavated in the Musconetcong Valley in the northwestern part of the State, have largely been identified in valley and ridge zones (Marshall, 1982).

Archaic Period

The Archaic Period is marked by changes in subsistence and settlement patterns. While hunting and gathering were still the primary subsistence activities, the emphasis seems to have shifted toward hunting the smaller animals inhabiting the deciduous forests that developed during this time. Based on archaeological evidence, the settlement pattern that helps define the Archaic Period consisted of larger, more permanent habitation sites. In addition to game animals, the quantities of plant resources, as well as fish and shellfish remains that have been identified at these sites, indicate that the Archaic people were more efficiently exploiting the natural environment (Kraft, 1982).

An example of a typical Archaic Period site in southern New Jersey is the Indian Head Site, located about 35 mi (56 km) northeast of the Salem/HCGS site. The Indian Head Site is a large multi-component site with evidence of both Middle and Late Archaic Period occupations.

Woodland Period

The Woodland Period marks the introduction of ceramic manufacture, as clay vessels replaced the earlier carved soapstone vessels. Hunting and gathering subsistence activities persisted, however, the period is notable for the development of horticulture. As horticulture became of increasing importance to the subsistence economy of the Woodland people, settlement patterns were affected. Habitation sites increased in size and permanence, as a larger population size could be sustained due to the more efficient exploitation of the natural environment for subsistence (Kraft, 1982).

Examples of Woodland Period occupations in southern New Jersey are well documented in the many Riggins Complex sites recorded in the Cohansey Creek and Maurice River drainages.

Contact Period

European exploration of the Mid-Atlantic Region began in the 16th century, and by the early 17th century, maps of the area were being produced (aclink.org). The Dutch ship *Furtuyn* explored the Mullica River in 1614. The Dutch and Swedish were the first to colonize the area, though they were eventually forced to give control of lands to the British in the later part of the 17th century. These settlements mark the beginning of the Contact Period, a time of ever-increasing contact between the Native Americans of the region and the Europeans.

The native groups of the southern New Jersey region were part of the widespread Algonquin cultural and linguistic tradition (Kraft, 1982). Following initial contact, a pattern of Indian/European trade developed and the Native Americans began to acquire European-made tools, ornaments, and other goods. This pattern is reflected in the archaeological record, as the artifact assemblages from Contact Period sites contain both Native American and European cultural material.

At the time of contact, the Lenni Lenape inhabited the Salem/HCGS area. The Lenni Lenape, who eventually became known as the Delaware tribe, also occupied lands throughout New Jersey, as well as in present-day Pennsylvania and New York (Eaton, 1899). The group occupying southern New Jersey spoke the Southern Unami dialects of the Algonquin language (Kraft, 2001).

Historic Period

The first European settlement in the vicinity of the Salem/HCGS site occurred in 1638, when a Swedish fort was established along the Delaware River in the present day town of Elsinborough (CSS, 2010). This settlement was short lived, as the location was plagued with mosquitoes and was eventually deemed untenable. Later attempts to settle the area by Swedish, Finnish, and Dutch groups also met with limited success. In 1675, the Englishman John Fenwick and his group of colonists landed along the Delaware River, north of the original Swedish settlement at Elsinborough (Brown, 2007). They established “Fenwicks Colony” and the town of Salem. In 1790, the population of Salem County was 10,437. By 1880, the county’s population had more than doubled in size, reaching 24,579. Today, approximately 65,000 people inhabit Salem County (USCB, 2010c).

During the 18th and 19th century, the predominant industries in Salem County included commercial fishing, shipping of agricultural products, ship building businesses, glass manufacturing, and farming (DSC, 2010). In the latter part of the 19th century, the DuPont Company established a gunpowder manufacturing plant in Salem County. At its peak, in the early part of the 20th century, the plant employed nearly 25,000 workers. The DuPont facilities continued operation into the late 1970s. In addition to generation of electric power at the Salem and HCGS sites, furniture and glass manufacturing have been the predominate industries in Salem County in the latter part of the 20th and the early part of the 21st centuries[2].

[2] Personal communication with B. Gallo, Editor of Today’s Sunbeam, Salem County, New Jersey. March 9, 2010.

2.2.9.2 Historic and Archaeological Resources at the Salem/Hope Creek Site

Previously Identified Resources

The New Jersey State Museum (NJSM) houses the State's archaeological site files, and the New Jersey State Historical Preservation office (SHPO) houses information on historic resources such as buildings and houses, including available information concerning the National or State Register eligibility status of these resources. The NRC cultural resource team visited the NJSM and collected site files on archaeological sites and information on historic resources located within or nearby the Salem/HCGS property. Online sources were used to identify properties listed on the National Register of Historic Places (NRHP) in Salem County, NJ, and New Castle County, DE (NRHP, 2010).

A review of the NJSM files to identify archaeological resources indicated that no archaeological or historic sites have been recorded on Artificial Island. The nearest recorded prehistoric archaeological site, 35CU99, is located approximately 3.5 mi (5.6 km) southeast of the plant site, in Cumberland County. 35CU99 is an Archaic Period archeological site containing stone tools and evidence of stone tool making activity. The closest NRHP-listed site is the Joseph Ware House, which is located 6 mi (9.6 km) to the northeast, in Hancock's Bridge. To date, 6 properties within a 10-mi (16 km) radius of the Salem/HCGS site in Salem County, NJ, have been listed on the NRHP. A total of 17 NRHP-listed sites in New Castle County, DE, fall within a 10-mi radius of the Salem/HCGS site.

Potential Archaeological Resources

The Salem and HCGS sites are located on a man-made island in the Delaware River. This would suggest a very low potential for the discovery of previously undocumented prehistoric archaeological sites on the plant property. However, given the age of the artificial island upon which the generating stations were constructed, it is possible that previously undocumented historic-period resources may be present. Further research would be required to determine historic period land use patterns on the island during the 20th century.

2.3 Related Federal Project Activities

The Staff reviewed the possibility that activities of other Federal agencies might impact the renewal of the operating licenses for Salem and HCGS. Any such activity could result in cumulative environmental impacts and the possible need for a Federal agency to become a cooperating agency in the preparation of the Salem and HCGS SEIS.

The Staff has determined that there are no Federal projects that would make it desirable for another Federal agency to become a cooperating agency in the preparation of the SEIS. Federal facilities and parks and wildlife areas within 50 mi (80 km) of Salem and HCGS are listed below.

- Coast Guard Training Center, Cape May (New Jersey)
- Dover Air Force Base (Delaware)
- Aberdeen Test Center (Maryland)

- United States Defense Government Supply Center, Philadelphia (Pennsylvania)
- Federal Correctional Institution, Fairton (New Jersey)
- Federal Detention Center, Philadelphia (Pennsylvania)
- New Jersey Coastal Heritage Trail
- Great Egg Harbor National Scenic and Recreational River (New Jersey)
- New Jersey Pinelands National Reserve
- Captain John Smith Chesapeake National Historic Trail (Delaware, Maryland)
- Chesapeake Bay Gateways Network (Delaware, Maryland)
- Hopewell Furnace – National Historic Site (Pennsylvania)
- Cape May National Wildlife Refuge (New Jersey)
- Supawna Meadows National Wildlife Refuge (New Jersey)
- Eastern Neck National Wildlife Refuge (Maryland)
- Bombay Hook National Wildlife Refuge (Delaware)
- Prime Hook National Wildlife Refuge (Delaware)
- Independence National Historical Park (Pennsylvania)

The USACE is involved in a project that could affect resources in the vicinity of Salem and HCGS. The USACE plans on deepening the Delaware River main navigation channel from Philadelphia to the Atlantic Ocean to a depth of 45 ft (14 m). This channel passes close to Artificial Island and the Salem and HCGS effluent discharge area. Studies determined that potential minor changes in hydrology, including salinity, would be possible. Temporary increases in turbidity would be expected during construction (USACE, 2009).

Although it is not a Federal project, the potential construction of a fourth unit at the Salem and HCGS site would require action by a Federal agency. PSEG submitted an early site permit application to the NRC regarding possible construction of one or two new reactor units at the Salem and HCGS site on Artificial Island (PSEG, 2010f).

The NRC is required under Section 102(2)(c) of the National Environmental Policy Act of 1969 (NEPA), as amended, to consult with and obtain the comments of any Federal agency that has jurisdiction by law or special expertise with respect to any environmental impact involved. The NRC consulted with the NMFS and the FWS. Federal agency consultation correspondence and comments on the SEIS are presented in Appendix D.

2.4 References

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10 CFR Part 54. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants."

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

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

10 CFR Part 72. *Code of Federal Regulations*, Title 10, *Energy*, Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Thank Class C Waste."

16 USC 1456. *United States Code*. Title 16, Chapter 33, Part 1456, "Coordination and Cooperation."

40 CFR Part 81. *Code of Federal Regulations*, Title 40, *Protection of the Environment*, Part 81, "Designation of Areas for Air Quality Planning Purposes."

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3.0 ENVIRONMENTAL IMPACTS OF REFURBISHMENT

License renewal actions include refurbishment actions 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. If such actions were planned, the potential environmental effects of refurbishment actions would be identified and the analysis would be summarized within this section.

Environmental issues associated with refurbishment activities are discussed in the "Generic Environmental Impact Statement (GEIS) for License Renewal of Nuclear Plants", NUREG-1437, Vol. 1 and 2 (NRC, 1996; NRC, 1999).[1] The GEIS includes a determination of whether or not the analysis of the environmental issues can be applied to all plants and whether or not additional mitigation measures are warranted. Issues are then assigned a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1 issues are those that meet all of the following criteria:

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

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

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

For issues that meet the three Category 1 criteria, no additional plant-specific analysis is required in this supplemental environmental impact statement (SEIS) unless new and significant information is identified. Category 2 issues are those that do not meet one or more of the criteria for Category 1 and, therefore, an additional plant-specific review of these issues is required. Environmental issues associated with refurbishment, which were determined to be Category 1 and Category 2 issues, are listed in Tables 3-1 and 3-2, respectively.

Requirements for the renewal of operating licenses for nuclear power plants include the preparation of an integrated plant assessment (IPA) pursuant to Section 54.21 of Title 10 of the *Code of Federal Regulations* (CFR). The IPA must identify and list systems, structures, and components subject to an aging management review. The GEIS (NRC, 1996) provides helpful information on the scope and preparation of refurbishment activities to be evaluated. Environmental resource categories to be evaluated for impacts of refurbishment include terrestrial resources, threatened and endangered species, air quality, housing, public utilities and water supply, education, land use, transportation, and historic and archaeological resources. Items that are subject to aging and might require refurbishment include, for

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

example, the reactor vessel piping, supports, and pump casings (see 10 CFR 54.21 for details), as well as items that are not subject to periodic replacement.

PSEG Nuclear, LLC (PSEG) performed IPAs on Salem Nuclear Generating Station, Units 1 and 2 (Salem) and Hope Creek Generating Station (HCGS) pursuant to 10 CFR 54.21. This assessment did not identify the need to undertake any major refurbishment or replacement actions to maintain the functionality of important systems, structures, and components during the Salem or HCGS license renewal periods or other facility modifications associated with license renewals that would affect the environment or plant effluents (PSEG, 2009a; PSEG, 2009b); therefore, an assessment of refurbishment activities is not considered in this SEIS.

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	
Onsite land use	3.2
Human Health	
Radiation exposures to the public during refurbishment	3.8.1
Occupational radiation exposures during refurbishment	3.8.2
Socioeconomics	
Public services: public safety, social services, and tourism and recreation	3.7.4; 3.7.4.3; 3.7.4.4; 3.7.4.6
Aesthetic impacts (refurbishment)	3.7.8

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
Offsite 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 NRC prepared the GEIS and the associated revision to 10 CFR Part 51. If an applicant plans to undertake refurbishment activities for license renewal, the applicant's Environmental Report (ER) and NRC staff's environmental impact statement must address environmental justice.

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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4.0 ENVIRONMENTAL IMPACTS OF OPERATION

This chapter addresses potential environmental impacts related to the period of extended operation of Salem Nuclear Generating Station, Units 1 and 2 (Salem) and Hope Creek Generating Station (HCGS). These impacts are grouped and presented according to resource. Generic issues (Category 1) rely on the analysis provided in the *Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants* (GEIS) prepared by the U.S. Nuclear Regulatory Commission (NRC) (NRC, 1996; 1999a) and are discussed briefly. NRC staff (the Staff) analyzed site-specific issues (Category 2) for Salem and HCGS and assigned them a significance level of SMALL, MODERATE, or LARGE. Some remaining issues are not applicable to Salem and HCGS because of site characteristics or plant features. Section 1.4 of this report explains the criteria for Category 1 and Category 2 issues and defines the impact designations of SMALL, MODERATE, and LARGE.

4.1 Land Use

Land use issues are listed in Table 4-1. The Staff did not identify any Category 2 issues for land use. The Staff also did not identify any new and significant information during the review of the applicant's environmental reports (ERs) (PSEG, 2009a; PSEG, 2009b), the site audit, or the scoping process. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS. For these issues, the GEIS concludes that the impacts are SMALL.

Table 4-1. Land Use Issues. *Section 2.2.1 of this report describes the land use around Salem and HCGS.*

Issues	GEIS Section	Category
Onsite land use	4.5.3	1
Power line right-of-way	4.5.3	1

4.2 Air Quality

The air quality issue applicable to the Salem and HCGS facilities is listed in Table 4-2. The Staff did not identify any Category 2 issues for air quality. The Staff also did not identify any new and significant information during the review of the applicant's ER (PSEG, 2009a; 2009b), the site audit, or the scoping process. Therefore, there are no impacts related to this issue beyond those discussed in the GEIS. For these issues, the GEIS concludes that the impacts are SMALL.

Table 4-2. Air Quality Issue. *Section 2.2.2 of this report describes air quality in the vicinity of Salem and HCGS.*

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

4.3 Ground Water

The following sections discuss the Category 2 ground water issue applicable to Salem and HCGS, which is listed in Table 4-3.

Table 4-3. Ground Water Use and Quality Issues. *Section 2.2.3 of this report discussed ground water use and quality at Salem and HCGS.*

Issues	GEIS Section	Category
Ground Water use conflicts (potable and service water, plants using >100 gallons per minute [gpm])	4.8.1.1	2

4.3.1 Ground Water Use Conflicts (plants using >100 gpm)

NRC specifies as issue 33 in Title 10 of the Code of Federal Regulations (CFR) Part 51, Subpart A, Appendix B, Table B-1, that “Plants that use more than 100 gpm may cause groundwater use conflicts with nearby groundwater users.” The NRC further states in 10 CFR 51.53(c)(3)(ii)(C), that “If the applicant’s plant ... pumps more than 100 gallons (total onsite) of groundwater per minute, an assessment of the impact of the proposed action on groundwater use must be provided..” This applies to Salem and HCGS because, as discussed in section 2.1.7.1, the Salem and HCGS groundwater wells combined to produce an average of 210 million gallons per year (790,000 cubic meters [m^3] per year) from 2002 to 2008, which is a combined average of 0.58 million gallons per day (MGD; 2,200 m^3 per day), or 400 gallons per minute (gpm; 1.5 m^3/minute).

A groundwater withdrawal rate of over 100 gpm (0.38 m^3/minute) has the potential to create a cone of depression large enough to affect offsite wells and groundwater supplies, limiting the amount of groundwater available for the plant’s surrounding areas. As discussed in 2.1.7.1, the facilities operate four primary production wells, including PW-5 and PW-6 at Salem, and HC-1 and HC-2 at HCGS. Three of these wells (PW-5, HC-1, and HC-2) produce groundwater from the Upper Potomac-Raritan-Magothy (PRM) Aquifer, and the fourth (PW-6) produces groundwater from the Middle PRM Aquifer. Therefore, potential impacts in both aquifers need to be considered. There are also two stand-by wells located at Salem (PW-2 and PW-3). These wells are screened in the Mount Laurel-Wenonah Aquifer. Because these wells could be used during the relicense period, potential impacts in this aquifer were evaluated.

To evaluate whether the production from the Salem and HCGS wells could affect offsite groundwater users, the Staff evaluated several lines of evidence, including measurements of onsite groundwater levels, identification of potentially-affected offsite users, comparison of water withdrawal rates to the authorized rate and rates for other authorized users, and identification of regulatory groundwater use restrictions.

In the ER, PSEG Nuclear, LLC (PSEG, the applicant) presented results of the measurement of groundwater levels in the onsite production wells (TetraTech, 2009). Water levels in many of the production wells, and some observation wells, were measured in July and/or September, 1987 (Dames & Moore, 1988), and then again measured monthly from 2000 to the present day. This data set allows an evaluation of the long-term trend in water levels in order to determine if groundwater usage is exceeding aquifer recharge in the local area. For the Mount Laurel-Wenonah Aquifer, water levels in PW-2, PW-3, and an observation well (OW-G) are all higher in elevation in 2008 than they were in 1987 and the early 2000s. This indicates no drawdown of the aquifer, as would be expected because there has been little or no production from this aquifer.

For the Middle PRM Aquifer, water levels were measured in production well PW-6 and observation well OW-6 (TetraTech, 2009). In both wells, original measurements in 1987 showed water depths of more than about 100 feet (ft; 30 meters (m)), and by the time the next measurement was made in 2000, water depths ranged from 50 to 60 ft (15 to 18 m). Water depths remained in the range of 50 to 60 ft (15 to 18 m) throughout the 2000s, with no apparent trend. While the reason for the 40 to 50 ft (15 to 18 m) rise in water levels between 1987 and 2000 is not discernible, this rise is documented only by a single measurement in each well. Because there are not trends in water levels since 2000, the production from the Middle PRM Aquifer does not appear to have had any long-term effect on water availability within the aquifer.

For the Upper PRM Aquifer, water levels were measured in production wells PW-5, HC-1, HC-2, and observation wells OW-J and OW-I (TetraTech, 2009). In each case, the water level measurements appear to show a slight, but steady, long-term decline in water level elevation. Original measurements in wells PW-5 and HC-1 in 1987 indicated water depths at approximately 72 to 76 ft (22 to 23 m). By 2000, water depths in these two wells ranged to 82 to 85 feet. By 2005 and through 2008, monthly water level measurements in these two wells occasionally reached depths of 88 to 95 ft (27 to 29 m). Water levels in well OW-I similarly declined, from 58 ft (18 m) in 1987, to 62 to 74 ft (19 to 23 m) in 2000, and 70 to 88 feet (21 to 27 m) in 2008. The same trend was observed in wells NC-2 and OW-J, although water levels in these wells were not measured in 1987. In both of these wells, water level depths started in the range of 69 to 84 ft (21 to 26 m) in 2000, and ranged from 92 to 102 ft (28 to 31) in 2008.

The reason for the declining water levels in the Upper PRM Aquifer over the last decade cannot be determined from the limited data set, but they could indicate that long-term production is resulting in dewatering of the aquifer, which could potentially cause groundwater use conflicts. The results could also be due to: continuing development of the cone of depression for the withdrawal system before it stabilizes, long-term precipitation trends that are not associated with production, or the limited duration of the monitoring period.

Because the trend in water levels in the Upper PRM Aquifer may indicate potential groundwater use limitations, the Staff identified other local users of the aquifer, and evaluated regional trends and regulatory actions to determine if groundwater use conflicts could exist. Due to the rural location of the facilities, there are no other local municipalities or industrial facilities which use groundwater from any aquifer, including the Upper PRM Aquifer. As discussed in Section 2.2.7, the closest municipal use of groundwater for potable water supply is the Artesian Water

Company's Bayview system in New Castle County, Delaware (DNREC, 2003). The Bayview system is located approximately 3.5 miles (mi; 5.6 kilometers [km]) west of the site, and supplies 132 residents from two wells in the Mount Laurel-Wenonah Aquifer. In Salem County, the City of Salem uses groundwater as a component of their water supply. The City of Salem system is located 9 mi (14 km) from the Salem and HCGS facilities, and serves approximately 9,000 persons. The two largest water supply systems in Salem County (the Pennsgrove and Pennsville systems) both produce water from the Upper PRM Aquifer (EPA, 2010; NJAW, 2010; NJDEP, 2007), but both systems are located more than 15 mi (24 km) to the north of the Salem and HCGS facilities.

In addition to being distant from potentially affected users, the water volume produced from the Upper PRM Aquifer by the Salem and HCGS wells is also small compared to municipal users in the region. The authorized water withdrawal rate for all six production wells at the Salem and HCGS facilities is 43.2 million gallons (164,000 m^3) per 30 day period (1.44 MGD [5,470 m^3/day]) (DRBC, 2000). The actual production rate is approximately 0.58 MGD (2,200 m^3/day), or about 40% of the authorized volume. The Pennsville system is authorized by DRBC to produce 1.75 MGD (6,600m^3/day) (PA Bulletin, 2005) to service approximately 13,500 residents; therefore, the volume produced by the Salem and HCGS facilities is approximately equivalent to a municipal supply system servicing less than 4,500 persons.

Additional information on groundwater use conflicts in the region is found in studies associated with the Water-Supply Critical Areas in the New Jersey Coastal Plain. Two areas (Critical Area 1 and Critical Area 2) were established in 1986 to manage withdrawals from aquifers which had water level declines that were a cause of concern (Watt, 2000). The management measures included reducing authorized withdrawals and new allocations from specific aquifers, including the Upper and Middle PRM Aquifers, and shifting water supply sources from confined aquifers to shallow unconfined aquifer and surface water sources. These measures resulted in a region-wide rise in groundwater levels. Currently, both the USGS and New Jersey Department of Environmental Protection (NJDEP) are performing additional monitoring and modeling studies in order to determine if water management strategies in the Critical Areas can be modified in response to their success in recovering groundwater levels (Voronin, 2005).

Although groundwater use conflicts were enough of a regional concern to cause designation of the Critical Areas, the Salem and HCGS facility location was not included within either of the two Critical Areas. Critical Area 2 includes a small portion of eastern Salem County, but does not include the northern portion of the county (location of the Pennsville and Pennsgrove water systems) or the western portion of the county (location of Salem and HCGS). Also, the success of the program in allowing groundwater levels to recover suggests that groundwater use conflicts in western Salem County are likely to become less of a concern, rather than greater.

Based on these lines of evidence, it appears that although groundwater production at Salem and HCGS may be contributing to a gradual reduction in groundwater availability locally, this reduction is not likely to impact other groundwater users. Therefore, the Staff concludes that impacts on nearby groundwater users would be SMALL.

4.4 Surface Water

The following sections discuss the surface water quality issues applicable to Salem and HCGS, which are listed in Table 4-4. The Staff did not identify any new and significant information during the review of the applicant's ER (PSEG, 2009a; 2009b), the site audit, or the scoping process. Therefore, no impacts are related to these issues beyond those discussed in the GEIS. For these issues, the GEIS concludes that the impacts are SMALL.

Table 4-4. Surface Water Quality Issues. *Section 2.2.4 of this report describes surface water quality conditions at Salem and HCGS.*

Issues	GEIS Section	Category
Altered current patterns at intake and discharge structures	4.2.1.2.1	1
Altered salinity gradients	4.2.1.2.2	1
Temperature effects on sediment transport capacity	4.2.1.2.3	1
Scouring caused by discharged cooling water	4.2.1.2.3	1
Eutrophication	4.2.1.2.3	1
Discharge of chlorine or other biocides	4.2.1.2.4	1
Discharge of sanitary wastes and minor chemical spills	4.2.1.2.4	1
Discharge of other metals in wastewater	4.2.1.2.4	1

4.5 Aquatic Resources

4.5.1 Categorization of Aquatic Resources Issues

The Category 1 and Category 2 issues related to aquatic resources and applicable to HCGS and Salem are listed in Table 4-5 and discussed below. Section 2.1.6 of this report describes the HCGS and Salem cooling water systems, and Section 2.2.5 describes the potentially affected aquatic resources.

Table 4-5. Aquatic Resources Issues.

Issues	GEIS Section	Category
For All Plants		
Accumulation of contaminants in sediments or biota	4.2.1.2.4	1
Entrainment of phytoplankton and zooplankton	4.2.2.1.1	1
Cold shock	4.2.2.1.5	1
Thermal plume barrier to migrating fish	4.2.2.1.6	1
Distribution of aquatic organisms	4.2.2.1.6	1
Premature emergence of aquatic insects	4.2.2.1.7	1
Gas supersaturation (gas bubble disease)	4.2.2.1.8	1
Low dissolved oxygen in the discharge	4.2.2.1.9	1
Losses from parasitism, predation, and disease among organisms exposed to sublethal stresses	4.2.2.1.10	1
Stimulation of nuisance organisms	4.2.2.1.11	1
For Plants with Cooling-Tower-Based Heat Dissipation Systems[(a)]		
Entrainment of fish and shellfish in early life stages	4.3.3	1
Impingement of fish and shellfish	4.3.3	1
Heat shock	4.3.3	1
For Plants with Once-Through Heat Dissipation Systems[(b)]		
Entrainment of fish and shellfish in early life stages	4.2.2.1.2	2
Impingement of fish and shellfish	4.2.2.1.3	2
Heat shock	4.2.2.1.4	2

[(a)]Applicable to HCGS.
[(b)]Applicable to Salem.

The Staff did not identify any new and significant information related to Category 1 aquatic resources issues during the review of the applicant's ERs for Salem (PSEG, 2009a) and HCGS (PSEG, 2009b), the site audit, or the scoping process. Consequently, there are no impacts related to the generic, Category 1 issues beyond those discussed in the GEIS.

Entrainment of fish and shellfish in early life stages, impingement of fish and shellfish, and heat shock are Category 1 issues at power plants with closed-cycle cooling systems are Category 2 issues at plants with once-through cooling systems. Hope Creek uses a closed-cycle cooling system with a cooling tower. This type of cooling system substantially reduces the volume of water withdrawn by the plant and substantially reduces entrainment, impingement, and thermal discharge effects (heat shock potential). Entrainment, impingement, and heat shock are Category 1 issues for Hope Creek and do not require further analysis to determine that their impacts during the relicensing period would be SMALL. In contrast, the cooling water system at Salem is a once-through system, and for such systems entrainment, impingement, and heat shock are Category 2 issues that require site-specific analysis. The remainder of Section 4.5 discusses these Category 2 issues for Salem.

4.5.2 Entrainment of Fish and Shellfish in Early Life Stages

Entrainment occurs when early life stages of fish and shellfish are drawn into cooling water intake systems along with the cooling water. Cooling water intake systems are designed to screen out larger organisms, but small life stages, such as eggs and larvae, can pass through the screens and be drawn into the plant condensers. Once inside, organisms may be killed or injured by heat, physical stress, or chemicals.

Regulatory Background

Section 316(b) of the Clean Water Act of 1977 (CWA) requires that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available (BTA) for minimizing adverse environmental impacts (33 USC 1326). In July 2004, the U.S. Environmental Protection Agency (EPA) published the Phase II Rule implementing Section 316(b) of the CWA for Existing Facilities (69 FR 41576), which applied to large power producers that withdraw large amounts of surface water for cooling (50 MGD or more) (189,000 m^3/day or more). The rule became effective on September 7, 2004 and included numeric performance standards for reductions in impingement mortality and entrainment that would demonstrate that the cooling water intake system constitutes BTA for minimizing impingement and entrainment impacts. Existing facilities subject to the rule were required to demonstrate compliance with the rule's performance standards during the renewal process for their National Pollutant Discharge Elimination System (NPDES) permit through development of a Comprehensive Demonstration Study (CDS). As a result of a Federal court decision, EPA officially suspended the Phase II rule on July 9, 2007 (72 FR 37107) pending further rulemaking. EPA instructed permitting authorities to utilize best professional judgment in establishing permit requirements on a case-by-case basis for cooling water intake structures at Phase II facilities until it has resolved the issues raised by the court's ruling.

EPA delegated authority for NPDES permitting to NJDEP in 1984. In 1990, NJDEP issued a draft New Jersey Pollutant Discharge Elimination System (NJPDES) permit that proposed closed-cycle cooling as BTA for Salem. In 1993, NJDEP concluded that the cost of retrofitting Salem to closed-cycle cooling would be wholly disproportionate to the environmental benefits realized, and a new draft permit was issued in 1994 (PSEG, 1999a). The 1994 final NJPDES permit stated that the existing cooling water intake system was BTA for Salem, with certain conditions (NJDEP, 1994).

Conditions of the 1994 permit included improvements to the screens and Ristroph buckets, a monthly average limitation on cooling water flow of 3,024 MGD (11.4 million m^3/day), and a pilot study for the use of a sound deterrent system. In addition to technology and operational measures, the 1994 permit required restoration measures that included a wetlands restoration and enhancement program designed to increase primary production in the Delaware Estuary and fish ladders at dams along the Delaware River to restore access to traditional spawning runs for anadromous species such as blueback herring and alewife. A Biological Monitoring Work Plan (BMWP) was also required to monitor the efficacy of the technology and operational measures employed at the site and the restoration programs funded by PSEG (NJDEP, 1994). The BMWP included monitoring plans for fish utilization of restored wetlands, elimination of impediments to fish migration, bay-wide trawl survey, and beach seine survey, in addition to the entrainment and impingement abundance monitoring (PSEG, 1994). The main purpose of these studies was to monitor the success of the wetland restoration activities and screen modifications undertaken by PSEG.

The 2001 NJPDES permit required continuation of the restoration programs implemented in response to the 1994 permit, an Improved Biological Monitoring Work Plan (IBMWP), and a more detailed analysis of impingement mortality and entrainment losses at the facility (NJDEP, 2001). The 2006 NJPDES permit renewal application responded to the requirement for a detailed analysis by including a CDS as required by the Phase II rule and an assessment of alternative intake technologies (AIT). The AIT assessment includes a detailed analysis of the costs and benefits associated with the existing intake configuration and alternatives along with an analysis of the costs and benefits of the wetlands restoration program that PSEG implemented in response to the requirements of the 1994 NJPDES permit (PSEG, 2006c).

The IBMWP was submitted to NJDEP in April 2002 and approved in July 2003. A reduction in the frequency of monitoring at fish ladder sites that successfully pass river herring was submitted in December 2003 and approved was in May 2004. In 2006 PSEG submitted a revised IBMWP that proposed a reduction in sampling at the restored wetland sites. Sampling would be conducted at representative locations instead of at every restoration site (PSEG, 2006c).

Salem’s 2006 NJPDES permit renewal application included a CDS because the Phase II rule was still in effect at that time. The CDS for Salem was completed in 2006 and included an analysis of impingement mortality and entrainment at the facility’s cooling water intake system. According to PSEG (2006c), this analysis shows that the changes in technology and operation of the Salem cooling water intake system satisfied the performance standards of the Phase II rule and that the current configuration constitutes BTA. In 2006, NJDEP administratively continued Salem’s 2001 NJPDES permit (NJ0005622), and no timeframe has been determined for issuance of the new NJPDES permit.

<u>Entrainment Studies</u>

Prior to construction of the Salem facility, baseline biological studies were begun in 1968 to characterize the biological community in the Delaware Estuary. The study area consisted of the estuary 10 mi (16 km) to the north and south of Salem. In 1969 with the passing of the National Environmental Policy Act (NEPA), the study program was expanded to include ichthyoplankton and benthos studies and to gather information on the feeding habits and life histories of the common species. In 1973 the Atomic Energy Commission (AEC) published its Final

Environmental Statement (FES) for Salem, which concluded that the effects of impingement and entrainment on the biological community of the Delaware Estuary would not be significant (PSEG, 1999a).

The Salem facility began operation in 1977, and monitoring has been performed on an annual basis since then to evaluate the impacts on the aquatic environment of the Delaware Estuary from entrainment of organisms through the cooling water system. Methods and results of these studies are summarized in several reports, including the 1984 316(b) Demonstration (PSEG, 1984), the 1999 316(b) Demonstration (PSEG, 1999a), and the 2006 316(b) Demonstration (PSEG, 2006c). In addition, biological monitoring reports were submitted to NJDEP on an annual basis from 1995 through the present (PSEG, 1996; 1997; 1998; 1999b; 2000; 2001; 2002; 2003; 2004; 2005; 2006a; 2007a; 2008a; 2009c).

The 1977 316(b) rule included a provision to select Representative Important Species (RIS) to focus the investigations, and previous demonstrations evaluated RIS as well as additional target species (PSEG, 1984; 1999a). The 2006 CDS used the term Representative Species (RS) to comprise both RIS and target species and to be consistent with the published Phase II Rule. RS were selected based on several criteria including susceptibility to impingement and entrainment at the facility, importance to the ecological community, recreational or commercial value, and threatened or endangered status (PSEG, 2006c).

The 1984 316(b) Demonstration was a five-year study from 1978 to 1983 that focused on 11 RS, including nine fish species and two macroinvertebrates. These species are weakfish (*Cynoscion regalis*), bay anchovy (*Anchoa mitchilli*), white perch (*Morone americana*), striped bass (*Morone saxatilis*), blueback herring (*Alosa aestivalis*), alewife (*Alosa pseudoharengus*), American shad (*Alosa sapidissima*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), opossum shrimp (*Neomysis americana*), and scud (*Gammarus* sp.) (PSEG, 1984).

In 1999 PSEG submitted a 316(b) demonstration that included the same RS fish species as the previous studies and added the blue crab (*Callinectes sapidus*). Scud and opossum shrimp were removed from the list of RS because they have high productivity, high natural mortality, and assessments completed prior to PSEG's 1999 NJPDES application concluded that Salem does not and will not have an adverse environmental impact on these macroinvertebrates (PSEG, 1999a).

The 316(b) demonstration submitted during the 2006 NJPDES renewal process included an estimation of entrainment losses for the RS developed from data collected during annual entrainment monitoring conducted in accordance with the IBMWP. A revised RS list was developed that included the nine finfish and the blue crab from previous studies and added the Atlantic silverside (*Menidia menidia*), Atlantic menhaden (*Brevoortia tyrannus*), and bluefish (*Pomotomus saltrix*) (PSEG, 2006c).

Entrainment samples typically were collected from the circulating water system intake bays 11A, 12B, or 22A or at discharge standpipes 12 or 22. From August 1977 through May 1980, intake samples were collected from the circulating water after it passed through the travelling screens and the circulating water pumps. In June 1980 the sample location was changed to the discharge pipes (PSEG, 1984). Beginning in 1994, samples were collected from either intake bay 12B or 22A (PSEG, 1996; 1997; 1998; 1999b; 2000; 2001; 2002; 2003; 2004; 2005; 2006a; 2007a; 2008a; 2009c).

Samples were collected by pumping water through a Nielsen fish pump through a 1.0 meter (m; 3.2 feet [ft]) diameter, 0.5 milimeter (mm; 0.02 inches) mesh, conical plankton net in an abundance chamber. A total sample volume of 50 to 100 m^3 (13,000 to 26,000 gallons) was filtered at a rate not to exceed 2.0 m^3/minute (500 gpm). Sample contents were rinsed into a jar and preserved for laboratory analysis. Ichthyoplankton collected was identified to the lowest practical taxon and life stage, counted, and a subset was measured (PSEG, 1984).

From August 1977 to April 1978, entrainment samples were collected monthly from September through May and twice monthly from June through August. In 1979, samples were collected once monthly in March, April, October, and November; twice monthly in May, August, and September, and four times monthly in June and July. In 1980 through 1982 additional samples were collected every fourth day from May through October. Samples were collected every 4 hours (hrs) during a 24-hr period (PSEG, 1984). In 1994 and 1995 samples were collected three times a day, once a week from January through December (PSEG, 1994; 1996). Beginning in April 1996 samples were typically collected three times a week in the summer months (April through September) and once a week throughout the remainder of the year (PSEG, 1997; 1998; 1999b; 2000; 2001; 2002; 2003; 2004; 2005; 2006a; 2007a; 2008a; 2009c). Samples were collected every 4 hrs during a 24-hr period.

Ichthyoplankton samples also were collected from June through August in 1981 and 1982 adjacent to the intake structure in five horizontal offshore strata to develop model inputs for bay anchovy and weakfish. These samples were collected with a conical plankton net 0.5 m (1.6 ft) wide with a mesh size of 0.5 mm (0.02 in; PSEG, 1984).

Entrainment survival studies were conducted from 1977 through 1982. Survival studies were conducted twice in 1977 and three times in 1978. In 1979 no samples were collected for survival studies. In 1980 sampling was conducted from April through October with 10 events. In 1981 and 1982 the sampling schedule was expanded to include four times monthly in June and July, twice monthly in May and August, and once each in September and October with 14 events occurring in May through October of 1981 and 11 events in June through September of 1982. Sampling locations for the survival studies were the same as for the abundance studies. Intake and discharge locations were sampled with a lag to account for plant transit time with duplicate sampling gear to account for sampling induced mortality (PSEG, 1984).

Samples were collected using a centrifugal fish transfer pump and a one-screen larval table until 1980. After 1980 a low velocity flume was used to allow for a larger sample volume. Specimens were taken to an onsite laboratory where their condition was recorded. Individuals were classified as live, stunned, or dead according to pre-established criteria. Live and stunned specimens were held for 12 hrs to determine latent mortality (PSEG, 1984).

In addition, tests were conducted from 1979 through 1981 to quantify mortality caused by the collection equipment. Tests were conducted with alewife, blueback herring, white perch, weakfish, spot, *N. americana*, and *Gammarus* spp. Mortality rates due to the larval table, the low velocity flume, and the fish pump combined with the larval table were estimated separately. Entrainment simulation tests also were conducted from 1974 through 1982 to quantify the effects of pressure and temperature changes on entrained organisms (PSEG, 1984).

For the 1984 316(b) Demonstration, weekly entrainment densities (numbers of organisms per volume of water) were estimated based on densities in both the intake and the estuary. These projected densities then were used along with estimated weekly mortality rates to project annual entrainment losses due to the facility. Weekly mortality rates were estimated from the results of the onsite studies, simulation studies conducted in the laboratory, and literature values. Mortality rates were calculated for the effects of mechanical and chemical stresses separately from thermal stresses. Total entrainment mortality was estimated under the assumption that the thermal and nonthermal mortality rates are independent of one another as shown in the following equation (PSEG, 1984).

$$M_T = 1 - (1 - M_n) \times (1 - M_t)$$

where

M_T = total entrainment mortality rate

M_n = nonthermal mortality rate

M_n = thermal mortality rate

Projected entrainment losses for each species were calculated on a daily basis using the following equation. Daily entrainment losses were then summed on a weekly basis and projected based on plant operating schedules (PSEG, 1984).

Daily entrainment loss = $CWS1_i + SWS1_i + CWS2_i + SWS2_i$

$CWS1_i = K1 \times Density_i \times (F_i - R \times F_i) / (1 - R + R \times F_i)$

$SWS1_i = K2 \times Density_i \times (1 – R)$

where

$CWS1_i$ = entrainment loss at Unit No. 1 circulating waters system (CWS) on the i th day

$SWS1_i$ = entrainment loss at Unit No. 1 service water system (SWS) on the i th day

$CWS2_i$ = entrainment loss at Unit No. 2 CWS on the i th day

$SWS2_i$ = entrainment loss at Unit No. 2 SWS on the i th day

K1 = plant withdrawal at Unit No. 1 CWS on the i th day

= 11.672 m^3/sec x 86,400 seconds x the number of CWS pumps operating in Unit No. 1

K2 = plant withdrawal at Unit No. 1 SWS on the i th day

= 0.686 m^3/sec x 86,400 seconds x the number of CWS pumps operating in Unit No. 1

$Density_i$ = estimated entrainment density on the i th day

F_i = estimated total entrainment density on the i th day

R = recirculation factor

The 1999 316(b) Demonstration (PSEG, 1999a) used data from entrainment monitoring that was conducted annually from 1995 through 1998 in accordance with the BMWP. PSEG calculated total entrainment loss by species and life stage by summing the individual occurrences in samples taken at the intakes for both the circulating water system (CWS) and the service water system (SWS) for Units 1 and 2; using correction factors for collection efficiency, recirculation (re-entrainment), and mortality; and then scaling for plant flow. The equation used for this calculation of entrainment loss follows (PSEG, 1999a).

$$E = \sum_{i=1}^{K} \sum_{j=1}^{365} D_y \cdot C^{-1} \cdot \left(\frac{f_{y-} R f_{ij}}{1 - R + R f_{ij}} \right) \cdot Q_y$$

where

E = entrainment (number of organisms)

i = i [th] water system, i.e., Unit 1 CWS, Unit 1 SWS, Unit 2 CWS, and Unit 2 SWS

j = j [th] day of the year

D_y = average concentration (number per m^3 of intake water)

C = collection efficiency

F_{ij} = daily through-plant mortality

R = recirculation factor

Q_y = average daily plant flow for *i* [th] water system (m^3)

PSEG (1999a) used the results of these calculations to estimate densities for each week of the year, which then were scaled up based on weekly flow through the facility to estimate total entrainment losses for each year by species (Table 4-6). The years 1978 through 1981 were a transitional period between the beginning of commercial operation of Salem Unit 1 in 1978 and Unit 2 in 1982 (PSEG, 1999a).

In the 2006 316(b) Demonstration, PSEG estimated annual entrainment losses for the years 2002 through 2004 by using entrainment density data from sampling conducted at the intakes and scaling for total water withdrawal volume using the same methodology as described above for the 1999 316(b) study (Table 4-7). Entrainment losses were calculated by assuming an entrainment mortality rate of 100 percent (PSEG, 2006c). From 1978 through 1998 (Table 4-6) and 2002 through 2004 (Table 4-7), bay anchovy was the species with the greatest entrainment losses for all life stages (PSEG, 1999a; 2006c).

Results of the annual entrainment monitoring for the RS at Salem from 1995 through 2008 were reported in annual biological monitoring reports for 1995 through 2008 (PSEG, 1996; 1997; 1998; 1999b; 2000; 2001; 2002; 2003; 2004; 2005; 2006a; 2007a; 2008a; 2009c). Total annual entrainment was reported by species and life stage based on mean density expressed as number of organisms per 100 cubic meters (n/100 m^3) of water withdrawn through the intake screens (Table 4-8).

Table 4-9 provides a list of species collected during the annual entrainment monitoring conducted at Salem from 1995 through 2008 and their average densities in cooling water during that period. On average, the RS constituted approximately 75 percent of total entrainment abundance based on average densities for these species from 1995 through 2008, and bay anchovy alone made up approximately 50 percent of total entrainment during this period.

Entrainment Reductions

Due to the potential for entrainment to have adverse effects on the aquatic environment in the vicinity of Salem, and in response to the requirements of the 1994 NJPDES permit, PSEG has employed technological and operational changes to reduce entrainment and impingement and mitigate their effects on the Delaware Estuary. While improvements to the cooling water intake system were targeted mainly toward reducing impingement mortality, improvement in entrainment rates also has resulted. In response to the requirements of the 1994 NJPDES permit, PSEG made modifications to the trash racks, intake screens, and fish return system (PSEG, 1999a).

Improved intake screen panels were installed that use a thinner wire in the mesh (14 gage instead of 12 gage), which in combination with smaller screen openings allowed for a 20 percent decrease in through-screen velocity. Lower velocities through the screens allow more small fish to be able to swim away from the screens and escape entrainment. Screen openings also were reduced in size from 10 mm (3/8 inch) square mesh to 6 mm (1/4 inch) wide by 13 mm (1/2 inch) high rectangular mesh. The smaller screen openings reduce the size of organisms that can be drawn through the screens, thus reducing entrainment. The smaller screen mesh excludes more organisms, which then may be impinged and could be returned to the estuary alive (PSEG, 1999a). While impingement mortality rates for these smaller organisms generally are higher than for larger organisms, they are lower than estimated entrainment mortality rates (PSEG, 1999a).

Table 4-6. Estimated Annual Entrainment Losses for Representative Species (RS) at Salem, 1978 to 1998

Year	Estimated Annual Entrainment Losses (in Millions)										
	Alewife	American shad	Atlantic croaker	Bay anchovy	Blueback herring	Striped bass	Spot	Weakfish	White perch	Atlantic menhaden	Silversides[(1)]
1978	0.008	0.004	0.784	7,962.1	0.775	0.026	5.096	399.818	0.000	0.000	79.935
1979	0.050	0	14.515	3,535.1	0.019	0.020	1.095	23.193	0.625	0.072	18.083
1980	0.860	0.015	0.756	15,155.9	2.813	0	10.296	256.708	27.514	4.277	145.109
1981	2.002	0	8.157	11,714.1	11.853	0	5.418	45.765	0.969	9.207	113.240
1982	0	0	0	3,712.9	0.017	0	29.963	74.457	18.857	4.157	22.201
1985	0.163	0.126	0.933	29,463.7	1.151	0	0.184	63.616	0.447	0	0
1986	0.348	0.059	0.492	45,248.6	1.594	0	0.858	110.397	0.654	0	0
1987	0	0.062	0.000	40,172.4	0.082	0	0.055	61.267	0.628	0	0
1988	0.749	0	1.710	22,331.5	2.988	0	73.502	57.063	8.968	0	0
1989	0.541	0	56.341	10,163.5	2.395	47.946	1.027	3.026	192.131	0	0
1990	0.101	0	123.375	7,678.4	0.260	1.313	4.395	6.685	2.626	0	0
1991	0	0	131.798	19,506.6	0	0.778	1.096	72.478	1.108	0	0
1992	0.319	0	71.352	1,570.5	0.864	1.728	0.000	10.375	3.393	0	0
1993	0.676	0	75.030	11,774.2	2.340	108.065	0.585	122.672	37.635	0	0
1994	0.697	0	24.783	1,120.3	2.623	7.490	46.859	88.781	66.927	0	0
1995	0.477	0.014	31.454	1,404.5	0.082	0.579	0.071	335.083	2.039	177.221	31.019
1996	0.083	0.028	4.385	70.6	0.425	7.289	0.025	14.258	16.800	3.039	1.227
1997	0.053	0.747	71.819	1,811.8	0.318	6.505	0.007	12.601	7.865	16.668	6.919
1998	14.480	0	132.130	2,003.7	59.282	448.563	0.020	76.343	412.839	480.557	51.528

[(1)] Silversides were not identified to species.

Source: NJPDES Application (PSEG, 1999a).

Table 4-7. Estimated Annual Entrainment and Annual Entrainment Losses for Representative Species (RS) at Salem, 2002-2004

	Total Entrained (in millions)			Entrainment Losses (in millions)		
Taxon	**2002**	**2003**	**2004**	**2002**	**2003**	**2004**
Alewife	9.8	5.2	2.5	9.4	4.5	2.4
American shad	0	0	0	0	0	0
Atlantic croaker	448.0	211.5	213.2	182.5	86.4	87.9
Bay anchovy	946.4	366.4	2,343.2	946.4	366.4	2,343.2
Blueback herring	1.1	1.7	1.1	1.0	1.6	0.934
Spot	2.3	0.047	0	0.454	0.009	0
Striped bass	403.6	120.3	35.7	159.5	37.6	14.3
Weakfish	29.2	11.9	46.8	19.2	8.5	32.8
White perch	18.7	19.5	25.8	18.0	13.9	23.9
Atlantic silverside	44.8	3.6	10.1	44.8	3.6	10.1
Atlantic menhaden	190.3	4.9	6.8	190.3	4.9	6.8

Source: Comprehensive Demonstration Study (PSEG, 2006c).

Table 4-8. Entrainment Densities for Representative Species (RS) at Salem, 1995-2008

	Density (n/100 m^3)													
Taxon	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Alewife	0.01	–	–	–	–	–	0.05	<0.01	0.11	0.02	<0.01	0.02	0.05	<0.01
American shad	–	0.01	0.01	–	–	0.00	–	–	–	–	–	–	–	–
Atlantic croaker	3.03	1.60	8.19	9.48	15.45	6.70	4.17	12.52	2.62	5.05	5.56	10.51	5.88	7.74
Atlantic menhaden	2.91	0.38	0.46	1.68	2.23	1.34	1.04	4.92	0.20	0.47	1.06	5.01	1.47	16.21
Atlantic silverside	0.13	0.29	0.69	0.22	2.20	0.36	0.09	0.95	0.15	0.47	0.55	0.29	0.12	0.10
Bay anchovy	66.55	17.43	42.95	61.88	292.14	12.72	8.86	24.18	13.15	100.52	54.57	101.45	174.66	41.87
Blueback herring	–	0.02	–	0.00	0.01	0.09	0.03	0.01	<0.01	0.02	<0.01	<0.01	0.01	<0.01
Blueback herring/alewife	0.01	0.12	–	2.06	0.02	0.05	0.01	0.11	0.07	0.07	0.05	–	0.03	0.72
Bluefish	0.01	–	–	–	–	0.00	–	–	–	–	–	–	–	<0.01
Spot	0.01	–	–	0.00	0.09	0.09	0.01	0.10	<0.01	–	0.25	<0.01	0.03	0.14
Striped bass	0.03	1.55	0.02	11.50	0.03	13.97	9.07	7.20	5.07	1.84	4.03	0.55	42.34	1.72
Weakfish	11.86	3.69	0.76	1.99	6.61	2.48	2.25	0.64	0.43	1.10	2.09	0.70	1.44	0.52
White perch	0.02	0.88	–	4.49	0.11	6.15	0.06	0.10	0.44	0.64	0.24	0.55	1.19	0.01
White perch/striped bass	0.06	1.10	–	3.63	0.00	–	–	<0.01	0.87	0.44	0.40	0.11	10.69	0.02
Eggs	47.54	0.51	21.41	41.84	278.18	0.35	2.97	8.42	2.06	74.22	28.56	78.20	149.59	23.82
Larvae	48.46	26.52	31.66	78.64	97.93	47.13	29.13	67.53	46.10	51.12	62.67	82.92	103.57	39.65
Juveniles	11.84	7.87	19.15	13.11	21.17	11.10	7.27	16.74	5.67	7.84	9.46	15.99	10.79	21.86
Adults	0.14	0.07	0.20	0.23	0.29	0.18	0.13	0.15	0.15	0.20	0.27	0.26	0.25	0.19

Note: Blank spaces (–) indicate the species was not identified in entrainment samples that year.

Source: Biological Monitoring Program Annual Reports (PSEG, 1996; 1997; 1998; 1999b; 2000; 2001; 2002; 2003; 2004; 2005; 2006a; 2007a; 2008a; 2009c).

Table 4-9. Species Entrained at Salem During Annual Entrainment Monitoring, 1995-2008

Common Name	Scientific Name	Average Density (n/100 m^3)
Bay anchovy	***Anchoa mitchilli***	**72.35**
Naked goby	*Gobiosoma bosc*	27.58
Striped bass	***Morone saxatilis***	**7.07**
Atlantic croaker	***Micropogonias undulatus***	**7.04**
Atlantic menhaden	***Brevoortia tyrannus***	**6.91**
Weakfish	***Cynoscion regalis***	**2.81**
Goby	Gobiidae	2.61
White perch/striped bass	***Morone* spp.**	**1.57**
White perch	***Morone americana***	**1.15**
Atlantic silverside	***Menidia menidia***	**0.66**
Unidentifiable silverside	Antherinidae	0.47
Blueback herring/alewife	***Alosa spp.***	**0.37**
Silversides	*Menidia* spp.	0.22
Northern pipefish	*Syngnathus fuscus*	0.18
American eel	*Anguilla rostrata*	0.13
Unidentifiable fish		0.13
Summer flounder	*Paralichthys dentatus*	0.12
Hogchoker	*Trinectes maculatus*	0.10
Spot	***Leiostomus xanthurus***	**0.09**
Inland silverside	*Menidia beryllina*	0.08
Herrings	Clupeidae	0.08
Black drum	*Pogonias cromis*	0.07
Carps and minnows	Cyprinidae	0.06
Gizzard shad	*Dorosoma cepedianum*	0.06
Unidentifiable larvae		0.06
Atlantic herring	*Clupea harengus*	0.06
Alewife	***Alosa pseudoharengus***	**0.05**
Smallmouth flounder	*Etropus microstomus*	0.04
Rough silverside	*Membras martinica*	0.03
Blueback herring	***Alosa aestivalis***	**0.03**
Yellow perch	*Perca flavescens*	0.03
Spotted hake	*Urophycis regia*	0.02
Killifishes	*Fundulus* spp.	0.02
Mummichog	*Fundulus heteroclitus*	0.01
Northern searobin	*Prionotus carolinus*	0.01
Quillback	*Carpiodes cyprinus*	0.01
Unidentifiable eggs		0.01
Silver perch	*Bairdiella chrysoura*	0.01
Winter flounder	*Pseudopleuronectes americanus*	0.01

Common Name	Scientific Name	Average Density (n/100 m^3)
Threespine stickleback	*Gasterosteus aculeatus*	0.01
Atlantic needlefish	*Strongylura marina*	0.01
Unidentifiable		0.01
Blackcheek tonguefish	*Symphurus plagiusa*	0.01
Oyster toadfish	*Opsanus tau*	0.01
Common carp	*Cyprinus carpio*	0.01
American shad	***Alosa sapidissima***	**0.01**
Striped cusk-eel	*Ophidion marginatum*	0.01
Windowpane	*Scophthalmus aquosus*	0.004
Green goby	*Microgobius thalassinus*	0.004
Northern puffer	*Sphoeroides maculatus*	0.004
Feather blenny	*Hypsoblennius hentz*	0.004
American sand lance	*Ammodytes americanus*	0.004
Bluefish	***Pomatomus salatrix***	**0.003**
Unidentifiable juvenile		0.003
Striped searobin	*Prionotus evolans*	0.003
Conger eel	*Conger oceanicus*	0.003
Inshore lizardfish	*Synodus foetens*	0.003
Unidentifiable drum	Sciaenidae	0.003
Eastern silvery minnow	*Hybognathus regius*	0.003
Perches	Percidae	0.003
Northern kingfish	*Menticirrhus saxatilis*	0.003
Bluegill	*Lepomis macrochirus*	0.002
Banded killifish	*Fundulus diaphanus*	0.002
Unidentifiable sucker	Catostomidae	0.002
Striped anchovy	*Anchoa hepsetus*	0.002
Northern stargazer	*Astroscopus guttatus*	0.002
White crappie	*Pomoxis annularis*	0.002
Tautog	*Tautoga onitis*	0.002
Unidentifiable porgy	Sparidae	0.001
Spanish mackerel	*Scomberomorus maculatus*	0.001
Black sea bass	*Centropristis striata*	0.001
Sheepshead minnow	*Cyprinodon variegauts*	0.001
Striped killifish	*Fundulus majalis*	0.001
Unidentifiable sunfish	Centrarchidae	0.001
White sucker	*Catostomus commersoni*	0.001
Channel catfish	*Ictalurus punctatus*	0.001

(1) Species in **bold** are RS at Salem.

(2) Average density expressed as number of organisms entrained (n) per 100 cubic meters (m^3) of water withdrawn through the intake screens.

Source: Biological Monitoring Program Annual Reports (PSEG, 1996; 1997; 1998; 1999b; 2000; 2001; 2002; 2003; 2004; 2005; 2006a; 2007a; 2008a; 2009c).

Table 4-10. Entrainment Densities for Representative Species (RS) at Salem, 1978-2008

	Density (n/100 m^3)														
Taxon	**1978**	**1979**	**1980**	**1981**	**1982**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**
Alewife	–	–	0.03	–	–	–	0.01	–	0.01	–	–	–	–	–	–
Alosa sp.	–	–	–	–	–	–	–	–	–	0.14	0.01	–	0.02	0.15	0.11
American shad	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Atlantic croaker	0.10	0.02	0.02	1.24	–	0.02	0.07	–	0.07	2.76	0.72	3.47	2.51	2.71	1.19
Atlantic menhaden	–	0.02	0.25	1.13	0.27	–	–	–	–	–	–	–	–	–	–
Atlantic silverside	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Bay anchovy	349.64	1848.55	845.68	706.22	148.12	1799.26	2527.17	2094.53	618.68	314.27	243.26	416.78	111.59	416.25	27.22
Blueback herring	0.06	–	0.07	0.12	–	0.03	–	–	0.04	–	–	–	–	–	–
Blueback herring/alewife	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Morone sp.	–	–	–	–	–	–	–	–	–	0.21	0.01	–	0.03	0.90	0.01
Bluefish	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Silversides	6.32	15.33	4.77	4.04	0.86	–	–	–	–	–	–	–	–	–	–
Spot	0.07	0.10	1.53	0.86	3.69	0.04	0.01	–	1.64	0.02	0.16	0.09	–	0.01	1.17
Striped bass	0.05	–	–	–	–	–	–	–	–	1.87	0.01	0.03	0.06	3.63	0.29
Weakfish	16.31	3.35	5.15	1.20	2.63	1.77	4.50	3.09	1.11	0.08	0.28	1.43	0.25	1.91	2.46
White perch	–	–	0.09	–	0.26	–	0.01	0.01	0.10	4.16	0.03	0.01	0.07	0.46	0.81
White perch/striped bass	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Taxon	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Alewife	0.01	–	–	–	–	–	0.05	< 0.01	0.11	0.02	< 0.01	0.02	0.05	< 0.01
Alosa sp.	0.01	0.13	–	1.58	–	–	–	–	–	–	–	–	–	–
American shad	0.01	–	–	–	–	0.00	–	–	–	–	–	–	–	–
Atlantic croaker	3.07	1.64	12.48	8.52	15.45	6.70	4.17	12.52	2.62	5.05	5.56	10.51	5.88	7.74
Atlantic menhaden	2.90	0.37	0.86	3.19	2.23	1.34	1.04	4.92	0.20	0.47	1.06	5.01	1.47	16.21
Atlantic silverside	–	–	–	–	2.20	0.36	0.09	0.95	0.15	0.47	0.55	0.29	0.12	0.10
Bay anchovy	64.18	17.63	52.89	53.31	292.14	12.72	8.86	24.18	13.15	100.52	54.57	101.45	174.66	41.87
Blueback herring	–	0.02	–	0.10	0.01	0.09	0.03	0.01	< 0.01	0.02	< 0.01	< 0.01	0.01	< 0.01
Blueback herring/alewife	–	–	–	–	0.02	0.05	0.01	0.11	0.07	0.07	0.05	–	0.03	0.72
Morone sp.	0.06	1.11	–	2.92	–	–	–	–	–	–	–	–	–	0.02
Bluefish	–	–	–	–	–	0.00	–	–	–	–	–	–	–	< 0.01
Silversides	0.99	0.30	0.96	0.87	–	–	–	–	–	–	–	–	–	–
Spot	0.01	0.03	–	0.00	0.09	0.09	0.01	0.10	< 0.01	–	0.25	< 0.01	0.03	0.14
Striped bass	0.03	1.58	0.03	9.92	0.03	13.97	9.07	7.20	5.07	1.84	4.03	0.55	42.34	1.72
Weakfish	11.78	3.75	0.77	1.80	6.61	2.48	2.25	0.64	0.43	1.10	2.09	0.70	1.44	0.52
White perch	0.02	0.90	–	3.73	0.11	6.15	0.06	0.10	0.44	0.64	0.24	0.55	1.19	0.01
White perch/striped bass	–	–	–	–	0.00	–	–	< 0.01	0.87	0.44	0.40	0.11	10.69	–

Note: Blank spaces (–) indicate the species was not identified in entrainment samples that year.
Source: Biological Monitoring Program Annual Reports (PSEG, 2000; 2001; 2002; 2003; 2004; 2005; 2006a; 2007a; 2008a; 2009c)

4.5.3 Impingement of Fish and Shellfish

Impingement occurs when fish and shellfish are held against the intake screens by the force of the water being drawn into the cooling system. Impingement mortality can occur directly as a result of the force of the water, or indirectly due to stresses from the time spent on the screens or as a result of being washed off the screens.

Regulatory Background

EPA regulates impingement and entrainment under Section 316(b) of the CWA through the NPDES permit renewal process. A history of NPDES permitting at Salem can be found in Section 4.5.2 under the heading Regulatory Background.

Impingement Studies

PSEG has performed annual impingement monitoring at the Salem plant since 1977 in order to determine the impacts that impingement at Salem might have on the aquatic environment of the Delaware Estuary. The monitoring program described in the early 316(b) demonstration focused on seven target fish species. The two macroinvertebrates included in the entrainment study program are too small to be impinged and, therefore, were not included in the impingement study program. The fish species are weakfish, bay anchovy, white perch, striped bass, blueback herring, alewife, American shad, spot, and Atlantic croaker (PSEG, 1984).

Impingement abundance samples were collected at the CWS and SWS intakes from May 1977 through December 1982. CWS samples were collected at least four times per day at six-hour intervals three days a week from May 1977 through September 1978. In September 1978 sampling frequency was increased to a minimum of 10 samples per day six days a week. In the spring of 1980, sampling frequency was reduced to four times a day, but remained at six days a week (PSEG, 1984).

Impinged organisms are washed off the CWS intake screens and returned to the Delaware Estuary through a fish return system. Impingement samples were collected in fish counting pools constructed for this purpose that are located adjacent to the fish return system discharge troughs at both the northern and southern ends of the CWS intake structure. Screen-wash water was diverted into the counting pools for an average sample duration of 3 minutes (min; depending on debris load, sampling time varied from 1 to 15 min). Water then was drained from the pools, and organisms were sorted by species, counted, measured, and weighed (PSEG, 1984).

Impingement abundance samples were collected from the SWS intake screens by a high-pressure spray wash into collection baskets through a trough. Screen washes were conducted at either 12 hr or 24 hr intervals depending on debris loads. Samples were collected from the SWS three times a week from April 1977 through September 1979. Organisms were sorted, counted, and weighed (PSEG, 1984).

Special impingement-related studies in addition to impingement monitoring studies also were performed. Studies were conducted from 1979 through February 1982 to quantify impingement collection efficiency. Studies of blueback herring, bay anchovy, white perch, weakfish, spot, and Atlantic croaker were conducted to determine the percentage of different size classes of fish that would not be collected by the screen washing and fish collection procedures (PSEG, 1984).

Because individual organisms that are impinged on the intake screens are washed off and returned to the estuary, studies of impingement mortality rates also were conducted from May 1977 through December 1982. Studies were conducted to estimate the percentage of impinged individuals that do not survive being impinged and washed from the intake screens (initial mortality) and the percentage that exhibit delayed mortality and do not survive for a longer period of at least two days (extended or latent mortality). Studies of initial mortality were conducted at a rate of three times per week until October 1978, after which samples were collected six times per week if impingement levels for target species exceeded predetermined levels. Initial mortality studies were conducted using the same counting pools as the abundance samples. Screen-wash water was diverted into the counting pool, samples were held for five min, the water was drained from the pool, and organisms were sorted as live, damaged, or dead. Each subset was identified to species and the total number and weight, maximum and minimum lengths, and length frequency distribution were recorded. Studies of latent mortality were conducted using the organisms classified as live or damaged in the studies of initial mortality. At the beginning of the latent mortality studies, only organisms classified as live were used, but damaged fish also were evaluated after November 1978. Two-day latent mortality studies were conducted at least weekly and entailed holding impinged organisms in aerated tanks for 48 hrs. Organisms were monitored continuously for the first 30 min, at hour intervals for the next four hrs, and then at approximately 24-hr intervals. Control specimens also were collected with a seine and subjected to the same survival study (PSEG, 1984).

Impingement mortality was found to be seasonally variable and dependent on several environmental factors, including temperature and salinity. Initial and latent mortality rates were estimated on a monthly basis and summed to provide a total mortality rate (PSEG, 1984). Estimated impingement mortality rates by species evaluated are summarized in Table 4-11.

Table 4-11. Estimated Impingement Mortality Rates by Species at Salem, 1977-1982

Taxon	Estimated Impingement Mortality (percent)
Spot	30.2 – 67.7
Blueback herring	71.9 - 100
Alewife	72.6 – 100
American shad	20.8 – 100
Atlantic croaker	38.8 – 87.9
Striped bass	10.0 – 84.8
White perch	29.4 – 52.9
Bay anchovy	77.0 – 95.1
Weakfish	71.2 – 78.3

Source: PSEG, 1984.

PSEG submitted a 316(b) demonstration in 1999 as part of the application for NJPDES permit renewal (PSEG, 1999a). This demonstration assessed the effects of Salem's cooling water intake structure on the biological community of the Delaware Estuary (PSEG, 1999a). It focused on the same RS fish species as the earlier studies and added the blue crab (*Callinectes sapidus*). Impingement losses at Salem were estimated using impingement density (the number of impinged individuals collected divided by the total volume sampled, expressed as number/m^3) and adjusting for impingement survival, collection efficiency, and recirculation factor. This result was then scaled by month using the water withdrawal rates and summed for the year to provide annual impingement losses for the facility. Estimated annual impingement losses for the RS at Salem from 1978 through 1998 are summarized in Table 4-12. Bay anchovy was the species most frequently lost to impingement from 1978 to 1998, constituting 46 percent of the RS impingement loss. Weakfish was the next most frequently lost species, making up 20 percent of the RS impingement losses (PSEG, 1999a).

Impingement monitoring was conducted annually in accordance with the BMWP from 1995 through 2002. In 2002, the IBMWP was developed to include improvements to the BMWP. These monitoring plans include provisions to quantify impingement and entrainment losses at Salem, as well as fish populations in the Delaware Estuary and the positive effects of the restoration program (PSEG, 2006c).

Table 4-12. Estimated Annual Impingement Losses for Representative Species (RS) at Salem, 1978 to 1998

	Estimated Annual Impingement Losses									
Year	Alewife	American Shad	Atlantic croaker	Bay anchovy	Blueback herring	Blue crab	Spot	Striped bass	Weakfish	White perch
1978	17,057	4,549	125,822	2,623,694	438,248	111,627	84,519	3,213	6,391,256	254,688
1979	11,513	2,144	8,494	1,321,105	651,005	97,434	292,471	9,625	580,628	541,715
1980	11,301	6,382	93,232	11,046,658	460,638	501,000	146,794	4,350	1,821,462	403,453
1981	647,832	8,820	14,996	11,264,933	364,803	347,436	857,167	1,895	1,818,578	344,726
1982	46,951	9,406	2,975	3,846,612	418,130	122,032	979,961	542	967,867	261,912
1983	19,584	5,359	2,326	3,784,994	224,303	100,953	681,704	924	1,038,356	143,904
1984	128,002	3,266	853	2,444,847	1,335,665	87,890	316,579	430	357,125	300,333
1985	4,676	11,033	275,670	3,771,190	162,478	1,011,790	183,679	193	1,263,119	582,528
1986	20,788	11,007	233,915	2,011,567	467,361	1,228,076	52,445	2,875	756,956	1,033,048
1987	74,461	24,120	1,245,098	3,346,956	157,496	834,857	2,204	6,673	1,095,105	715,912
1988	31,082	35,182	4,046	4,657,784	357,896	1,247,649	1,917,236	10,450	427,218	646,825
1989	137,998	65,138	24,168	781,653	891,085	344,310	119,381	26,006	184,538	760,842
1990	50,074	15,393	5,787	1,373,446	168,555	178,511	120,833	28,003	170,778	768,431
1991	21,275	22,874	45,535	1,719,784	137,107	307,591	134,807	10,089	575,349	688,724
1992	23,847	64,807	55,267	1,286,667	120,649	370,591	2,999	20,966	841,319	1,158,199
1993	23,267	22,087	176,279	596,243	100,999	387,190	16,869	74,100	723,366	1,043,913
1994	22,946	6,315	31,538	178,764	31,835	491,199	247,677	23,612	2,130,349	1,266,489
1995	14,745	7,940	610,261	363,601	143,846	1,012,348	27,435	10,812	890,341	321,359
1996	1,321	829	21,010	18,802	5,548	83,457	7,281	9,191	130,459	75,006
1997	5,899	819	266,558	309,018	50,879	475,443	30,245	12,779	1,582,441	228,996
1998	8,037	2,214	2,370,135	1,104,126	57,267	280,741	2,654	10,660	1,572,811	124,351

Source: PSEG, 1999a.

The 316(b) demonstration submitted during the 2006 NJPDES renewal process (PSEG, 2006c) included the CDS as required by the Phase II rule and a demonstration that the plant satisfies the impingement mortality and entrainment reductions required by the rule. The CDS included an estimation of impingement losses for the RS developed from data collected during annual impingement monitoring conducted in accordance with the IBMWP. A revised RS list was developed for the IBMWP and subsequently used in the 2006 CDS that included the nine finfish and the blue crab from previous studies and added the Atlantic silverside (*Menidia menidia*), Atlantic menhaden (*Brevoortia tyrannus*), and bluefish (*Pomotomus saltrix*) (PSEG, 2006c).

Estimated annual impingement and impingement losses for the study period 2002 to 2004 are summarized in Table 4-13. Atlantic croaker was the species most impinged in 2002 and the RS most often lost to impingement that year. White perch was the RS most impinged in 2003 and 2004, while weakfish was the species most often lost to impingement in those years.

Table 4-13. Estimated Annual Impingement and Annual Impingement Losses for Representative Species (RS) at Salem, 2002-2004

	Total Impingement			Impingement Losses		
Taxon	**2002**	**2003**	**2004**	**2002**	**2003**	**2004**
Alewife	87,001	31,275	134,149	10,996	16,360	63,492
American shad	5,879	31,584	227,103	1,672	15,354	72,486
Atlantic croaker	21,313,809	620,754	3,260,494	6,332,522	143,298	332,644
Bay anchovy	424,168	475,799	544,177	197,496	326,839	341,135
Blueback herring	184,095	133,328	1,110,952	28,113	50,790	265,866
Spot	1,131	2,714	366	253	721	133
Striped bass	101,208	776,934	505,340	5,351	167,332	66,007
Weakfish	722,090	3,129,152	3,531,713	428,300	1,953,299	2,118,736
White perch	2,044,207	9,424,768	11,181,299	163,505	773,818	970,462
Atlantic silverside	509,142	220,114	156,495	138,270	44,951	48,609
Atlantic menhaden	534,646	31,211	20,420	360,931	21,769	15,724
Blue crab	2,739,118	356,983	831,320	172,725	27,483	57,931
Bluefish	45,292	31,311	44,533	3,884	7,592	17,433

Source: PSEG, 2006c.

Table 4-14 provides a summary of annual impingement densities based on monitoring results for RS at Salem from the annual monitoring reports for the period 1995 through 2007. Impingement densities were calculated by relating impingement abundance to the circulating water flow and extrapolating to the number of organisms impinged per million m^3 for every week of each year (PSEG, 1999a). The four most commonly impinged species were Atlantic croaker (23 percent), blue crab (21 percent), white perch (19 percent), and weakfish (14 percent). Table 4-15 provides a list of species collected and average densities impinged during this period.

Table 4-14. Impingement Densities for Representative Species (RS) at Salem, 1995-2008

	Density ($n/10^6$ m^3)													
Taxon	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Blue crab	1901.05	620.48	2033.08	824.27	636.84	393.89	606.88	502.13	76.41	171.28	1895.82	694.73	797.66	640.45
Alewife	3.09	5.47	10.8	12.09	15.78	27.41	20.55	13.91	4.84	25.99	8.19	2.41	7.66	0.66
American shad	3.1	2.63	1.00	3.39	14.5	3.82	0.57	0.79	6.43	43.24	10.11	4.01	16.98	1.7
Atlantic croaker	887.71	112.71	623.81	1489.08	625.94	403.53	412.56	3820.65	101.22	626.74	845.57	1405.31	951.09	545.25
Atlantic menhaden	14.72	9.9	38.36	78.79	15.78	20.5	25.55	88.9	6.26	4.82	22.22	44	27.49	57.85
Atlantic silverside	44.15	12.61	40.7	43.54	111.15	49.67	42.28	78.46	35.67	25.71	24.08	46.89	44.52	56.28
Bay anchovy	136.82	66.52	229.13	367	127.83	122.62	84.1	74.09	89.5	93.89	49.33	202.44	132.62	72.27
Blueback herring	30.78	8.64	126.62	107.8	110.7	73.14	81.06	31.05	23.27	156.55	19.75	25.37	17.76	7.34
Bluefish	2.69	8.88	6.41	4.79	2.55	6.00	1.14	7.89	8.14	11.67	2.06	7.44	2.95	5.7
Spot	10.28	3.38	88.74	3.94	0.53	7.28	0.05	0.34	0.8	0.14	55.11	10.38	3.73	23.65
Striped bass	64.89	82.05	62.91	28.61	52.83	102.49	54.62	20.04	159.93	110.86	29.72	10.22	47.88	32.56
White perch	641.12	543.08	1625.16	425.98	384.33	273.32	263.56	427.71	1771.18	2113.19	1042.62	360.51	429.81	662.14
Weakfish	1071.27	441.89	1370.74	528.95	228.01	369.57	524.64	172.98	530.71	725.72	930.88	343.81	379.65	304.8

Source: Biological Monitoring Program Annual Reports (PSEG, 1996; 1997; 1998; 1999b; 2000; 2001; 2002; 2003; 2004; 2005; 2006a; 2007a; 2008a; 2009c).

Table 4-15. Species Impinged at Salem and Average Impingement Densities, Based on Annual Impingement Monitoring for 1995-2008

Common Name(1)	Scientific Name(1)	Average Density ($n/10^6\ m^3$) (2)
Atlantic croaker	***Micropogonias undulatus***	**917.94**
Blue crab	***Callinectes sapidus***	**842.50**
White perch	***Morone americana***	**783.12**
Weakfish	***Cynoscion regalis***	**565.97**
Hogchoker	*Trinectes maculatus*	231.95
Spotted hake	*Urophycis regia*	135.03
Bay anchovy	***Anchoa mitchilli***	**132.01**
Striped bass	***Morone saxatilis***	**61.40**
Blueback herring	***Alosa aestivalis***	**58.56**
Atlantic silverside	***Menidia menidia***	**46.84**
Gizzard shad	*Dorosoma cepedianum*	42.11
Atlantic menhaden	***Brevoortia tyrannus***	**32.51**
Threespine stickleback	*Gasterosteus aculeatus*	27.64
Striped cusk-eel	*Ophidion marginatum*	20.78
Spot	***Leiostomus xanthurus***	**14.88**
Alewife	***Alosa pseudoharengus***	**11.35**
Northern searobin	*Prionotus carolinus*	10.53
American shad	***Alosa sapidissima***	**8.02**
Yellow perch	*Perca flavescens*	7.71
Black drum	*Pogonias cromis*	6.29
Atlantic herring	*Clupea harengus*	6.05
Eastern silvery minnow	*Hybognathus regius*	5.60
Bluefish	*Pomatomus saltatrix*	5.59
American eel	*Anguilla rostrata*	5.32
Channel catfish	*Ictalurus punctatus*	4.90
Silver perch	*Bairdiella chrysoura*	4.62
Summer flounder	*Paralichthys dentatus*	4.48
Northern kingfish	*Menticirrhus saxatilis*	4.29
Oyster toadfish	*Opsanus tau*	3.68
Northern pipefish	*Syngnathus fuscus*	3.59
Red hake	*Urophycis chuss*	3.26
Naked goby	*Gobiosoma bosc*	3.25
Winter flounder	*Pseudopleuronectes americanus*	2.59
Windowpane	*Scophthalmus aquosus*	2.41
Mummichog	*Fundulus heteroclitus*	2.13
Smallmouth flounder	*Etropus microstomus*	2.00
Bluegill	*Lepomis macrochirus*	1.89
Striped searobin	*Prionotus evolans*	1.81
Scup	*Stenotomus chrysops*	1.38
Harvestfish	*Peprilus alepidotus*	1.01
Striped killifish	*Fundulus majalis*	1.00
Butterfish	*Peprilus triacanthus*	0.87
Black sea bass	*Centropristis striata*	0.83
Brown bullhead	*Ameiurus nebulosus*	0.76
River herring	*Alosa* spp.	0.75
Unknown spp.	Unknown spp.	0.52

Common Name(1)	Scientific Name(1)	Average Density ($n/10^6\ m^3$) (2)
Sea lamprey	*Petromyzon marinus*	0.52
Skilletfish	*Gobiesox strumosus*	0.51
Rainbow smelt	*Osmerus punctatus*	0.48
Northern stargazer	*Astroscopus guttatus*	0.45
Fourspine stickleback	*Apeltes quadracus*	0.44
Conger eel	*Conger oceanicus*	0.43
Striped mullet	*Mugil cephalus*	0.43
Temperate bass	*Morone* sp.	0.38
Rough silverside	*Membras martinica*	0.36
Striped anchovy	*Anchoa hepsetus*	0.36
Inland silverside	*Menidia beryllina*	0.33
White mullet	*Mugil curema*	0.32
Spotfin butterflyfish	*Chaetodon ocellatus*	0.28
Atlantic needlefish	*Strongylura marina*	0.27
Yellow bullhead	*Ameiurus natalis*	0.26
Crevalle jack	*Caranx hippos*	0.25
Black crappie	*Pomoxis nigromaculatus*	0.24
Banded killifish	*Fundulus diaphanus*	0.24
Silver hake	*Merluccius bilinearis*	0.23
Lookdown	*Selene vomer*	0.20
Blackcheek tonguefish	*Symphurus plagiusa*	0.20
Permit	*Trachinotus falcatus*	0.16
Common carp	*Cyprinus carpio*	0.14
Sheepshead minnow	*Cyprinodon variegatus*	0.14
Pumpkinseed	*Lepomis gibbosus*	0.14
Northern puffer	*Sphoeroides maculatus*	0.14
Sheepshead	*Archosargus probatocephalus*	0.13
Florida pompano	*Trachinotus carolinus*	0.13
Fourspot flounder	*Paralichthys oblongus*	0.12
Smooth dogfish	*Mustelus canis*	0.12
Tessellated darter	*Etheostoma olmstedi*	0.12
Lined seahorse	*Hippocampus erectus*	0.11
Inshore lizardfish	*Synodus foetens*	0.11
Pinfish	*Lagodon rhomboides*	0.11
Golden shiner	*Notemigonus crysoleucas*	0.11
Atlantic spadefish	*Chaetodipterus faber*	0.10
White crappie	*Pomoxis annularis*	0.10
Unidentifiable Fish	Unidentifiable fish	0.10
White catfish	*Ameiurus catus*	0.10
White sucker	*Catostomus commersoni*	0.09
Spotfin killifish	*Fundulus luciae*	0.09
Pigfish	*Orthopristis chrysoptera*	0.09
Feather blenny	*Hypsoblennius hentz*	0.09
Spanish mackerel	*Scomberomorus maculatus*	0.09
Bluespotted cornetfish	*Fistularia tabacaria*	0.09
Spottail shiner	*Notropis hudsonius*	0.08
Goosefish	*Lophius americanus*	0.08
Atlantic thread herring	*Opisthonema oglinum*	0.07
Green sunfish	*Lepomis cyanellus*	0.07

Common Name(1)	Scientific Name(1)	Average Density ($n/10^6$ m^3) (2)
Redfin pickerel	*Esox americanus*	0.07
Spotfin mojarra	*Eucinostomus argenteus*	0.07
Redeared sunfish	*Lepomis microlophus*	0.07
Tautog	*Tautoga onitis*	0.06
Fat sleeper	*Dormitator maculatus*	0.06
Largemouth bass	*Micropterus salmoides*	0.06
Cownose	*Rhinoptera bonasus*	0.06
Satinfin shiner	*Cyprinella analostana*	0.06
Rainbow trout	*Oncorhynchus mykiss*	0.06
Redbreast sunfish	*Lepomis auritus*	0.06
Green goby	*Microgobius thalassinus*	0.06
Eastern mudminnow	*Umbra pygmaea*	0.06
Mud sunfish	*Acantharchus pomotis*	0.05
Atlantc sturgeon	*Acipenser oxyrhynchus*	0.05
Atlantic cutlassfish	*Trichiurus lepturus*	0.05
Southern kingfish	*Menticirrhus americanus*	0.05

(1) Species in **bold** are RS at Salem.
(2) Average density expressed as number of fish impinged (n) per million (10^6) cubic meters (m^3) of water withdrawn through the intake screens.
Source: Biological Monitoring Program Annual Reports (PSEG, 1996; 1997; 1998; 1999b; 2000; 2001; 2002; 2003; 2004; 2005; 2006a; 2007a; 2008a; 2009c).

Due to the differences in methods used during the more than 30 years since Salem Unit 1 began commercial operation in 1978, it is difficult to compare impingement estimates across studies. The NRC staff used impingement density as a metric to evaluate trends in impingement and abundance of RS in water withdrawn at the Salem intake over the operational period 1978 through 2008 (Table 4-16). NRC staff plotted impingement density by year to provide an indication of trends in the abundance of RS species at the Salem intake. The annual average densities of most of the 13 RS were highly variable from year to year, but trends were discernable for all but three species (Atlantic silverside, bay anchovy, and bluefish). Spot was the only species with an apparent overall trend of declining densities. In contrast, the densities of Atlantic menhaden appear to show a slight increasing trend, and the densities of eight species (alewife, American shad, Atlantic croaker, blue crab, blueback herring, striped bass, weakfish, and white perch) show apparent increasing trends, with most beginning notable increases in densities around 1993 to 1998. Overall, impingement densities of 12 of the 13 RS generally have been stable or increasing over the decades during which Salem has operated. The trend of declining densities of spot appears to reflect a widespread reduction in abundance in the species range well beyond Delaware Bay (ASFMC, 2008) and, thus, does not appear to be associated with Salem. Overall, these apparent trends do not suggest impacts on most fish populations in the estuary in the vicinity of the intake over the period of Salem operation.

Table 4-16. Impingement Densities for Representative Species (RS) at Salem, 1978-2008

	Density (n/10^6 m^3)															
Taxon	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
Alewife	0.26	0.95	0.89	26.35	2.02	0.75	3.81	0.13	0.75	2.04	0.94	3.70	1.33	0.75	0.89	0.91
American shad	0.12	0.39	0.41	0.38	0.69	0.38	0.20	0.48	0.64	1.04	1.57	2.78	0.70	1.14	4.04	0.95
Atlantic croaker	7.04	0.42	5.89	0.70	0.15	0.30	0.09	9.36	7.23	43.97	0.42	1.66	0.25	3.21	7.55	11.22
Atlantic menhaden	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Atlantic silverside	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Bay anchovy	228.56	204.95	459.35	406.60	97.15	142.69	106.59	81.99	55.35	78.23	94.96	19.52	36.61	40.94	17.09	16.44
Blue crab	56.97	44.45	151.83	66.59	16.33	16.24	19.73	141.62	181.63	109.58	160.39	47.22	38.04	45.42	75.99	65.48
Blueback herring	28.28	27.13	17.98	14.93	17.79	10.80	54.15	4.54	10.04	4.40	7.90	27.43	4.70	6.19	5.27	2.77
Bluefish	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Spot	15.42	52.60	17.58	45.34	60.92	47.50	32.48	4.37	3.85	0.09	96.29	7.08	5.43	5.38	0.12	0.98
Striped bass	0.83	2.58	0.64	0.18	0.09	0.04	0.08	0.13	0.39	1.95	1.62	3.84	3.84	2.08	3.59	15.85
Weakfish	910.81	149.03	105.78	78.91	43.69	49.78	30.34	55.38	36.60	52.25	18.39	7.27	10.70	25.20	48.07	40.86
White perch	32.27	69.78	33.33	33.24	25.47	20.91	23.30	25.69	75.29	49.20	38.93	52.33	57.08	52.80	55.23	123.43

	Density (n/10^6 m^3)														
Taxon	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Alewife	0.65	3.09	5.47	10.8	12.09	15.78	27.41	20.55	13.91	4.84	25.99	8.19	2.41	7.66	0.66
American shad	0.32	3.1	2.63	1	3.39	14.5	3.82	0.57	0.79	6.43	43.24	10.11	4.01	16.98	1.7
Atlantic croaker	3.59	887.71	112.71	623.81	1489.08	625.94	403.53	412.56	3820.65	101.22	626.74	845.57	1405.31	951.09	545.25
Atlantic menhaden	—	14.72	9.9	38.36	78.79	15.78	20.5	25.55	88.9	6.26	4.82	22.22	44	27.49	57.85
Atlantic silverside	—	44.15	12.61	40.7	43.54	111.15	49.67	42.28	78.46	35.67	25.71	24.08	46.89	44.52	56.28
Bay anchovy	5.11	136.82	66.52	229.13	367	127.83	122.62	84.1	74.09	89.5	93.89	49.33	202.44	132.62	72.27
Blue crab	88.60	1901.05	620.48	2033.08	824.27	636.84	393.89	606.88	502.13	76.41	171.28	1895.82	694.73	797.66	640.45
Blueback herring	1.30	30.78	8.64	126.62	107.8	110.7	73.14	81.06	31.05	23.27	156.55	19.75	25.37	17.76	7.34
Bluefish	—	2.69	8.88	6.41	4.79	2.55	6	1.14	7.89	8.14	11.67	2.06	7.44	2.95	5.7
Spot	26.78	10.28	3.38	88.74	3.94	0.53	7.28	0.05	0.34	0.8	0.14	55.11	10.38	3.73	23.65
Striped bass	0.73	64.89	82.05	62.91	28.61	52.83	102.49	54.62	20.04	159.93	110.86	29.72	10.22	47.88	32.56
Weakfish	132.51	1071.27	441.89	1370.74	528.95	228.01	369.57	524.64	172.98	530.71	725.72	930.88	343.81	379.65	304.8
White perch	96.26	641.12	543.08	1625.16	425.98	384.33	273.32	263.56	427.71	1771.18	2113.19	1042.62	360.51	429.81	662.14

Note: Blank spaces (–) indicate the species was not identified in impingement samples that year.

Source: Biological Monitoring Program Annual Reports (PSEG, 1996; 1997; 1998; 1999b; 2000; 2001; 2002; 2003; 2004; 2005; 2006a; 2007a; 2008a; 2009c).

Reductions in Impingement Mortality

Due to the potential for impingement to have adverse effects on the aquatic environment in the vicinity of Salem and requirements of the 1994 NJPDES permit, PSEG has taken steps to reduce impingement mortality and its effects in the Delaware Estuary. PSEG has made many improvements to the cooling water intake system at Salem over the years, including modifications to the intake screens and fish return system (PSEG, 1999a).

Improved intake screen panels have a smooth mesh surface to allow impinged fish to more easily slide across the panels. The Ristroph buckets and screen-wash system were modified to increase survival of impinged organisms. The new buckets are constructed from smooth, non-metallic materials and have several design elements that minimize turbulence inside the bucket, including a reshaped lower lip, mounting hardware located behind the screen mesh, a flow spoiler inside the bucket, and flap seals to prevent fish and debris from bypassing their respective troughs (PSEG, 1999a). The screen wash system was redesigned to provide an optimal spray pattern using low-pressure nozzles to more gently remove organisms from the screens prior to use of high pressure nozzles that remove debris. In addition, the maximum screen rotation speed was increased from 17.5 feet per minute (fpm) (5.3 m/min) to 35 fpm (11 m/min) to reduce the differential pressure across the screens during times of high debris loading. The screens are continuously rotated, and the rotation speed automatically adjusts as the pressure differential increases. The fish return trough was redesigned from the original rectangular trough to incorporate a custom formed fiberglass trough with radius rounded corners. The fish return system has a bi-directional flow that is coordinated with the tidal cycle to minimize re-impingement. The flow from the trough discharges to the downstream side of the cooling water intake system on the ebb tide and to the upstream side on the flood tide (PSEG, 1999a).

PSEG (199a) reports estimates of impingement mortality with the modified screens were compared to estimates of mortality with the original screens to assess the reduction in impingement mortality due to the screen modifications. The assessment relied on data from impingement studies conducted in 1995, 1997, and 1998 and compared to data collected in 1978 through 1982 when impingement survival studies were conducted for the original screen configuration. A side-by-side comparison also was conducted in 1995 when only one of the units had the modified intake system. Table 4-17 showing data from PSEG (1999a) provides a comparison of estimated impingement mortality rates for the original screens versus the modified screens.

PSEG (1999a) concluded that results from the comparison of 1997 and 1998 data for the modified screens to data from 1978 to 1982 for the original screens indicate that the modified intake system generally provides reductions in impingement mortality. The study found that white perch, bay anchovy, Atlantic croaker, spot, and *Alosa* species (blueback herring, alewife, and American shad combined) had lower mortality rates for all months studied during the 1997 and 1998 studies compared to those estimated for the 1978 to 1982 study of the original screens. In contrast, weakfish had higher mortality rates for the modified screens in June and July, but lower in August and September. Those authors speculated that this difference may result from the much smaller size of the weakfish impinged in June and July – impingement mortality rates for smaller fish generally are higher than for larger fish (however, they are lower than estimated entrainment mortality rates, and the modifications to improve impingement survival increase this difference). PSEG (1999a) found that the 1995 side-by-side study showed higher survival rate estimates for weakfish with the modified screens.

Table 4-17. Comparison of Impingement Mortality Rates (percent) for Original Screens (1978-1982 and 1995 Studies) and Modified Screens (1995 and 1997-1998 Studies)

		Original Screens		Modified Screens	
Taxon	**Month**	**1978-1982**	**1995**	**1995**	**1997-1998**
Weakfish	June	39	33	17	79
	July	51	31	18	82
	August	52	51	25	38
	September	40	-	-	12
	October	53	-	-	-
White perch	January	13	-	-	-
	February	16	-	-	-
	March	12	-	-	-
	April	15	-	-	7
	October	21	-	-	-
	November	16	-	-	7
	December	8	-	-	2
Bay anchovy	April	-	-	-	54
	May	81	-	-	55
	June	89	-	-	78
	July	90	-	-	80
	August	85	-	-	-
	September	72	-	-	-
	October	65	-	-	35
	November	32	-	-	28
Atlantic croaker	April	-	-	-	42
	May	-	-	-	34
	June	-	-	-	28
	July	-	-	-	35
	October	-	-	-	5
	November	-	-	-	2
	Dec-Jan	49	-	-	15
Spot	June	31	-	-	-

	July	48	-	-	-
	August	47	-	-	-
		Original Screens		**Modified Screens**	
	October	38	-	-	-
	November	19	-	-	7
	December	29	-	-	-
Alosa species	Mar-Apr	89	-	-	18
	Oct - Dec	31	-	-	22

Note: Mortality rate estimates for *Alosa* species for original screens are based on blueback herring only while estimates for modified screens are based on *Alosa* species (blueback herring, alewife, and American shad combined). Estimates include initial and 48-hr latent mortalities.
Blank spaces (-) indicate months in which the species was not identified in sufficient numbers in the impingement survival studies to allow reliable estimates of impingement mortality rates.
Source: PSEG, 1999a.

4.5.4 Heat Shock

NRC uses the term heat shock to refer to the acute thermal stress caused by exposure to a sudden elevation of water temperature that adversely affects the metabolism and behavior of fish and can lead to death. Heat shock can occur at power plants when the cooling water discharge elevates the temperature of the surrounding water.

The NRC considers heat shock to be a generic (Category 1) issue at power plants with closed-cycle cooling systems. HCGS uses closed-cycle cooling and if NRC finds no new and significant information, site-specific evaluation is not required to determine that impacts to fish and shellfish from heat shock associated with the continued operation of HCGS during the renewal term would be SMALL. In contrast, heat shock is a Category 2 issue at power plants with once-through cooling systems. Salem has a once-through cooling system; therefore, heat shock is considered a site-specific (Category 2) issue for Salem, and a site-specific analysis is required to determine the level of impact that heat shock may have on the aquatic environment. The potential for heat shock at Salem is discussed below.

Regulatory Background

The Delaware River Basin Commission (DRBC) is a federal interstate compact agency charged with managing the water resources of the Delaware River Basin without regard to political boundaries. It regulates water quality in the Delaware River and Delaware Estuary through DRBC Water Quality Regulations, including temperature standards. The temperature standards for Water Quality Zone 5 of the Delaware Estuary, where the Salem discharge is located, state that the temperature in the river outside of designated heat dissipation areas (HDAs) may not be raised above ambient by more than 4 degrees Fahrenheit (°F; 2.2 degrees Celsius [°C]) during non-summer months (September through May) or 1.5°F (0.8°C) during the summer (June through August), and a maximum temperature of 86°F (30.0°C) in the river cannot be exceeded year-round (18 CFR 410; DRBC, 2001). HDAs are zones outside of which the DRBC temperature-increase standards shall not be exceeded. HDAs are established on a case-by-case basis. The thermal mixing zone requirements and HDAs that had been in effect for Salem since it initiated operations in 1977 were modified by the DRBC in 1995 and again in 2001

(DRBC, 2001), and the 2001 requirements were included in the 2001 NJPDES permit. The HDAs at Salem are seasonal. In the summer period (June through August), the Salem HDA extends 25,300 ft (7,710 m) upstream and 21,100 ft (6,430 m) downstream of the discharge and does not extend closer than 1,320 ft (402 m) from the eastern edge of the shipping channel. In the non-summer period (September through May), the HDA extends 3,300 ft (1,000 m) upstream and 6,000 ft (1,800 m) downstream of the discharge and does not extend closer than 3,200 ft (970 m) from the eastern edge of the shipping channel (DRBC, 2001).

Section 316(a) of the CWA regulates thermal discharges from power plants. This regulation includes a process by which a discharger can obtain a variance from thermal discharge limits when it can be demonstrated that the limits are more stringent than necessary to protect aquatic life (33 USC 1326). PSEG submitted a comprehensive Section 316(a) study for Salem in 1974, filed three supplements through 1979, and provided further review and analysis in 1991 and 1993. In 1994, NJDEP granted PSEG's request for a thermal variance and concluded that the continued operation of Salem in accordance with the terms of the NJPDES permit "would ensure the continued protection and propagation of the balanced indigenous population of aquatic life" in the Delaware Estuary (NJDEP, 1994). The 1994 permit continued the same thermal limitations that had been imposed by the prior NJPDES permits for Salem. This variance has been continued through the current NJPDES permit. PSEG subsequently provided comprehensive Section 316(a) Demonstrations in the 1999 and 2006 NJPDES permit renewal applications for Salem. NJDEP reissued the Section 316(a) variance in the 2001 NJPDES Permit (NJDEP, 2001).

The Section 316(a) variance for Salem limits the temperature of the discharge, the difference in temperature (ΔT) between the thermal plume and the ambient water, and the rate of water withdrawal from the Delaware Estuary (NJDEP, 2001). During the summer period the maximum permissible discharge temperature is 115°F (46.1°C). In non-summer months, the maximum permissible discharge temperature is 110°F (43.3°C). The maximum permissible temperature differential year round is 27.5°F (15.3°C). The permit also limits the amount of water that Salem withdraws to a monthly average of 3,024 MGD (11 million m^3/day) (NJDEP, 2001).

In 2006, PSEG submitted an NJPDES permit renewal application (PSEG, 2006c) with a request for renewal of the Section 316(a) variance. The variance renewal request summarizes studies that have been conducted at the Salem plant, including the 1999 Section 316(a) Demonstration, and evaluates the changes in the thermal discharge characteristics, facility operations, and aquatic environment since the time of the 1999 Section 316(a) Demonstration. PSEG concluded that Salem's thermal discharge had not changed significantly since the 1999 application and that the thermal variance should be continued. In 2006, NJDEP administratively continued Salem's NJPDES permit (NJ0005622), including the Section 316(a) variance. No timeframe for issuance of the new NJPDES permit has been determined.

Characteristics of the Thermal Plume

Cooling water from Salem is discharged through six adjacent 10 ft (3 m) diameter pipes spaced 15 ft (4.6 m) apart on center that extend approximately 500 ft (150 m) from the shore (PSEG, 1999c). The discharge pipes are buried for most of their length until they discharge horizontally into the water of the estuary at a depth at mean tidal level of about 31 ft (9.5 m). The discharge is approximately perpendicular to the prevailing currents. Figure 4-1 provides a plan view of the Salem discharge, and Figure 4-2 is a section view. At full power, Salem is designed to discharge approximately 3,200 MGD (12 million m^3/day) at a velocity of about 10 fps (3 m/s). The location of the discharge and its general design characteristics have remained essentially the same over the period of operation of the Salem facility (PSEG, 1999c).

The thermal plume at Salem can be defined by the regulatory thresholds contained in the DRBC water quality regulations, consisting of the 1.5°F (0.83°C) isopleth of ΔT during the summer period and the 4°F (2.2°C) isopleth of ΔT during non-summer months. Thermal modeling, to characterize the thermal plume, has been conducted numerous times over the period of operation of Salem. Since Unit 2 began operation in 1981, operations at Salem have been essentially the same and studies have indicated that the characteristics of the thermal plume have remained relatively constant (PSEG, 1999c).

The most recent thermal modeling was conducted during the 1999 Section 316(a) Demonstration. Three linked models were used to characterize the size and shape of the thermal plume: an ambient temperature model, a far-field model (RMA-10), and a near-field model (CORMIX). The plume is narrow and approximately follows the contour of the shoreline at the discharge. The width of the plume varies from about 4,000 ft (1,200 m) on the flood tide to about 10,000 ft (3,000 m) on the ebb tide. The maximum plume length extends to approximately 43,000 ft (13,000 m) upstream and 36,000 ft (11,000 m) downstream (PSEG, 1999c). Figures 4-3 through 4-6 depict the expansion and contraction of the surface and bottom plumes through the tidal cycle. Table 4-18 includes the surface area occupied by the plume within each ΔT isopleth through the tidal cycle.

The thermal plume consists of a near-field region, a transition region, and a far-field region. The near-field region, also referred to as the zone of initial mixing, is the region closest to the outlet of the discharge pipes where the mixing of the discharge with the waters of the Delaware Estuary is induced by the velocity of the discharge itself. The length of the near-field region is approximately 300 ft (90 m) during ebb and flood tides and 1,000 ft (300 m) during slack tide. The transition region is the area where the plume spreads horizontally and stratifies vertically due to the buoyancy of the warmer waters. The length of the transition region is approximately 700 ft (200 m). In the far-field region, mixing is controlled by the ambient currents induced mainly by the tidal nature of the receiving water. The ebb tide draws the discharge downstream, and the flood tide draws it upstream. The boundary of the far-field region is delineated by a line of constant ΔT (PSEG, 1999c).

1 **Table 4-18. Surface Area within Each ΔT Contour through the Tidal Cycle**

	Ebb: 6/2/1998 at 0830 hrs		End of Ebb: 6/2/1998 at 0000 hrs		Flood: 6/4/1998 at 1630 hrs		End of Flood: 5/31/1998 at 1600 hrs	
ΔT (°F)	Surface Area (Acres)	Percent of Estuary Area	Surface Area (Acres)	Percent of Estuary Area	Surface Area (Acres)	Percent of Estuary Area	Surface Area (Acres)	Percent of Estuary Area
>13	0.08	0.00002	0.00	0.00000	0.00	0.00000	0.00	0.00000
>12	0.46	0.00010	0.47	0.00010	0.21	0.00004	0.00	0.00000
>11	0.98	0.00020	2.15	0.00045	0.61	0.00013	0.00	0.00000
>10	1.66	0.00034	2.15	0.00045	1.15	0.00024	0.85	0.00018
>9	2.22	0.00046	2.15	0.00045	1.82	0.00038	1.93	0.00040
>8	3.19	0.00066	2.15	0.00045	2.64	0.00055	1.93	0.00040
>7	4.32	0.00090	5.10	0.00106	3.59	0.00075	1.93	0.00040
>6	5.61	0.00116	11.32	0.00235	4.68	0.00097	1.93	0.00040
>5	36.60	0.00760	21.43	0.00445	56.58	0.01174	2.14	0.00044
>4	150.08	0.03115	45.11	0.00936	245.94	0.05105	205.37	0.04263
>3	631.42	0.13106	739.88	0.15357	585.78	0.12158	920.75	0.19111
>2	1947.91	0.40430	2519.94	0.52303	2212.75	0.45927	2093.04	0.43442
>1.5	3156.56	0.65517	3725.19	0.77319	3703.61	0.76871	3596.95	0.74657

Notes:
Plant Conditions: Low flow (140,000 gpm/pump), high ΔT (18.6°F).
Total surface area of the estuary is 481,796 acres.
To convert acres to hectares, multiply by 0.4047.
Reasonable worst-case tide phases were selected based on analysis of time-temperature curves.
Running tides (e.g., ebb and flood) include area approximation of the intermediate field.
Source: PSEG, 1999c.

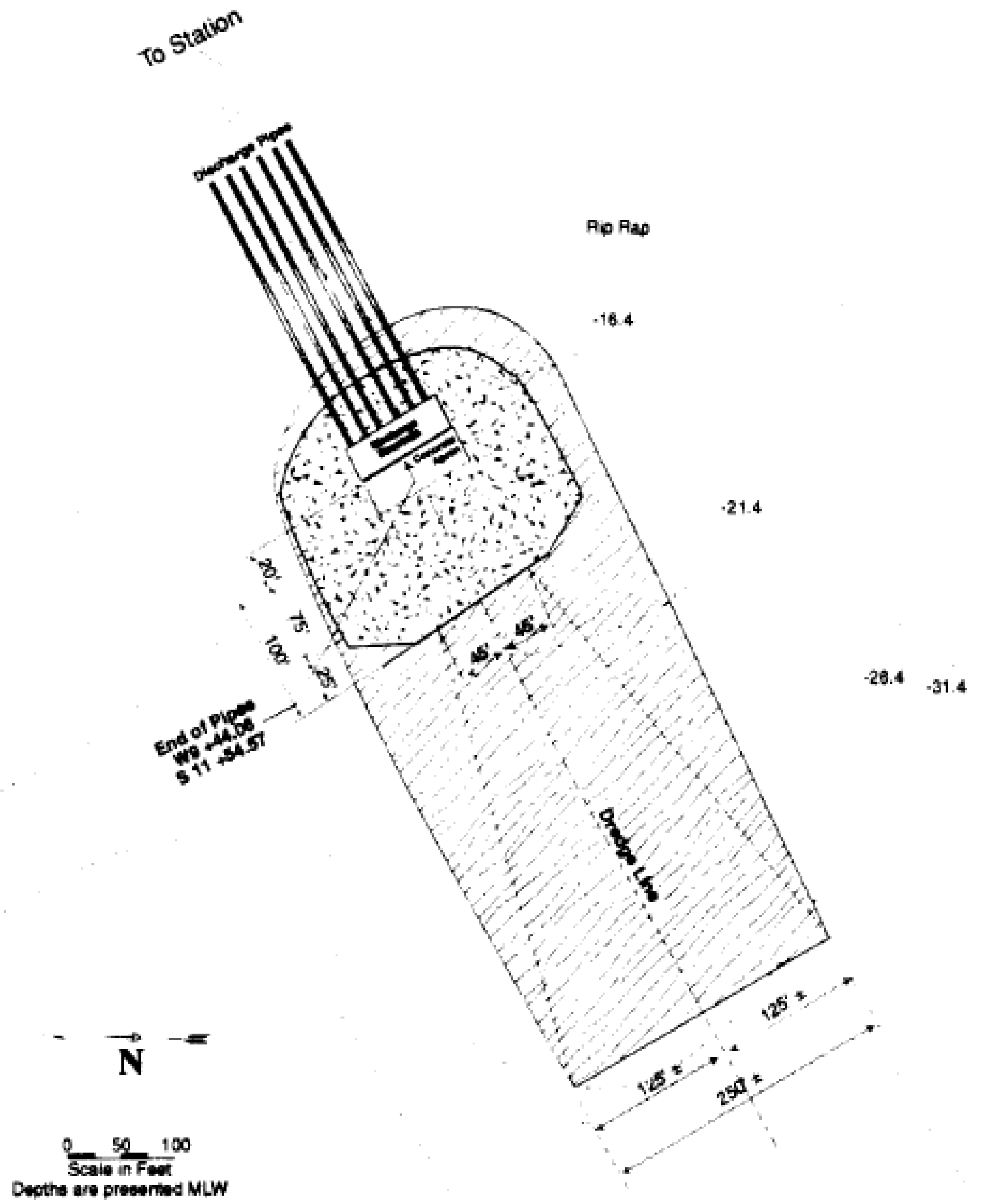


Figure 4-1. Plan View of Salem discharge pipes (Source: PSEG, 1999c).

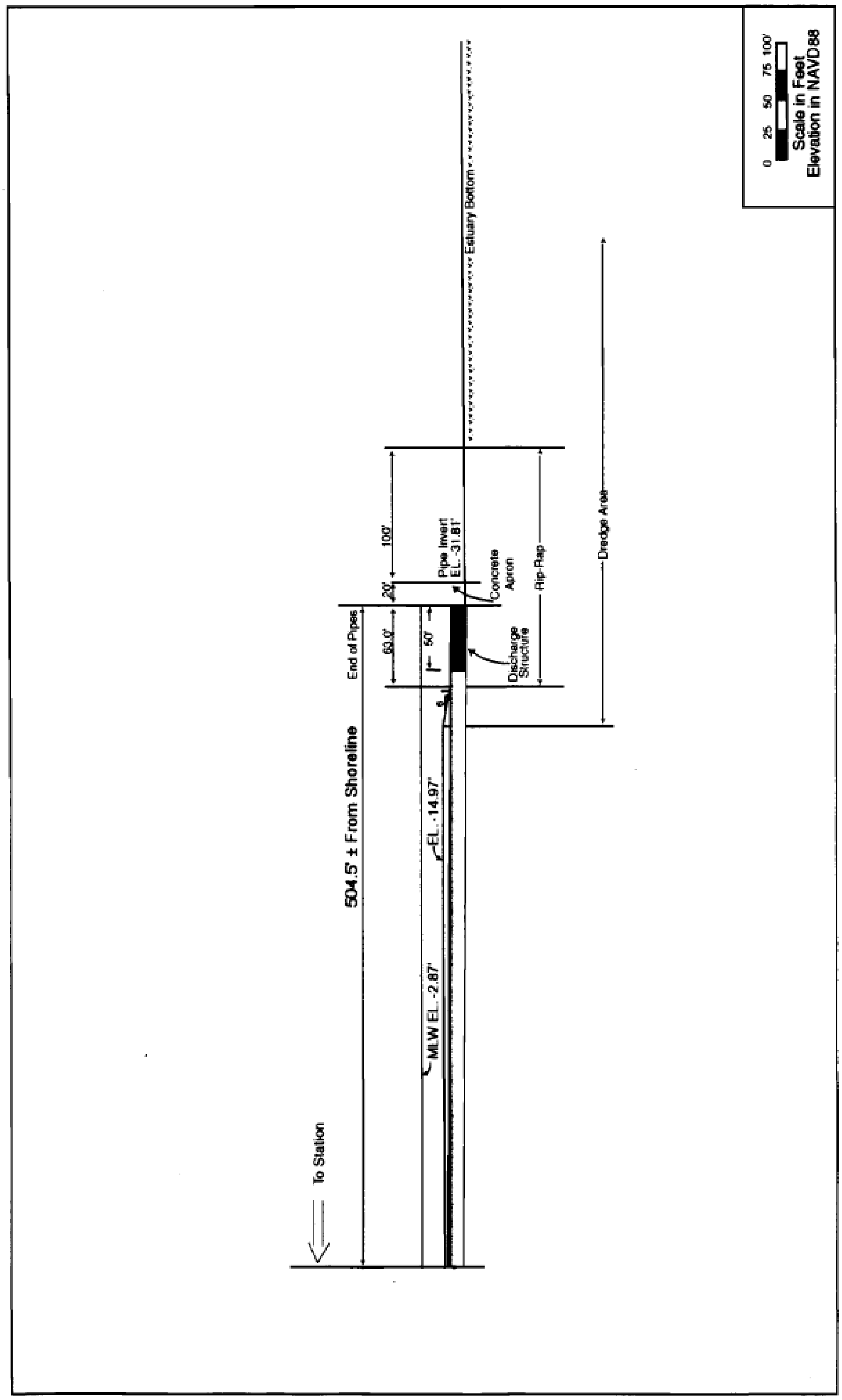
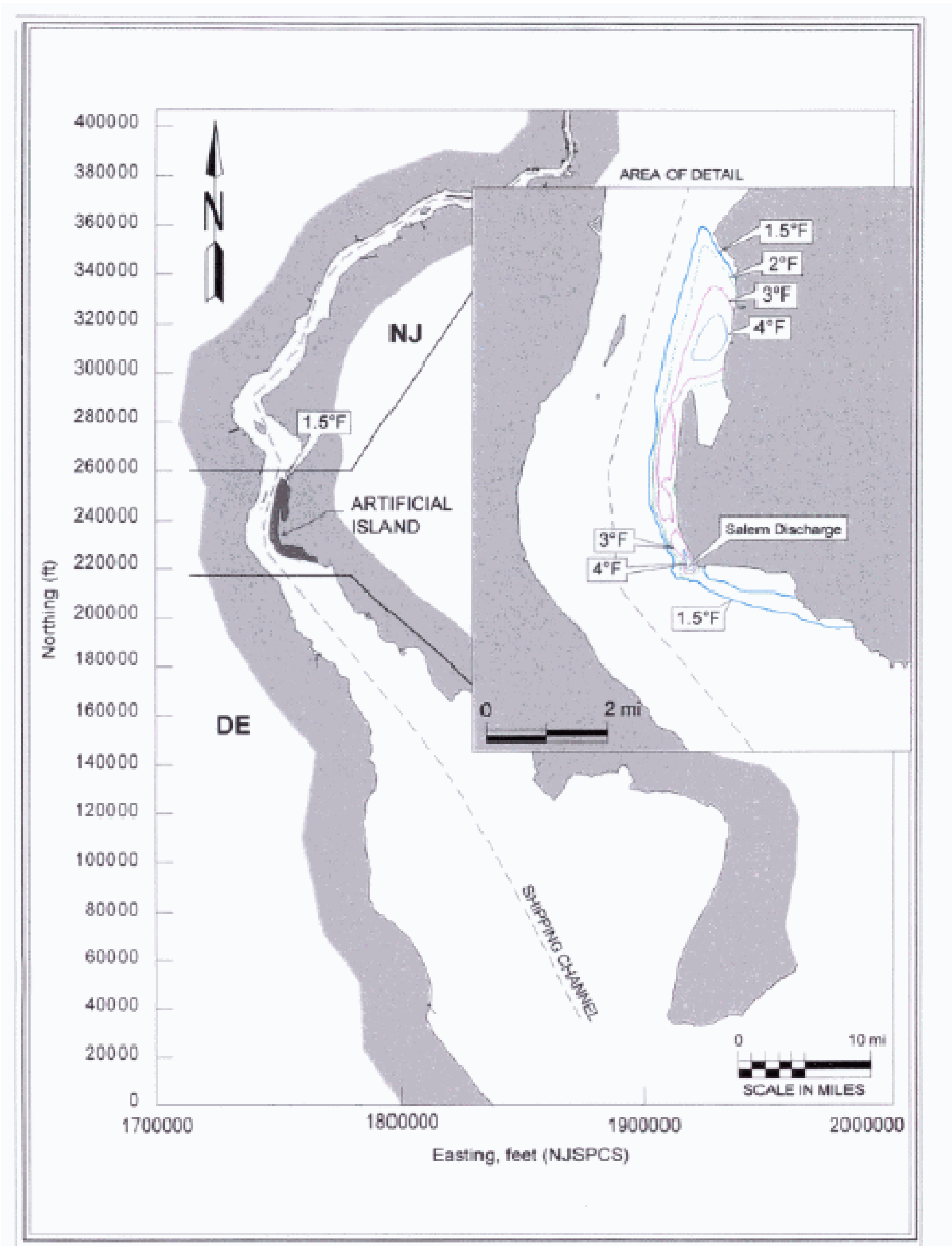


Figure 4-2. Section View of Salem discharge pipes (Source: PSEG, 1999c).



1
2 **Figure 4-3. Surface ΔT isotherms for Salem's longest plume at the end of flood on May**
3 **31, 1998 (Source: PSEG, 1999c).**

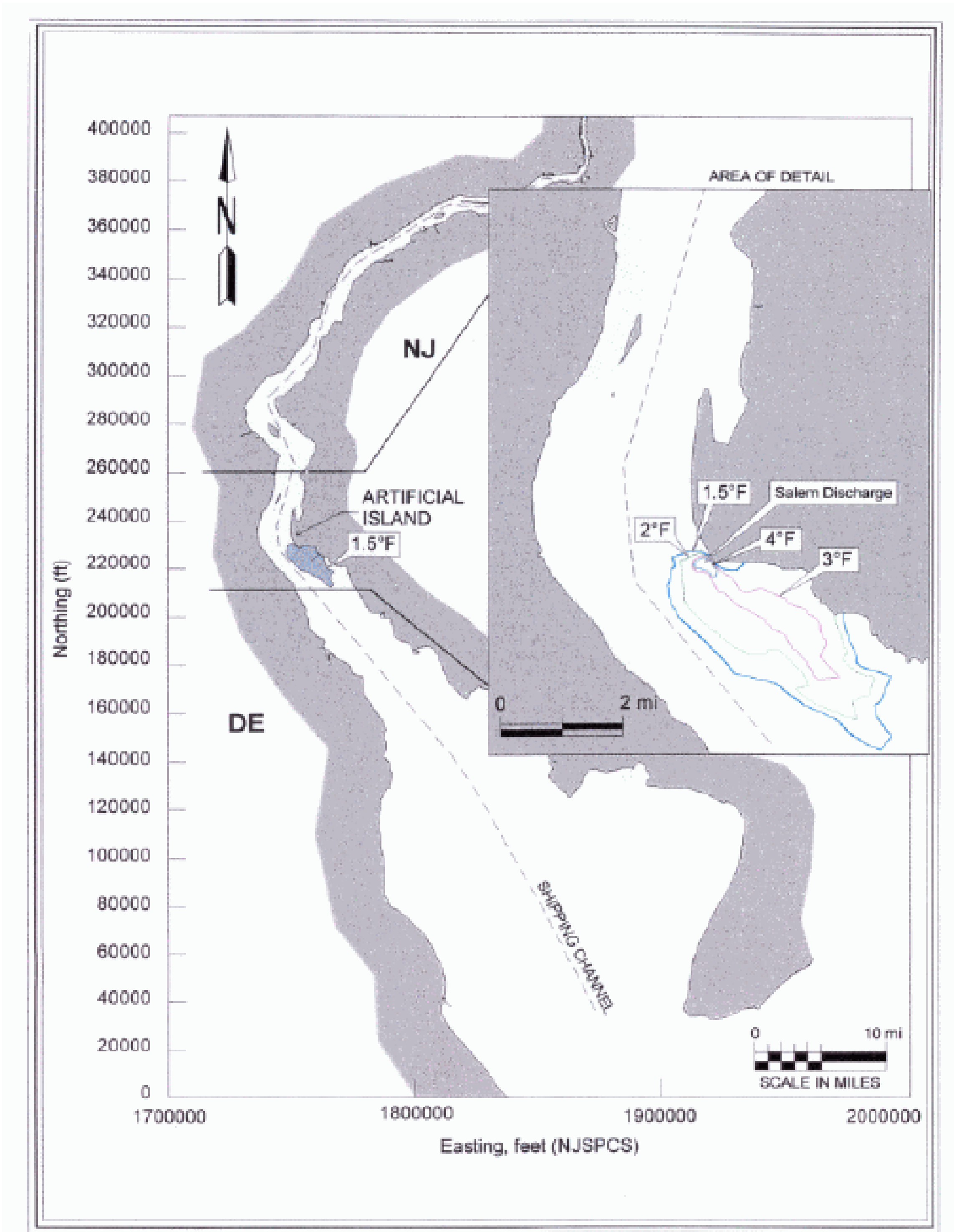


Figure 4-4. Surface ΔT isotherms for Salem at the end of ebb on June 2, 1998 (Source: PSEG, 1999c).

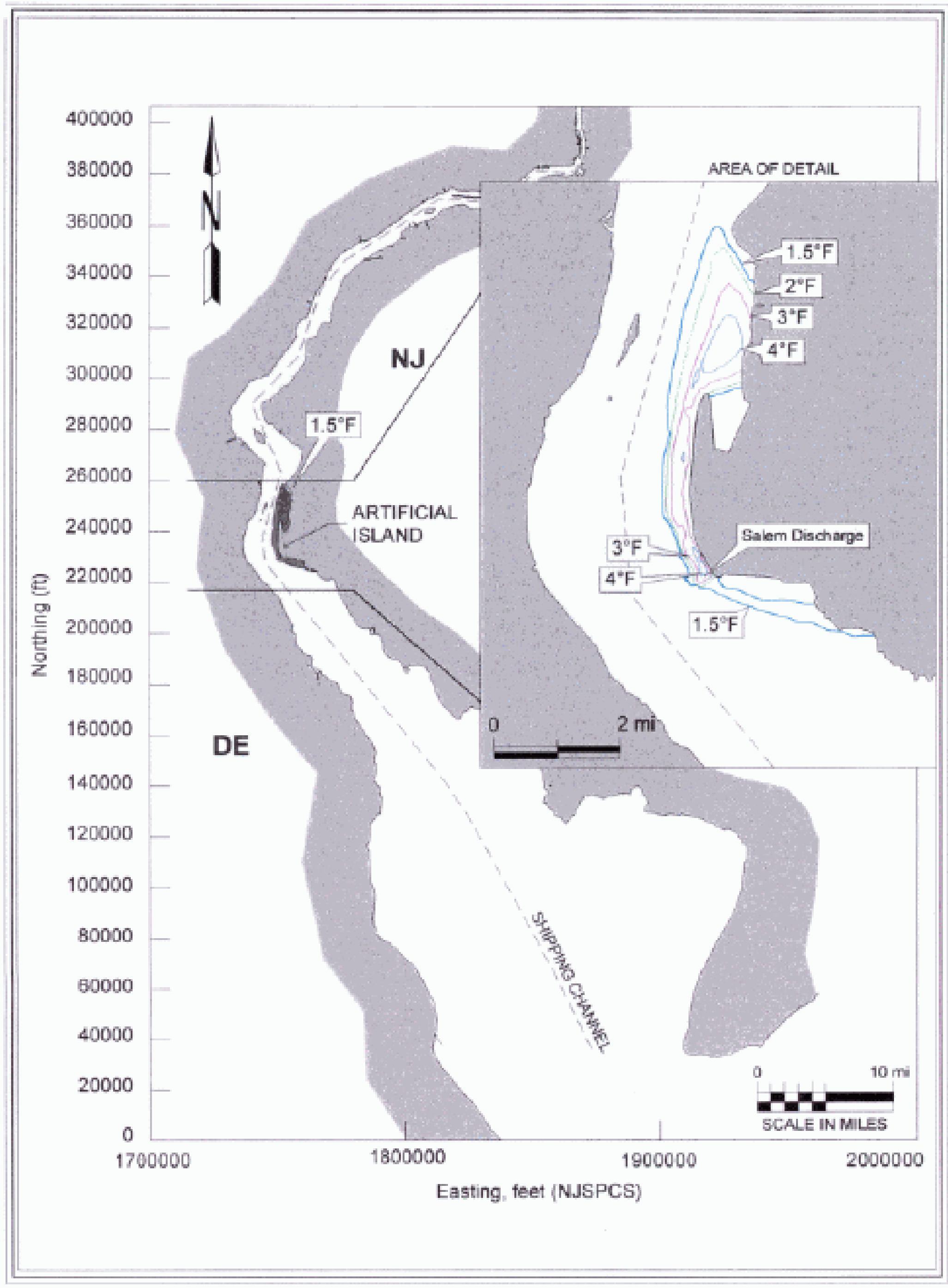


Figure 4-5. Bottom ΔT isotherms for Salem's longest plume at the end of the flood on May 31, 1998 (Source: PSEG, 1999c).

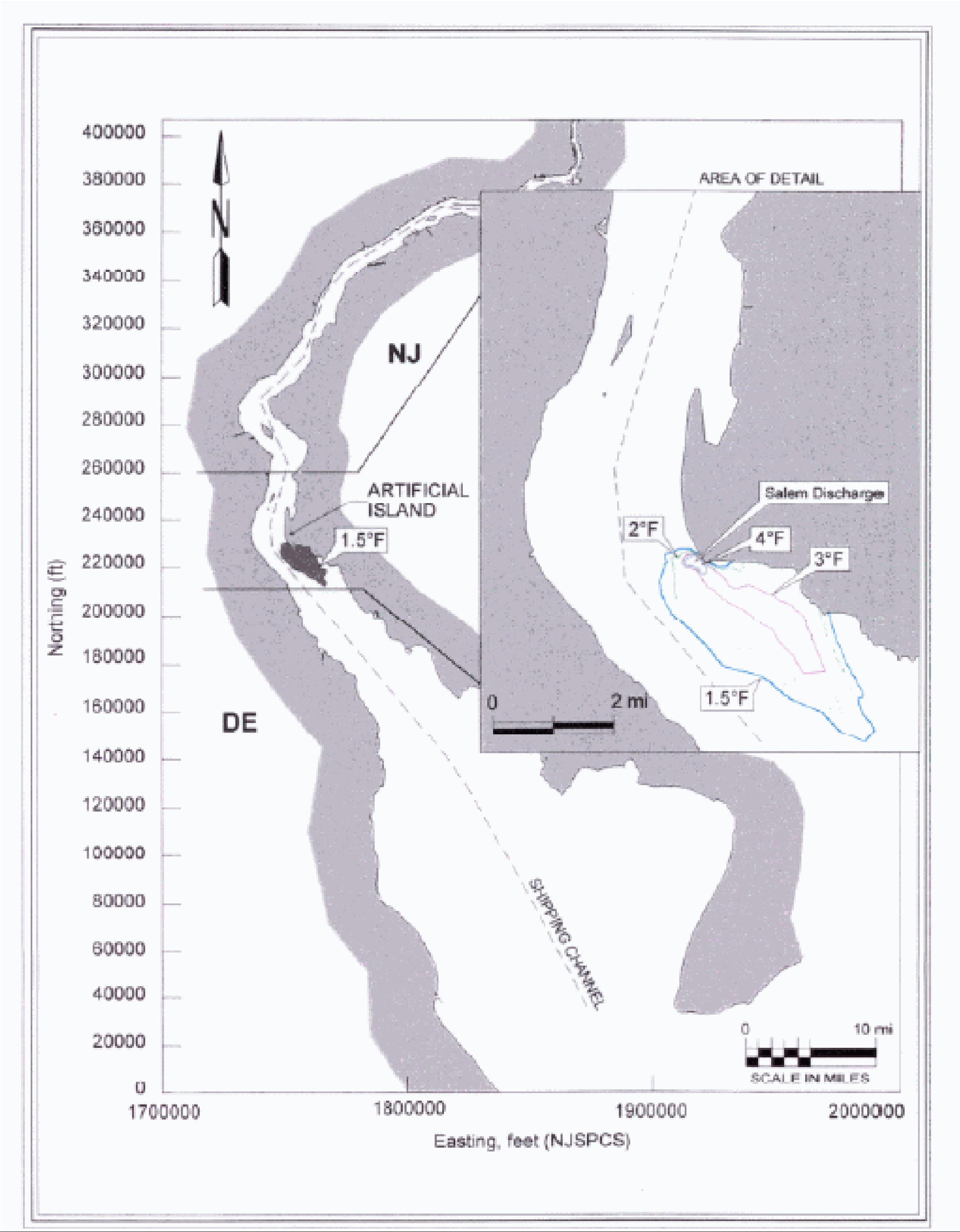


Figure 4-6. Bottom ΔT isotherms for Salem at the end of the ebb on June 2, 1998 (Source: PSEG, 1999c).

Thermal Discharge Studies

Extensive studies were conducted at Salem between 1968 and 1999 to determine the effects of the thermal plume on the biological community of the Delaware Estuary. Initial studies were conducted in 1968 to determine the location and design for the outfall that would best minimize the potential for adverse environmental effects. Several hydrothermal and biothermal studies subsequently have been conducted in support of requests for variance from thermal discharge limitations pursuant to Section 316(a). The Section 316(a) Demonstrations from 1974 through 1979 evaluated information on the life history, geographical distribution, and thermal tolerances of the RIS compared to the characteristics of the projected thermal plume. Supplements included information on the potential for Salem's thermal plume to promote the presence of undesirable organisms; use of the area in the vicinity of the Salem facility as spawning and nursery habitat; attraction of fish to the thermal plume and the potential for cold shock; effects of thermal plume entrainment on ichthyoplankton and zooplankton; effects of the plume on migration of anadromous fishes; and effects of the thermal plume on macroinvertebrates, such as blue crabs, oysters (*Crassostrea virginica*), and shipworms (Teredinidae), and other benthos (PSEG, 1975).

In 1995, PSEG applied to the DRBC for revision of the Salem Docket to provide seasonal HDAs to assure compliance with DRBC's water quality regulations. PSEG used mathematical modeling and statistical analyses to characterize the maximum size of the summer thermal plume (June through August) and non-summer thermal plume (September through May) in terms of the 24-hr average ΔT between the thermal plume and ambient water temperatures. PSEG also updated the information collected on the thermal tolerances, preferences, and avoidances of the RIS and conducted an evaluation of the potential for the thermal plume to have adverse effects on these species. The assessment indicated that Salem's thermal plume and the proposed HDAs would not have the potential to adversely affect aquatic life or recreational uses in the Delaware Estuary, and the DRBC granted the requested HDAs (PSEG, 1999c).

In 1999 PSEG submitted an application to renew the NJPDES permit for Salem, and the Section 316(a) Demonstration included provided another thermal plume characterization, biothermal assessment, and detailed analysis of the potential effects of Salem's thermal plume on the aquatic community. NJDEP reviewed this Section 316(a) Demonstration, determined that a "thermal discharge at the Station, which does not exceed a maximum of 115 ºF, is expected to assure the protection and propagation of the balanced indigenous population," and included a Section 316(a) variance in Salem's 2001 NJPDES permit (NJDEP, 2001).

The 1999 Section 316(a) Demonstration includes the most detailed and most recent evaluation of the potential effects of the thermal discharge on the aquatic environment near Salem. This evaluation includes a four-part assessment of the potential for the discharge to negatively affect the balanced indigenous community of the Delaware Estuary, including consideration of the following factors: (1) the vulnerability of the aquatic community to thermal effects; (2) the potential for the survival, growth, and reproduction of the RIS to be affected; (3) the potential for effects of other pollutants to be increased by heat; and (4) evidence of prior appreciable harm from the thermal discharge (PSEG, 1999c).

PSEG (1999d) concluded that the vulnerablity analysis indicates that the location and design of Salem's discharge minimize the potential for adverse environmental effects. They report that the high exit velocity produces rapid dilution, which limits high temperatures to relatively small areas in the zone of initial mixing in the immediate vicinity of the discharge. Fish and other nektonic organisms are essentially excluded from these areas due to high velocities and turbulence. PSEG (1999c) found that the offshore location and rapid dilution of the thermal discharge also places the highest temperature plumes in an area of the Estuary where productivity is lowest.

The RIS evaluation in the 1999 Section 316(a) Demonstration (PSEG, 1999c) included an assessment of the potential for the thermal plume to adversely affect survival, growth, and reproduction of the selected RIS. The RIS included alewife (*Alosa pseudoharengus*), American shad (*Alosa sapidissima*), Atlantic croaker (*Micropogonias undulatus*), bay anchovy (*Anchoa mitchilli*), blueback herring (*Alosa aestivalis*), spot (*Leiostomus xanthurus*), striped bass (*Morone saxatilis*), weakfish (*Cynoscion regalis*), white perch (*Morone americana*), blue crab (*Callinectes sapidus*), opossum shrimp (*Neomysis americana*), and scud (*Gammarus daiberi, G. fasciatus, G. tigrinus*). For each of the RIS, temperature requirements and preferences as well as thermal limits were identified and compared to temperatures in the thermal plume to which these species may be exposed (PSEG, 1999c).

This biothermal assessment (PSEG, 1999c) concluded that Salem's thermal plume would not have substantial effects on the survival, growth, or reproduction of the selected species from heat-induced mortality. Scud, blue crab, and juvenile and adult American shad, alewife, blueback herring, white perch, striped bass, Atlantic croaker, and spot have higher thermal tolerances than the temperature of the plume in areas where their swimming ability would allow them to be exposed. PSEG (1999c) concluded that juvenile and adult weakfish and bay anchovy could come into contact with plume waters that exceed their thermal tolerances during the warmer months, but the mobility of these organisms should allow them to avoid contact with these temperatures

The biothermal assessment also concluded that less-mobile organisms, such as scud, juvenile blue crab, and fish eggs, would not be likely to experience mortality from being transported through the plume. American shad, alewife, blueback herring, white perch, striped bass, Atlantic croaker, spot, and weakfish are not likely to spawn in the vicinity of the discharge. Scud, juvenile blue crab, and eggs and larvae that do occur in the vicinity of the discharge have higher temperature tolerances than the maximum temperature of the centerline of the plume in average years. PSEG (1999c) concluded that opossum shrimp, weakfish, and bay anchovy may experience some mortality during peak summer water temperatures in warm years (approximately 1 to 3 percent of the time).

Interactions of heat with other pollutants were also evaluated in the 1999 Section 316(a) Demonstration. The assessment concluded that the thermal plume has no observable effects on the dissolved oxygen level near the Salem discharge. In addition, the assessment indicates that there is no potential for plume interaction with other contaminants in the Estuary from other industrial, municipal, or agricultural sources such as polycarbonated biphenyols (PCBs), dichlorodiphenyltrichloroethane (DDT), dieldrin, polycyclic aromatic hydrocarbons (PAHs), tetrachloroethene (PCE), dichloroethene (DCE), and copper due to the low concentrations of such contaminants in the vicinity of Salem (PSEG, 1999c).

As part of the 1999 Section 316(a) Demonstration, an analysis of the biological community in the Delaware Estuary was conducted to determine whether there has been evidence of changes within the community that could be attributable to the thermal discharge at Salem. PSEG (1999c) concluded that observed changes in the species composition or overall abundance in organisms in the estuary since Salem began operation are within the range expected to occur as a result of natural variation or changes in water quality. PSEG found no indications of increases in populations of nuisance species or stress-tolerant species, and it found statistically significant increases in the abundance of juveniles for almost all species of RIS evaluated. PSEG (1999c) concluded that a declining trend for blueback herring was a coast-wide trend and not related to Salem’s operation.

4.5.5 Restoration Activities

In addition to the changes in technology and operations of the Salem facility, PSEG has implemented restoration activities that enhance the fish and shellfish populations in the Delaware Estuary. In compliance with Salem’s 1994 and 2001 NJPDES permits, PSEG implemented the Estuary Enhancement Program (EEP), which has preserved and/or restored more than 20,000 acres (ac; 8,000 hectares [ha]) of wetland and adjoining upland buffers (PSEG, 2009a).

In particular, the program restored 4,400 ac (1,800 ha) of formerly diked salt hay farms to reestablish conditions suitable for the growth of low marsh vegetation such as saltmarsh cord grass (*Spartina alterniflora*) and provide for tidal exchange with the estuary. These restored wetlands increase the production of fish and shellfish by increasing primary production in the detritus-based food web of the Delaware Estuary. Both primary and secondary consumers benefit from this increase in production, including many of the RS at Salem and federally managed species with essential fish habitat (EFH) in the estuary. PSEG (2006c) estimated the increase in production of secondary consumers due to this restoration to be at least 18.6 million lbs/yr (8.44 million kg/yr). These secondary consumers include species of fish and shellfish affected by impingement and entrainment at Salem, as well as other species.

The EEP also included the installation of 13 fish ladders at impoundments in New Jersey and Delaware (PSEG, 2009a). The fish ladders eliminate blockages to spawning areas for anadromous fish species such as alewife and blueback herring (both RS at Salem). Fish ladders were constructed in New Jersey at Sunset Lake, Stewart Lake (two ladders), Newton Lake and Cooper River Lake, and in Delaware at Noxontown Pond, Silver Lake (Dover), Silver Lake (Milford), McGinnis Pond, Coursey Pond, McColley Pond, Garrisons Lake, and Moore’s Lake (PSEG, 2009a). Most anadromous fish exhibit spawning site fidelity, returning to the same areas where they hatched to spawn. Therefore, PSEG undertook a stocking program that transplanted gravid adults into the newly accessible impoundments to induce future spawning runs (PSEG, 2009a).

Along with the active restoration programs described above, PSEG has provided funding through the EEP for many other programs in the area, including some managed by NJDEP and the Delaware Department of Natural Resources and Environmental Control (DNREC). Examples of these funded programs are restoration of three areas in Delaware dominated by common reed (*Phragmites australis*), State-managed artificial reef programs, revitalization of 150 ac (61 ha) of State-managed oyster habitat, and restoration of 964 ac (390 ha) of degraded wetlands at the Augustine Creek impoundment (PSEG, 2009a).

A requirement of the 2001 NJPDES permit for Salem was for PSEG to evaluate and quantify the increased production associated with its restoration activities and compare it to the production lost due to entrainment and impingement at the facility. These restoration production estimates were provided in Section 7 of the 2006 NJPDES permit renewal application (PSEG, 2006c). The assessment included estimates of increased production associated with the restoration of the three salt hay farms and 12 fish ladder sites. It did not include production associated with the restoration of marshes dominated by common reed, upland buffer areas, and artificial reefs (PSEG, 2006c).

PSEG (2006c) used an Aggregated Food Chain Model (AFCM) to estimate the annual production (lbs wet weight/yr) of secondary consumers attributable to the restoration of the salt hay farm sites. This method used data for the biomass of above-ground vegetation collected during the annual monitoring from 2002 through 2004 to estimate primary production (production of above-ground marsh vegetation). This primary production was then converted to production of secondary consumers through three trophic transfers: vegetation to detrital complex (dissolved and particulate organic matter, bacteria, fungi, protozoa, nematodes, rotifers, copepods, and other microscopic organisms) to primary consumers (zooplankton and macroinvertebrates) to secondary consumers (age-0 fish). PSEG also used two independent methods, an ecosystem model and a fish abundance model, to corroborate the AFCM estimates.

PSEG (2006c) calculated the production of secondary consumers attributable to the restoration of the salt hay marsh sites to be 11,228,415 lbs wet weight/yr (5,093,209 kg wet weight/yr). PSEG (2006c) concluded that the methods used were likely to have underestimated total production attributable to the salt hay marsh restoration because they did not include production associated with below-ground plant parts (roots and rhizomes), benthic algae, or other primary producers such as photosynthetic bacteria. PSEG (2006c) estimated the increase in production attributable to restoration of the salt hay farms to be 2.3 times the annual production lost from impingement and entrainment at Salem.

PSEG (2006c) estimated the annual production of river herring (blueback herring and alewife) attributable to the installation of fish ladders at 12 impoundments in New Jersey and Delaware using results from surveys of juvenile fish in the impoundments, which were then converted to weight using an age-1 average weight. PSEG (2006c) calculated the production of river herring due to the fish ladders to be 944 lbs wet weight/yr (428 kg wet weight/yr), which it estimated was equivalent to about 1/6 of the production of river herring lost to impingement and entrainment at the facility.

4.5.6 Conclusions

Entrainment, impingement, heat shock, and the restoration programs simultaneously affect the aquatic resources of the Delaware Estuary. PSEG has conducted extensive studies of the effects of entrainment (Section 4.5.2) and impingement (Section 4.5.3) at Salem over the more than 30-yr period during which it has been operating. PSEG also has conducted extensive studies of the thermal plume at Salem (Section 4.5.4) that have shown that the thermal discharge from operation of the Salem facility has not had a noticeable adverse effect on the balanced indigenous community of the Delaware Estuary in the vicinity of the outfall. Thus, PSEG was granted a thermal variance in accordance with Section 316(a) of the CWA in 1994, and this variance remains a part of the current NJPDES permit issued to PSEG in 2001 and was administratively continued in 2006. Multiple long-term, large-scale studies of the estuary by PSEG and State and Federal agencies have documented the ecological condition of the estuary through time and allowed the analysis of long-term trends in populations of RS. The results of the studies indicate that the processes of entrainment, impingement, and thermal discharge collectively have not had a noticeable adverse effect on the balanced indigenous community of the Delaware Estuary in the vicinity of Salem.

The Staff considered these results and reviewed the available information, including that provided by the applicant, the Staff's site visit, the States of New Jersey and Delaware, the NJPDES permits and applications, and other public sources. The NJDEP, not the NRC, is responsible for issuing and enforcing NPDES permits. NRC assumes that NJDEP will continue to apply the best information available to the evaluation and approval of future NJPDES permits. The Staff concludes that impacts to fish and shellfish from the collective effects of entrainment, impingement, and heat shock at Salem during the renewal term would be SMALL.

The Staff identified a variety of measures that could mitigate potential impacts resulting from continued operation of the Salem cooling water system, although 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]).

A few mitigation measures for the effects of the cooling water system on aquatic organisms include conversion to a closed cycle cooling water system, scheduling plant outages during historic peak impingement and entrainment periods, installing variable speed drive controllers on the pump motors to allow flow reductions during months of high biological activity, the use of dual-flow fine-mesh screens, and the use of a sound deterrent system for fish. These mitigation measures could reduce impacts by reducing the flow rate of water drawn into the facility, resulting in a commensurate decrease in impingement and entrainment, or by excluding organisms from the intake or deterring them from entering the area.

PSEG performed a cost-benefit analysis of these mitigation measures as part of its CDS for the 2006 NPDES permit renewal application (PSEG, 2006c). EPA's evaluation of the Salem NPDES permit renewal application would likely address any applicable site-specific mitigation measures that may reduce entrainment and impingement impacts. EPA's Phase II Rule has been suspended, and compliance with CWA Section 316(b) is presently based on EPA's best professional judgment.

4.6 Terrestrial Resources

The Category 1 issues related to terrestrial resources and applicable to Salem and HCGS are listed in Table 4-19. There are no Category 2 issues related to terrestrial resources. Section 2.2.6 provides a description of the terrestrial resources at the site of the Salem and HCGS facilities and in the surrounding area.

Table 4-19. Terrestrial Resources Issues Applicable to Salem and/or HCGS.

Issues	GEIS Section	Category
Cooling tower impacts on crops and ornamental vegetation[(a)]	4.3.4	1
Cooling tower impacts on native plants[(a)]	4.3.5.1	1
Bird collisions with cooling towers[(a)]	4.3.5.2	1
Power line right-of-way management (cutting and herbicide application)[(b)]	4.5.6.1	1
Bird collisions with power lines[(b)]	4.5.6.1	1
Impacts of electromagnetic fields on flora and fauna (plants, agricultural crops, honeybees, wildlife, livestock) [(b)]	4.5.6.3	1
Floodplains and wetland on power line right-of-way[(b)]	4.5.7	1

[(a)]Applicable only to HCGS.
[(b)]Applicable to Salem and HCGS.

The Staff did not identify any new and significant information during the review of the Salem and HCGS ER documents (PSEG, 2009a; 2009b), the Staff's site audit, the scoping process, or the evaluation of other available information (including bird mortality surveys conducted for the HCGS cooling tower from 1984 to 1986). Therefore, the NRC staff concludes that there would be no impacts related to these issues beyond those discussed in the GEIS (NRC, 1996). Regarding these issues, the GEIS concluded that the impacts are SMALL, and additional site-specific mitigation measures are not likely to be sufficiently beneficial to warrant implementation.

4.7 Threatened or Endangered Species

Potential impacts to threatened or endangered species are listed as a site-specific or Category 2 issue in 10 CFR Part 51, Subpart A, Appendix B, Table B-1. The GEIS section and category for this issue are listed in Table 4-20.

Table 4-20. Category 2 Issues Applicable to Threatened or Endangered Species During the Renewal Term

Issue	GEIS Section	Category
Threatened or endangered species	4.1	2

This site-specific 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 characteristics and habitats of threatened or endangered species in the vicinity of the site of the Salem and

HCGS facilities is discussed in Sections 2.2.7.1 and 2.2.7.2. The NRC contacted the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (FWS) on December 23, 2010 to request information on the occurrence of threatened, endangered, or other protected species in the vicinity of the site and the potential for impacts on those species from license renewal (NRC, 2009a; 2009b). On February 11, 2010, NMFS, identified the endangered shortnose sturgeon (*Acipenser brevirostrum*), and the Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) as having the potential to be affected by the proposed action (NMFS, 2010). The Atlantic sturgeon is currently a candidate species be considered for being listed as an endangered species. Additionally, NMFS identified four Federally listed sea turtle species: the loggerhead (*Caretta caretta*), Kemp's ridley (*Lepidochelys kempi*), green turtle (*Chelonia mydas*), and leatherback turtle (*Dermochelys coriacea*), as having the potential to be adversely affected by the proposed action. These six species, their habitats, and their life histories, are described in Section 2.2.7.1.

The FWS (2010) responded on June 29, 2010, and indicated that there are no Federally listed species known to occur in the vicinity of the Salem and HCGS sites. Potential habitat for the bog turtle (*Clemmys muhlenbergil)* and swamp pink (*Helonias bullata)* exist along the New Freedom North and New Freedom South transmission line ROWs; however, the FWS concluded that the continued operation of Salem and HCGS is unlikely to adversely affect these species (FWS, 2010).

4.7.1 Aquatic Threatened or Endangered Species of the Delaware Estuary

Pursuant to consultation requirements under Section 7 of the Endangered Species Act of 1973, the Staff sent a letter to NMFS dated December 23, 2009 (NRC, 2009a) requesting information on Federally listed endangered or threatened species and proposed or candidate species. In its response on February 11, 2010, NMFS stated that the shortnose sturgeon, the Atlantic sturgeon, and four sea turtle species are known to occur in the Delaware River and estuary in the vicinity of Salem and HCGS, and that no critical habitat is currently designated by NMFS near these facilities (NMFS, 2010).

At Salem, NMFS considers takes to include mortalities as well as turtles that are impinged but removed alive and released. In 1991, NMFS issued a Biological Opinion that found that continued operation of Salem and HCGS would affect threatened or endangered sea turtles but was not likely to jeopardize any populations, and it issued an Incidental Take Statement (ITS) for Kemp's ridley, green, and loggerhead turtles and shortnose sturgeon. The number of turtles impinged in 1991 was unexpectedly high, exceeding the incidental take allowed and resulting in additional consultation. An opinion issued in 1992 revised the ITS. The impingement of sea turtles exceeded the allowable take in 1992 as well, prompting additional consultation between NRC and NMFS (NMFS, 1999). A 1993 Biological Opinion (NMFS 1993) required that PSEG track all loggerhead sea turtles taken alive at the cooling water intake structure (CWIS) and released. Also in 1993, PSEG implemented a policy of removing the ice barriers from the trash racks on the intake structure during the period between May 1 and October 24, which resulted in substantially lower turtle impingement rates at Salem.

In 1999, NRC requested that the studies of released turtles be eliminated due to the reduction in the number of turtles impinged after the 1993 change in procedure regarding the removal of ice barriers. NMFS responded in 1999 with a letter and an incidental take statement stating that these studies could be discontinued because it appeared that the reason for the relatively high impingement numbers previously was the ice barriers that had been left on the intake structure during the warmer months (NMFS, 1999). This letter allowed an annual incidental take of 5 shortnose sturgeon, 30 loggerhead sea turtles, 5 green sea turtles, and 5 Kemp's ridley sea turtles. In addition, the statement required ice barrier removal by May 1 and replacement after October 24, and it required that in the warmer months the trash racks must be cleaned weekly and inspected every other hour, and in the winter they should be cleaned every other week. The statement requires that if a turtle is killed, the racks must be inspected every hour for the rest of the warm season. Dead shortnose sturgeon are required to be inspected for tags, and live sturgeon are to be tagged and released (NMFS, 1999). No sea turtles have been captured at Salem since 2001 (NMFS, 2009).

No shortnose sturgeon or sea turtles have been impinged at the HCGS intake structure (NMFS, 2009), and NMFS has not required monitoring at HCGS beyond normal cleaning of the intake structure (NMFS, 1993).

The Staff discusses the potential effects of entrainment, impingement, and thermal discharges on these and other important species in Sections 4.5.2, 4.5.3, and 4.5.4. Based on examination by the Staff of entrainment data provided by PSEG, there is no evidence that the eggs or larvae of either sturgeon species are commonly entrained at Salem and HCGS. Neither of the sturgeon species is on the list of species that has been identified in annual entrainment monitoring during the 1978 – 2008 period (Table 4.21). The life histories of these sturgeon, described in Section 2.2.7.1, suggest that entrainment of their eggs or larvae is unlikely. Shortnose sturgeon spawn upstream in freshwater reaches of the Delaware River and are most abundant between Philadelphia and Trenton. Their eggs are demersal and adhere to the substrate, and juvenile stages tend to remain in freshwater or fresher areas of the estuary for 3 to 5 years before moving to more saline areas such as the nearshore ocean. Thus, shortnose sturgeon eggs or larvae are unlikely to be present in the water column at the Salem or HCGS intakes well downstream of the spawning areas. Similarly, the life history of the Atlantic sturgeon makes entrainment of its eggs or larvae very unlikely.

Table 4-21. Impingement data for shortnose sturgeon and three sea turtle species with recorded impingements at Salem intakes, 1978-2008.

Year	Number Impinged[(1)]			
	Shortnose sturgeon	**Kemp's ridley sea turtle**	**Green sea turtle**	**Loggerhead sea turtle**
1978	2 (2)	0	0	0
1979	0	0	0	0
1980	0	1	1	2 (2)
1981	1 (1)	1 (1)	0	3 (2)
1982	0	0	0	1 (1)
1983	0	1 (1)	0	2 (2)
1984	0	1	0	2 (2)
1985	0	2 (1)	0	6 (5)
1986	0	1 (1)	0	0
1987	0	3 (1)	0	3
1988	0	2 (1)	0	8 (6)
1989	0	6 (2)	0	2
1990	0	0	0	0
1991	3 (3)	1	1	23 (1)
1992	2 (2)	4 (2)	1 (1)	10
1993	0	1	0	0
1994	2 (2)	0	0	1
1995	0	0	0	1 (1)
1996	0	0	0	0
1997	0	0	0	0
1998	3 (1)	0	0	1 (1)
1999	1	0	0	0
2000	1 (1)	0	0	2 (1)
2001	0	0	0	1 (1)
2002	0	0	0	0
2003	1 (1)	0	0	0
2004	2 (1)	0	0	1
2005	0	0	0	0
2006	0	0	0	0
2007	1 (1)	0	0	0
2008	1 (1)	0	0	0
2009	0	0	0	0
Total	20 (16)	24 (10)	3 (1)	69 (25)

(1) Numbers in parentheses indicate the number of individuals out of the yearly total shown that were either dead when found at the intakes or died afterward. Impingements of Atlantic sturgeon or leatherback sea turtles were not reported in the data on which this table was based.

Source: PSEG, 2010d.

Both sturgeon species and three of the four turtle species have been impinged at Salem. Atlantic sturgeon were collected in impingement studies in a single year, 2006 (PSEG, 2006a). From 1978 through 2009, 20 shortnose sturgeon were impinged at the Salem intakes, of which 16 died. Between 1978 and 2008, 24 Kemp's ridley sea turtles were impinged, of which ten died. Three green turtles (one died) and 69 loggerhead turtles (25 died) also were impinged. Impingement of the turtles was greatest in 1991 and 1992 (Table 4.21). After PSEG modified its use of the ice barriers in 1993, turtle impingement numbers returned to levels much lower than in 1991. From 1994 through 2009, Salem impinged seven sea turtles (all loggerheads), and four of these died. Also during this 16-yr period, 12 shortnose sturgeon were impinged, of which eight died. Sea turtles have not been impinged at Salem since 2004 (NMFS, 2009).

Section 4.5.4 discusses potential impacts of thermal discharges on the aquatic biota of the Delaware Estuary, and the Staff expects that impacts on fish and invertebrates, including those preyed upon by sturgeon and sea turtles, to be minimal. The high exit velocity of the discharge produces rapid dilution, which limits high temperatures to relatively small areas in the zone of initial mixing in the immediate vicinity of the discharge. Fish and many other organisms are largely excluded from these areas due to high velocities and turbulence. Shortnose and Atlantic sturgeon and the four sea turtle species have little potential to experience adverse effects from exposure to the temperatures at the discharge because of their life history characteristics and their mobility. Sturgeon spawning and nursery areas do not occur in the area of the discharge in the estuary, and adult sturgeon forage on the bottom while the buoyant thermal plume rises toward the surface. Sea turtles prefer warmer water temperatures, occur in the region only during warm months, and are unlikely to be sensitive to the localized area of elevated temperatures at the discharge. NMFS (1993) considered the possibility that the warm water near the discharge could cause sea turtles to remain in the area until surrounding waters are too cold for their safe departure in the fall, but it concluded that this scenario was not supported by any existing data.

The Staff reviewed information from the site audit, the applicant's ERs for Salem and HCGS, biological monitoring reports, other reports, and coordination with NMFS, FWS, and State regulatory agencies in New Jersey and Delaware regarding listed species. The Staff concludes that the impacts on Federally listed threatened or endangered aquatic species of the Delaware Estuary during an additional 20 years of operation of the Salem and HCGS facilities would be SMALL. NRC provides a Biological Assessment of the potential effects from the proposed license renewal for the Salem and HCGS facilities on Federally listed endangered or threatened species under NMFS jurisdiction in Appendix D.

4.7.2 Terrestrial and Freshwater Aquatic Threatened or Endangered Species

The FWS (2010) indicated that no Federally listed terrestrial species are known to occur on or in the vicinity of the Salem and HCGS sites. The FWS (2010) noted that areas of potential habitat and/or known occurrences of the bog turtle and swamp pink exist along the New Freedom North and New Freedom South transmission line ROWs, but that the continued operation of Salem and HCGS are unlikely to adversely affect either species because PSEG had previously committed to adopting FWS-recommended conservation measures along the transmission line ROWS. The Staff reviewed information from the site audit, ERs for Salem and HCGS, other reports, and coordinated with FWS and State regulatory agencies in New Jersey and Delaware regarding listed species. The NRC staff concludes that the impacts on Federally listed terrestrial and freshwater aquatic species from an additional 20 years of operation and maintenance of the Salem and HCGS facilities and associated transmission line ROWs would be SMALL.

4.8 Human Health

The human health issues applicable to Salem and HCGS are discussed below and listed in Table 4-22 for Category 1, Category 2, and uncategorized issues.

Table 4-22. Human Health Issues. *Table B-1 of Appendix B to Subpart A of 10 CFR Part 51 contains more information on these issues.*

Issues	GEIS Section	Category
Radiation exposures to the public during refurbishment	3.8.1[a]	1
Occupational radiation exposures during refurbishment	3.8.2[a]	1
Microbiological organisms (occupational health)	4.3.6	1
Microbiological organisms (public health, for plants using lakes or canals or discharging small rivers)	4.3.6[b]	2
Noise	4.3.7	1
Radiation exposures to public (license renewal term)	4.6.2	1
Occupation radiation exposures (license renewal term)	4.6.3	1
Electromagnetic fields – acute effects (electric shock)	4.5.4.1	2
Electromagnetic fields – chronic effects	4.5.4.2	Uncategorized

[a] - Issues apply to refurbishment, an activity that neither Salem nor HCGS plan to undertake.
[b] - Issue applies to plant features such as cooling lakes or cooling towers that discharge to small rivers. Neither Salem nor HCGS have applicable features.

4.8.1 Generic Human Health Issues

The Staff did not identify any new and significant information related to human health issues or radiation exposures during its review of the PSEG environmental reports, the site audit, or the scoping process. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS. For these issues, the GEIS concluded that the impacts are SMALL, and additional site-specific mitigation measures are not likely to be sufficiently beneficial to be warranted (Category 1 issues). These impacts will remain SMALL through the license renewal term.

4.8.2 Radiological Impacts of Normal Operations

Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, applicable to Salem and HCGS in regard to radiological impacts are listed in Table 4-22. PSEG stated in its ER that it was not aware of any new radiological issues associated with the renewal of the Salem and HCGS operating licenses. The Staff has not identified any new and significant information, during its independent review of PSEG's ER, the site audit, the scoping process, or its evaluation of other available information. Therefore, the Staff concludes that there would be no impact from radiation exposures to the public or to workers during the renewal term beyond those discussed in the GEIS.

According to the GEIS, the impacts to human health are SMALL, and additional plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted

- Radiation exposures to public (license renewal term). Based on information in the GEIS, the Commission found the following:

  Radiation doses to the public will continue at current levels associated with normal operations.

- Occupational exposures (license renewal term). Based on information in the GEIS, the Commission found the following:

  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 well below regulatory limits.

Therefore, the Staff expects that there would be no impacts during the renewal term beyond those discussed in the GEIS.

There are no Category 2 issues related to radiological impacts of routine operations.

The information presented below is a discussion of selected radiological programs conducted at Salem and HCGS.

Radiological Environmental Monitoring Program

PSEG conducts a radiological environmental monitoring program (REMP) to assess the radiological impact, if any, to its employees, the public, and the environment around the plant site. The REMP provides measurements of radiation and of radioactive materials for the exposure pathways and the radionuclides which lead to the highest potential radiation exposures to the public. The REMP supplements the radioactive effluent monitoring program by verifying that any measurable concentrations of radioactive materials and levels of radiation in the environment are not higher than those calculated using the radioactive effluent release measurements and transport models.

The objectives of the REMP are as follows:

- To fulfill the requirements of the radiological surveillance sections of the Plants' Technical Specifications and the Offsite Dose Calculation Manual.
- To determine whether any significant increase occurred in the concentration of radionuclides in critical pathways for the transfer of radionuclides through the environment to man.
- To determine if operation of the plants caused an increase in the radioactive inventory of long-lived radionuclides in the environment.
- To detect any change in ambient gamma radiation levels.

- To verify that operation of the plants have no detrimental effects on the health and safety of the public or on the environment.

An annual radiological environmental operating report is issued, which contains a discussion of the results of the monitoring program. The report contains data on the monitoring performed for the most recent year as well as graphs containing historical information. The REMP collects samples of environmental media in order to measure the radioactivity levels that may be present. The media samples are representative of the radiation exposure pathways that may impact the public. The REMP measures the aquatic, terrestrial, and atmospheric environment for radioactivity, as well as the ambient radiation. Ambient radiation pathways include radiation from radioactive material inside buildings and plant structures and airborne material that may be released from the plant. In addition, the REMP measures background radiation (i.e., cosmic sources, global fallout, and naturally occurring radioactive material, including radon). Thermoluminescent dosimeters (TLDs) are used to measure ambient radiation. The atmospheric environmental monitoring consists of sampling and analyzing the air for particulates and radioiodine. Terrestrial environmental monitoring consists of analyzing samples of locally grown vegetables and fodder crops, drinking water, groundwater, meat, and milk. The aquatic environmental monitoring consists of analyzing samples of surface water, fish, crabs, and sediment. An annual land use census is conducted to determine if the REMP needs to be revised to reflect changes in the environment or population that might alter the radiation exposure pathways. Salem and HCGS has an onsite groundwater protection program designed to monitor the onsite plant environment for early detection of leaks from plant systems and pipes containing radioactive liquid (PSEG, 2009a; 2009b; 2010c). Additional information on the groundwater protection program is contained later in this section and in the Ground Water Quality section in Chapter 2 of this document.

The Staff reviewed the Salem and HCGS annual radiological environmental operating reports for 2005 through 2009 to look for any significant impacts to the environment or any unusual trends in the data (PSEG, 2006b; 2007b; 2008c; 2009f; 2010c). A five year period provides a representative data set that covers a broad range of activities that occur at a nuclear power plant such as refueling outages, non-refueling outage years, routine operation, and years where there may be significant maintenance activities. Based on the Staff's review, no unusual trends were observed and the data showed that there was no significant radiological impact to the environment from operations at Salem and HCGS. Small amounts of radioactive material (i.e., tritium, cesium-137, and manganese-54) were detected below NRC's reporting values for radionuclides in environmental samples. Overall, the results, with the exception of the on-site groundwater contaminated with tritium, were comparable to the results obtained during the preoperational phase of the REMP and with historical results obtained since commercial operation.

The NJDEP's Bureau of Nuclear Engineering performs an independent Environmental Surveillance and Monitoring Program (ESMP) in the environment around the Salem and Hope Creek Nuclear Generating Stations. The ESMP provides a comprehensive monitoring strategy that ensures that New Jersey citizens are aware of and, if necessary, protected from harmful exposure to radioactive effluent discharges from New Jersey's nuclear power plants during normal or accident operations.

The specific objectives of the ESMP are to monitor pathways for entry of radioactivity into the environment in order to identify potential exposures to the population from routine and accidental releases of radioactive effluent, and to provide a summary and interpretation of this information to members of the public and government agencies.

The Staff reviewed the NJDEP's 2008 report (the most recent report available to the Staff at the time this draft SEIS was prepared) which contains information on the environmental sampling conducted during the time period of January 1, 2008 through December 31, 2008. The State reported the following: "Overall, the data collected by the NJDEP's ESMP throughout 2008 indicate that residents living in the area around Oyster Creek and Salem/Hope Creek nuclear power plants have not received measurable exposures of radiation above normal background" (NJDEP, 2009).

<u>Radiological Groundwater Protection Program</u>

In response to an identified radioactive liquid release from the Salem Unit 1 spent fuel pool in 2002, PSEG implemented a Remedial Action Work Plan (RAWP) and developed a voluntary Radiological Groundwater Protection Program (RGPP) in 2006 that added additional groundwater sampling locations, outside the scope of the REMP. The RAWP, which was reviewed by the NRC and approved by the NJDEP, is a program designed to remediate the site's groundwater to remove the tritiated groundwater and control the tritium plume from reaching the site boundary and impacting the off-site environment. The results of the RGPP groundwater monitoring program have been reported in the annual radiological environmental operating report since 2006.

The radiological monitoring data for 2009 showed a wide range of tritium concentrations in the on-site groundwater. For HCGS, the results show that tritium was detected at concentrations that ranged from the lower limit of detection value of 200 pico Curies per liter (pCi/L) to a maximum of 7,778 pCi/L. As a result of the positive indications of tritium, the applicant increased the sampling frequency for the monitoring wells. Subsequent sampling did not reproduce the highest levels observed; however, variations in the levels were observed throughout 2009. As a result, the applicant continues to track the concentrations of tritium in the groundwater to determine if a trend can be observed. For the Salem units, the results show that tritium was detected in on-site groundwater in concentrations that ranged from the lower limit of detection value of 200 pCi/L to a maximum of 2,259 pCi/L. The applicant is tracking the tritium concentration levels to determine if a trend can be observed (PSEG, 2010c). The Staff notes that no groundwater samples reached the NRC's reporting level of 20,000 pCi/L for tritium in environmental samples.

As part of the applicant's investigation for new and significant information that is relevant to its license renewal application, the issue of tritium in the groundwater was evaluated. The applicant's evaluation concludes that changes in tritium-related groundwater quality are not significant at Salem and would not preclude current or future uses of the groundwater for the following reasons:

- Although tritium concentrations are elevated in the shallow aquifer beneath Salem, PSEG has been performing remedial actions since 2004, and concentrations continue to decrease.
- Tritium concentrations in groundwater are due to an historic incident; the source (spend fuel pool water leak) has been eliminated.
- No tritium concentrations above either the EPA Drinking Water Standard or the NJDEP

Ground Water Quality Criterion have migrated to the property boundary or into geologic formations deeper than the shallow aquifer. Offsite tritium concentrations are below regulatory limits.

- There is no human exposure pathway and, therefore, no threat to public or employee health or safety.

Radioactive Effluent Release Program

All nuclear plants were licensed with the expectation that they would release radioactive material to both the air and water during normal operation. However, NRC regulations require that radioactive gaseous and liquid releases from nuclear power plants must meet radiation dose-based limits specified in 10 CFR Part 20, and as low as is reasonably achievable (ALARA) criteria in Appendix I to 10 CFR Part 50. The regulatory limits protect plant workers and members of the public from radioactive material released by a nuclear power plant. In addition, nuclear power plants are required to file an annual report to the NRC which lists the types and quantities of radioactive effluents released into the environment. The radioactive effluent release and radiological environmental monitoring reports are available for review by the public through the NRC's ADAMS electronic reading room on the NRC website.

The Staff reviewed the annual radioactive effluent release reports for 2005 through 2009 (PSEG, 2006d; 2007c; 2008b; 2008e; 2010b). The review focused on the calculated doses to a member of the public from radioactive effluents released from Salem and HCGS. The doses were compared to the radiation protection standards in 10 CFR 20.1301 and the ALARA dose design objectives in Appendix I to 10 CFR Part 50.

Dose estimates for members of the public are calculated based on radioactive gaseous and liquid effluent release data and atmospheric and aquatic transport models. The 2009 annual radioactive material release report (PSEG, 2010b) contains a detailed presentation of the radioactive discharges and the resultant calculated doses. The following summarizes the calculated dose to a member of the public located outside the Salem and HCGS site boundary from radioactive gaseous and liquid effluents released during 2009:

Salem Units 1 and 2

- The total-body dose to an offsite member of the public from radioactive liquid effluents from Salem Unit 1 was 3.22×10^{-05} millirem (mrem; 3.22×10^{-05} millisieverts [mSv]) and 2.72×10^{-05} mrem (2.72×10^{-07} mSv) for Unit 2, which is well below the 3 mrem (0.03 mSv) dose criterion for an individual reactor unit in Appendix I to 10 CFR Part 50.

- The maximum dose to any organ (i.e., skin, thyroid, liver, G.I. tract, etc.) of an offsite member of the public from radioactive liquid effluents from Salem Unit 1 was 8.60×10^{-05} mrem (8.60×10^{-07} mSv) and 8.89×10^{-05} (8.89×10^{-07} mSv) for Unit 2, which is well below the 10 mrem (0.1 mSv) dose criterion for an individual reactor unit in Appendix I to 10 CFR Part 50.

- The air dose at the site boundary from gamma radiation in gaseous effluents from Salem Unit 1 was 1.28×10^{-04} millirad (mrad; 1.28×10^{-06} megagray [mGy]), and 2.74×10^{-05} mrad (2.74×10^{-07} mGy) for Unit 2, which is well below the 10 mrad (0.1 mGy) dose criterion for an individual reactor unit in Appendix I to 10 CFR Part 50.

- The air dose at the site boundary from beta radiation in gaseous effluents from Salem Unit 1 was 3.14×10^{-04} mrad ($3.14\ 10^{-06}$ mGy) and 1.46×10^{-05} mrad (1.46×10^{-07} mGy) for Unit 2, which is well below the 20 mrad (0.2 mGy) dose criterion for an individual reactor unit in Appendix I to 10 CFR Part 50.
- The maximum dose to any organ (i.e., skin, thyroid, liver, G.I. tract, etc.) of a member of the public at the site boundary from radioactive iodine, tritium, and radioactive particulate matter from Unit 1 was 2.70×10^{-03} mrem (2.70×10^{-05} mSv) and 1.65×10^{-03} mrem (1.65 E-05 mSv) for Unit 2, which is well below the 15 mrem (0.15 mSv) dose criterion for an individual reactor unit in Appendix I to 10 CFR Part 50.

<u>Hope Creek Generating Station</u>

- The total-body dose to an offsite member of the public from radioactive liquid effluents from HCGS was 8.32×10^{-05} mrem (8.32×10^{-07} mSv), which is well below the 3 mrem (0.03 mSv) dose criterion for an individual reactor unit in Appendix I to 10 CFR Part 50.
- The maximum dose to any organ (i.e., skin, thyroid, liver, G.I. tract, etc.) of an offsite member of the public from radioactive liquid effluents from HCGS was 3.05×10^{-04} mrem (3.05×10^{-06} mSv), which is well below the 10 mrem (0.1 mSv) dose criterion for an individual reactor unit in Appendix I to 10 CFR Part 50.
- The air dose at the site boundary from gamma radiation in gaseous effluents from HCGS was 7.29×10^{-04} mrad (7.29×10^{-06} mGy), which is well below the 10 mrad (0.1 mGy) dose criterion for an individual reactor unit in Appendix I to 10 CFR Part 50.
- The air dose at the site boundary from beta radiation in gaseous effluents from HCGS was 7.34×10^{-04} mrad (7.34×10^{-06} mGy), which is well below the 20 mrad (0.2 mGy) dose criterion for an individual reactor unit in Appendix I to 10 CFR Part 50.
- The maximum dose to any organ (i.e., skin, thyroid, liver, G.I. tract, etc.) of a member of the public at the site boundary from radioactive iodine, tritium, and radioactive particulate matter from HCGS was 1.97×10^{-02} mrem (1.97×10^{-04} mSv), which is well below the 15 mrem (0.15 mSv) dose criterion for an individual reactor unit in Appendix I to 10 CFR Part 50.

<u>Salem – Hope Creek Site Total</u>

- The total-body dose to an offsite member of the public from the combined radioactive effluents from all three reactor units was 7.26×10^{-03} mrem (7.26×10^{-05} mSv), which is well below the 25 mrem (0.25 mSv) dose criterion in 40 CFR Part 190.
- The dose to any organ (i.e., skin, thyroid, liver, G.I. tract, etc.) of an offsite member of the public from the combined radioactive effluents from all three reactor units was 2.54 E-02 mrem (2.54×10^{-04} mSv), which is well below the 25 mrem (0.25 mSv) dose criterion in 40 CFR Part 190.
- The thyroid dose to an offsite member of the public from the combined radioactive effluents from all three reactor units was 2.41×10^{-02} mrem (2.41×10^{-04} mSv), which is well below the 75 mrem (0.75 mSv) dose criterion in 40 CFR Part 190.

Based on the Staff's review of the Salem and HCGS radioactive waste system's performance in controlling radioactive effluents and the resultant doses to members of the public in conformance with the ALARA criteria in Appendix I to 10 CFR Part 50, the Staff found that the 2009 radiological effluent data for Salem and HCGS are consistent, within reasonable variation attributable to operating conditions and outages, with the historical data. The results demonstrate that Salem and HCGS are operating in compliance with Federal radiation protection standards contained in Appendix I to 10 CFR Part 50, 10 CFR Part 20, and 40 CFR Part 190.

Routine plant operational and maintenance activities currently performed will continue during the license renewal term. Based on the past performance of the radioactive waste system to maintain the dose from radioactive effluents to be ALARA, similar performance is expected during the license renewal term.

The radiological impacts from the current operation of Salem and HCGS are not expected to change significantly. Continued compliance with regulatory requirements is expected during the license renewal term; therefore, the impacts from radioactive effluents would be SMALL.

4.8.3 Microbiological Organisms – Public Health

Both Salem and HCGS have thermal discharges to the Delaware Estuary, a large brackish, tidally-influenced water body that allows their thermal plumes to disperse quickly. There are no other facilities that release thermal discharges to the Estuary in the vicinity of Salem and HCGS.

Table B-1 of Appendix B to Subpart A of 10 CFR Part 51 and Table 4-22 list the effects of thermophilic microbiological organisms on human health as a Category 2 issue and requires the conduct of a plant-specific evaluation before license renewal. This issue applies to plant features such as cooling lakes or cooling towers that discharge to small rivers. NRC has determined that Salem and HCGS discharge to an estuary (NRC, 1996). Neither Salem nor HCGS use cooling ponds, cooling lakes, cooling canals, or discharge to a small river. Therefore, this issue does not apply and the effects of plant discharges on microbiological organisms do not need to be addressed for license renewal.

4.8.4 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) criteria, it was not possible to determine the significance of the electric shock potential (IEEE, 2007). Evaluation of individual plant transmission lines is necessary because the issue of electric shock safety was not addressed in the licensing process for some plants. For other plants, land use in the vicinity of transmission lines may have changed, or power distribution companies may have chosen to upgrade line voltage. To comply with 10 CFR 51.53(c)(3)(ii)(H), the applicant must provide an assessment of the impact of the proposed action on the potential shock hazard from the transmission lines if the transmission lines that were constructed for the specific purpose of connecting the plant to the transmission system do not meet the recommendations of the NESC for preventing electric shock from induced currents.

As described in Section 2.1.1.6, four 500-kilovolt (kV) transmission lines were specifically constructed to distribute power to the electrical grid from the Salem and HCGS. One 500-kV line, the HCGS-New Freedom line, was originally constructed to connect HCGS to the transmission system. Two additional lines, Salem-New Freedom North and Salem-Keeney (via Red Lion substation), were originally built for Salem but have since been connected to HCGS. The fourth line, Salem-New Freedom South, originates at Salem (PSEG, 2009a; 2009b).

PSEG conducted an analysis of the Salem HCGS transmission lines using a computer model of induced current under the line and the results were field verified. PSEG calculated electric field strength and induced current using a computer code called ACDCLINE, produced by the Electric Power Research Institute. The analysis determined that there are no locations under the transmission lines that have the capacity to induce more than 5 milliamperes (mA) in a vehicle parked beneath the line. Therefore, the lines meet the NESC 5 mA criterion. The maximum induced current calculated for the power lines was 4.2 mA for the Salem-New Freedom South line (PSEG, 2009a; 2009b).

PSEG also conducts regular aerial and ground surveillance and maintenance to ensure that design ground clearances do not change. The aerial patrols of all corridors include checks for encroachments, broken conductors, broken or leaning structures, and signs of burnt trees, any of which would be evidence of clearance problems. Ground inspections include examination for clearance at questionable locations, examination for integrity of structures, and surveillance for dead or diseased trees that might fall on the transmission line. Problems noted during any inspection are brought to the attention of the appropriate organizations for corrective action (PSEG, 2009a; 2009b).

The Staff has reviewed the available information, including the applicant's evaluation and computational results for the potential impacts of electric shock resulting from operation of Salem and HCGS and their associated transmission lines. The staff concludes that the potential impacts of electric shock during the renewal term would be SMALL.

4.8.5 Electromagnetic Fields – Chronic Effects

In the GEIS, the chronic effects of 60-hertz (Hz) electromagnetic fields from power lines were not designated as Category 1 or 2, and will not be until a scientific consensus is reached on the health implications of these fields.

The potential 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 report by NIEHS (NIEHS, 1999) contains the following conclusion:

> The NIEHS concludes that ELF-EMF (extremely low frequency-electromagnetic field) exposure cannot be recognized as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard. In our opinion, this finding is insufficient to warrant aggressive regulatory concern. However, because virtually everyone in the

> United States uses electricity and therefore is routinely exposed to ELF-EMF, passive regulatory action is warranted such as continued emphasis on educating both the public and the regulated community on means aimed at reducing exposures. The NIEHS does not believe that other cancers or non-cancer health outcomes provide sufficient evidence of a risk to currently warrant concern.

This statement is not sufficient to cause the Staff to change its position with respect to the chronic effects of electromagnetic fields. The NRC staff considers the GEIS finding of "not applicable" still appropriate and will continue to follow developments on this issue.

4.9 Socioeconomics

The socioeconomic issues applicable to Salem and HCGS during the license renewal term are listed in Table 4-23, including applicable GEIS section and category (Category 1, Category 2, or uncategorized).

Table 4-23. Socioeconomic Issues. *Section 2.2.8 of this report describes the socioeconomic conditions near Salem and HCGS.*

Issue	GEIS Section	Category
Housing impacts	4.7.1	2
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	1
Public services: public utilities	4.7.3.5	2
Public services: education (license renewal term)	4.7.3.1	1
Offsite land use (license renewal term)	4.7.4	2
Public services: transportation	4.7.3.2	2
Historic and archaeological resources	4.7.7	2
Aesthetic impacts (license renewal term)	4.7.6	1
Aesthetic impacts of transmission lines (license renewal term)	4.5.8	1
Environmental justice	Not addressed (a)	Uncategorized (a)

(a) Guidance related to environmental justice was not in place at the time the GEIS and the associated revisions to 10 CFR Part 51 were prepared. Therefore, environmental justice must be addressed in plant-specific reviews.

4.9.1 Generic Socioeconomic Issues

The NRC reviewed and evaluated the Salem and HCGS ERs (PSEG, 2009a; 2009b), scoping comments, and other available information, and visited the Salem and HCGS sites and did not identify any new and significant information that would change the conclusions presented in the

GEIS. Therefore, there would be no impacts related to the Category 1 issues during the period of extended operation beyond those discussed in the GEIS. For Salem and HCGS, the GEIS conclusions for Category 1 issues are incorporated by reference. Impacts for Category 2 and uncategorized issues are discussed in the following sections.

4.9.2 Housing Impacts

According to the 2000 Census, approximately 501,820 people lived within 20 mi (32 km) of Salem and HCGS, which equates to a population density of 450 persons per square mile (PSEG, 2009a; 2009b). This density translates to GEIS Category 4 – least sparse (greater than or equal to 120 persons per square mile within 20 mi [32km]). Approximately 5,201,842 people live within 50 mi (80 km) of Salem and HCGS (PSEG, 2009a; 2009b). This equates to a population density of 771 persons per square mile. Applying the GEIS proximity measures, this value translates to a Category 4 – in close proximity (greater than or equal to 190 persons per square mile within 50 mi [80 km]). Therefore, according to the sparseness and proximity matrix presented in the GEIS, the sparseness Category 4 and proximity Category 4 indicate that Salem and HCGS are located in a high population area.

Table B-1 of Appendix B to Subpart A of 10 CFR Part 51 states that impacts on housing availability are expected to be of small significance in high-density population areas where growth control measures are not in effect. Since Salem and HCGS are located in a high population area, and Cumberland, Gloucester, Salem, and New Castle Counties are not subject to growth control measures that would limit housing development, any changes in employment at Salem and HCGS would have little noticeable effect on housing availability in these counties. Since PSEG has no plans to add non-outage employees during the license renewal period, employment levels at Salem and HCGS would remain relatively constant with no additional demand for permanent housing during the license renewal term. In addition, the number of available housing units has kept pace with or exceeded the growth in the area population. Based on this information, there would be no additional impact on housing during the license renewal term beyond what has already been experienced.

4.9.3 Public Services: Public Utilities

As discussed in Section 4.7.4 of the GEIS, impacts on public utility services (e.g., water, sewer) are considered SMALL if the public utility has the ability to respond to changes in demand and would have no need to add or modify facilities. Impacts are considered MODERATE if service capabilities are overtaxed during periods of peak demand. Impacts are considered LARGE if additional system capacity is needed to meet ongoing demand.

Analysis of impacts on the public water and sewer systems considered both facility demand and facility-related population growth. As previously discussed in Section 2.1.7, Salem and HCGS obtain their potable water supply directly from groundwater sources. The facility does not purchase water from a public water system. Water usage by Salem and HCGS has not stressed the supply source capacity (usage is approximately 41 percent of the permitted withdrawal [DRBC, 2000; NJDEP, 2004b]) and is not currently an issue. PSEG has no plans to increase Salem and HCGS staffing due to refurbishment or new construction activities, and has identified no operational changes during the license renewal term that would increase potable water use by the facilities.

Since PSEG has no plans to add non-outage employees during the license renewal period, employment levels at Salem and HCGS would remain relatively unchanged with no additional demand for public water services. Public water systems in the region are adequate to meet the demand of residential and industrial customers in the area. Therefore, there would be no additional impact to public water services during the license renewal term beyond what is currently being experienced.

4.9.4 Offsite Land Use – License Renewal Period

Off-site land use during the license renewal term is a Category 2 issue. Table B-1 of Appendix B to Subpart A of 10 CFR Part 51 notes that "significant changes in land use may be associated with population and tax revenue changes resulting from license renewal." In Section 4.7.4 of the GEIS, the magnitude of land-use changes as a result of plant operation during the period of extended operation is defined 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.

Tax revenue can affect land use because it enables local jurisdictions to provide the public services (e.g., transportation and utilities) necessary to support development. Section 4.7.4.1 of the GEIS states that the assessment of tax-driven land-use impacts during the license renewal term should consider (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 jurisdiction's 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.

<u>Population-Related Impacts</u>

Since PSEG has no plans to add non-outage employees during the license renewal period, there would be no noticeable change in land use conditions in the vicinity of the Salem and HCGS. Therefore, there would be no population-related land use impacts during the license renewal term beyond those already being experienced.

Tax Revenue-Related Impacts

As previously discussed in Section 2.2.8.6, PSEG and the Salem site's minority owner Exelon pay annual real estate taxes to Lower Alloways Creek Township. From 2003 through 2009, the owners paid between $1.2 and $1.5 million annually in property taxes to Lower Alloways Creek Township. This represented between 54 and 59 percent of the township's total annual property tax revenue. Each year, Lower Alloways Creek Township forwards this tax money to Salem County, which provides most services to township residents. The property taxes paid annually for Salem and HCGS during 2003 through 2009 represent approximately 2.5 to 3.5 percent of Salem County's total annual property tax revenues during that time period. PSEG pays annual property taxes to the City of Salem for the Energy and Environmental Resource Center, located in Salem. However, the tax payments for the Center would continue even if the licenses for Salem and HCGS were not renewed; therefore, these tax payments are not considered in the evaluation of tax revenue-related impacts during the license renewal term.

Since PSEG started making payments to the local jurisdiction, population levels and land use conditions in Lower Alloways Creek Township and Salem County have not changed significantly, which might indicate that these tax revenues have had little or no effect on land use activities within the township or county.

Since PSEG has no plans to add non-outage employees during the license renewal period, employment levels at Salem and HCGS would remain relatively unchanged. There would be no increase in the assessed value of Salem and HCGS, and annual property tax payments to Lower Alloways Creek Township would be expected to remain relatively constant throughout the license renewal period. Based on this information, there would be no tax revenue-related land-use impacts during the license renewal term beyond those already being experienced.

4.9.5 Public Services: Transportation Impacts

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 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 (see 10 CFR 51.53(c)(3)(ii)(J)).

Since PSEG has no plans to add non-outage employees during the license renewal period, traffic volume and levels of service on roadways in the vicinity of Salem and HCGS would not change. Therefore, there would be no transportation impacts during the license renewal term beyond those already being experienced.

4.9.6 Historic and Archaeological Resources

The National Historic Preservation Act (NHPA) requires that Federal agencies take in to 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 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.

A review of the New Jersey State Museum (NJSM) files shows that there are no previously recorded archaeological or above ground historic architectural resources identified on the Salem/Hope Creek property. As noted in Section 2.2.9.1, literature review and background research of the plant property was conducted as part of the applicant's ER; however, no systematic pedestrian or subsurface archaeological surveys have been conducted at the Salem/Hope Creek site to date. Background research identified 23 National Register of Historic Places listed resources within a 10 mi (16 km) radius of the facility; however, none are located within the boundaries of the Salem/Hope Creek property.

There is little potential for historic and archaeological resources to be present on most of the Salem/Hope Creek property. As noted in Section 2.2.9.2, due to the fact that the Salem and Hope Creek generating stations are located on a manmade island, there is little potential for prehistoric archaeological resources to be present. However, because the creation of the island dates to the historic period, there is potential for historic-period archaeological resources to be present in areas not previously disturbed by construction activities.

No new facilities, service roads, or transmission lines are proposed for the Salem/Hope Creek site as a part of this operating license renewal, nor are refurbishment activities proposed. 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.

4.9.7 Environmental Justice

Under Executive Order (EO) 12898 (59 FR 7629), Federal agencies are responsible for identifying and addressing, as appropriate, potential disproportionately high and adverse human health and environmental impacts on minority and low-income populations. In 2004, the Commission issued a *Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions* (69 FR 52040), which states, "The Commission is committed to the general goals set forth in EO 12898, and strives to meet those goals as part of its NEPA review process."

The Council of Environmental Quality (CEQ) provides the following information in *Environmental Justice: Guidance Under the National Environmental Policy Act* (CEQ, 1997):

> **Disproportionately High and Adverse Human Health Effects.**
>
> Adverse health effects are measured in risks and rates that could result in latent cancer fatalities, as well as other fatal or nonfatal adverse impacts on human health. Adverse health effects may include bodily impairment, infirmity, illness, or death. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant (as employed by NEPA) and appreciably exceeds the risk or exposure rate for the general population or for another appropriate comparison group (CEQ, 1997).

Disproportionately High and Adverse Environmental Effects.

A disproportionately high environmental impact that is significant (as defined by NEPA) refers to an impact or risk of an impact on the natural or physical environment in a low-income or minority community that appreciably exceeds the environmental impact on the larger community. Such effects may include ecological, cultural, human health, economic, or social impacts. An adverse environmental impact is an impact that is determined to be both harmful and significant (as employed by NEPA). In assessing cultural and aesthetic environmental impacts, impacts that uniquely affect geographically dislocated or dispersed minority or low-income populations or American Indian tribes are considered (CEQ, 1997).

The environmental justice analysis assesses the potential for disproportionately high and adverse human health or environmental effects on minority and low-income populations that could result from the operation of Salem and HCGS during the renewal term. In assessing the impacts, the following definitions of minority individuals and populations and low-income population were used (CEQ, 1997):

Minority individuals

Individuals who identify themselves as members of the following population groups: Hispanic or Latino, American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, or two or more races, meaning individuals who identified themselves on a Census form as being a member of two or more races, for example, Hispanic and Asian.

Minority populations

Minority populations are identified when (1) the minority population of an affected area exceeds 50 percent or (2) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.

Low-income population

Low-income populations in an affected area are identified with the annual statistical poverty thresholds from the Census Bureau's Current Population Reports, Series P60, on Income and Poverty.

Minority Population in 2000

There are a total of 23 counties in the 50-mi (80-km) radius surrounding Salem and HCGS. Of these, seven are in New Jersey (Salem, Cumberland, Cape May, Atlantic, Gloucester, Camden and Burlington), three are in Delaware (New Castle, Kent and Sussex), six are in Pennsylvania (Philadelphia, Montgomery, Delaware, Chester, Lancaster, and York) and seven are in Maryland (Harford, Cecil, Baltimore, Kent, Queen Anne’s, Caroline and Talbot).

According to 2000 Census data, 35.1 percent of the population (1,872,783 persons) residing within a 80-km (50-mi) radius of Salem and HCGS identified themselves as minority individuals. The largest minority group was Black or African American (1,213,122 persons or 19.5 percent), followed by Asian (190,983 persons or 3.1 percent). A total of 341,886 persons (5.5 percent) identified themselves as Hispanic or Latino ethnicity (USCB, 2003).

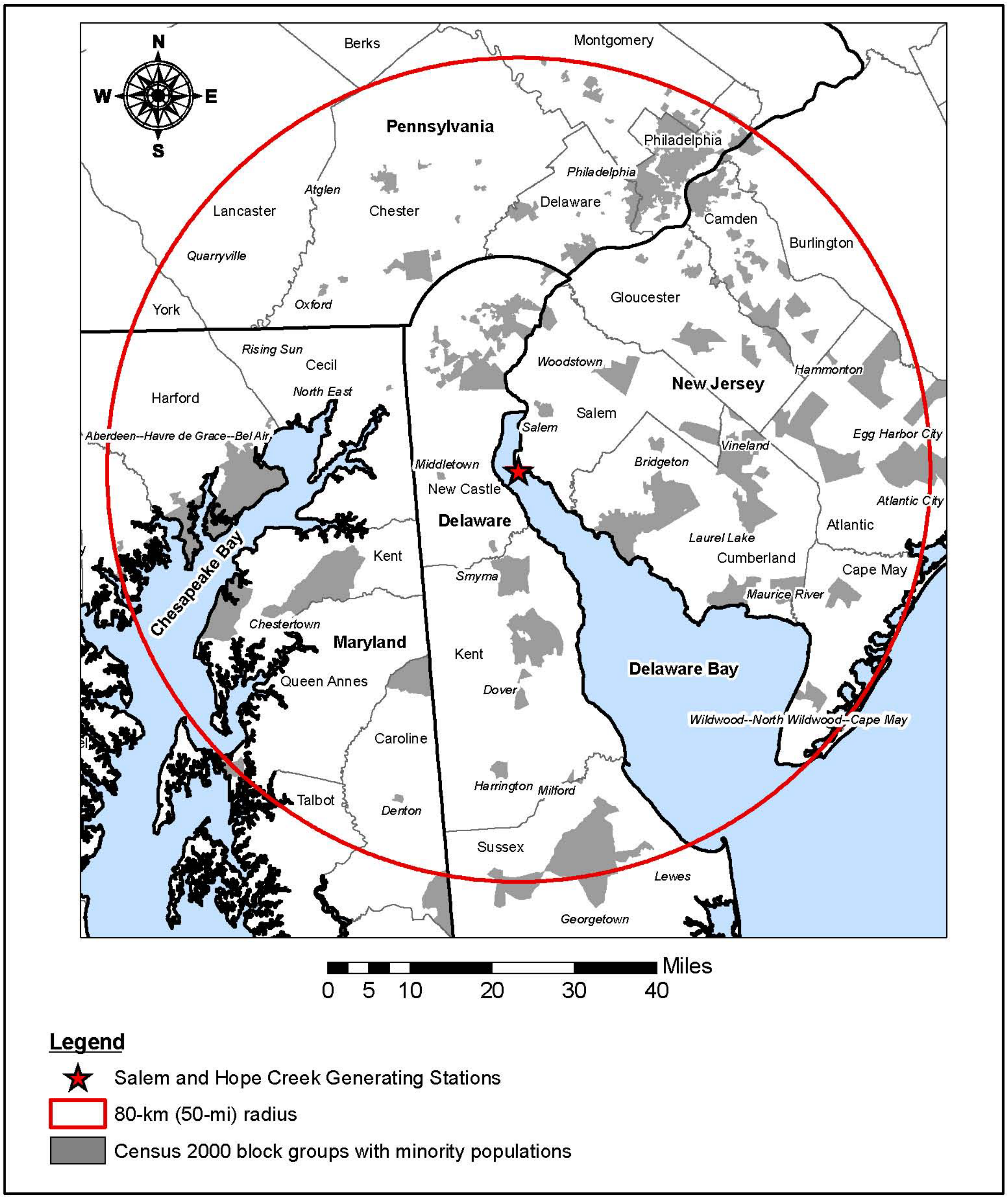
Of the 4,579 census block groups located wholly or partly within the 50-mi radius of Salem and HCGS, 1,860 block groups were determined to have minority population percentages that exceeded the 50-mi (80-km) radius percentage (USCB, 2000a). The largest minority group was Black or African American, with 1,284 block groups that exceed the 50-mi (80-km) radius percentage. These block groups are primarily located in Philadelphia County, Pennsylvania. There were 24 block groups with Asian, 94 block groups with Some Other Race, and 1 block group with Two or More Races minority classifications that exceeded the 50-mi (80-km) radius percentage. A total of 202 block groups exceeded the 80-km (50-mi) radius percentage for Hispanic or Latino ethnicity. The minority population nearest to Salem and HCGS is located in the City of Salem, New Jersey.

Based on 2000 Census data, Figure 4-7 shows minority block groups within an 50-mi (80-km) radius of Salem and HCGS.

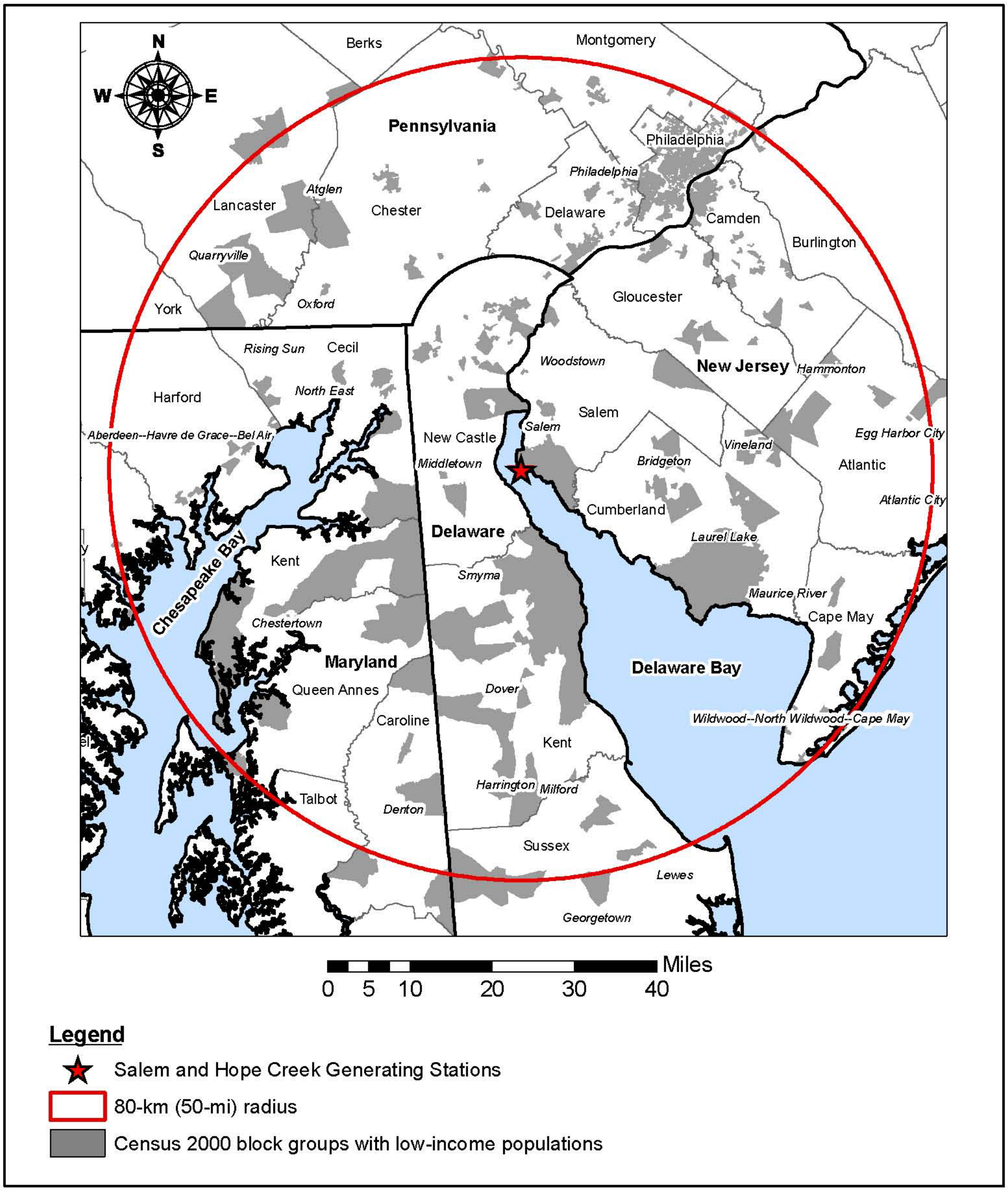
Low-Income Population in 2000

According to 2000 Census data, 119,283 families (2.2 percent) and 620,903 individuals (11.6 percent) residing within a 50-mi (80 km) radius of Salem and HCGS were identified as living below the Federal poverty threshold in 1999 (USCB, 2003). (The 1999 Federal poverty threshold was $17,029 for a family of four). The USCB reported 6.3 percent of families and 8.5 percent of individuals in New Jersey, 6.5 percent of families and 9.2 percent of individuals in Delaware, 7.8 percent of families and 11.0 percent of individuals in Pennsylvania, and 6.1 percent of families and 8.5 percent of individuals in Maryland living below the Federal poverty threshold in 1999 (USCB, 2000a; 2000b).

Census block groups were considered low-income block groups if the percentage of families and individuals living below the Federal poverty threshold exceeded the 50-mi (80 km) radius percentage. Based on 2000 Census data, there were 1,778 block groups within a 50-mi (80 km) radius of Salem and HCGS that could be considered low-income block groups. The majority of low-income population census block groups were located in Philadelphia County, Pennsylvania. The low-income population nearest to Salem and HCGS is located in Lower Alloways Creek Township in Salem County, New Jersey. Figure 4-8 shows low-income census block groups within a 50-mi (80 km) radius of Salem and HCGS.



1
2 Source: USCB, 2003
3
4 **Figure 4-7. Census 2000 minority block groups within a 50-mi radius of Salem and HCGS**



Source: USCB, 2003

Figure 4-8. Census 2000 low-income block groups within a 50-mi radius of Salem and HCGS

Analysis of Impacts

The NRC addresses environmental justice matters for license renewal through (1) identification of minority and low-income populations that may be affected by the proposed license renewal, and (2) examining any potential human health or environmental effects on these populations to determine if these effects may be disproportionately high and adverse.

The discussion and figures above indentifies the location of minority and low-income populations residing within a 50-mile (80-kilometer) radius of Salem and HCGS. This area of impact is consistent with the impact analysis for public and occupational health and safety, which also considers the radiological effects on populations located within a 50-mile (80-kilometer) radius of the plant. As previously discussed for the other resource areas in Chapter 4, the analyses of impacts for all resource areas indicated that the impact from license renewal would be SMALL.

Chapter 5 discusses the environmental impacts from postulated accidents that might occur during the license renewal term, which include both design basis and severe accidents. In both cases, the Commission has generically determined that impacts associated with such accidents are SMALL because nuclear plants are designed to successfully withstand design basis accidents, and that any risk associated with severe accidents were also SMALL.

Therefore, based on the overall findings discussed in Chapters 4 and 5, the NRC concludes that there would be no disproportionately high and adverse impacts to minority and low-income populations from the continued operation of Salem and HCGS during the license renewal term.

As part of addressing environmental justice associated with license renewal, the Staff also analyzed the risk of radiological exposure through the consumption patterns of special pathway receptors, including subsistence consumption of fish and wildlife, native vegetation, surface waters, sediments, and local produce; absorption of contaminants in sediments through the skin; and inhalation of plant materials. The special pathway receptors analysis, discussed below, is important to the environmental justice analysis because consumption patterns may reflect the traditional or cultural practices of minority and low-income populations in the area.

Subsistence Consumption of Fish and Wildlife

Section 4-4 of EO 12898 (59 FR 7629) directs Federal agencies, whenever practical and appropriate, to collect and analyze information on the consumption patterns of populations that rely principally on fish and/or wildlife for subsistence and to communicate the risks of these consumption patterns to the public. In this draft SEIS, the Staff considered whether there were any means for minority or low-income populations to be disproportionately affected by examining impacts to American Indian, Hispanic, and other traditional lifestyle special pathway receptors. Special pathways that took into account the levels of contaminants in native vegetation, crops, soils and sediments, surface water, fish, and game animals on or near Salem and HCGS were considered.

PSEG has an ongoing comprehensive Radiological Environmental Monitoring Program (REMP) at Salem and HCGS to assess the impact of site operations on the environment (see section 4.8.2 of this draft SEIS for a complete discussion of the REMP). To assess the impact of the plant on the environment, samples of environmental media are collected and analyzed for radioactivity. A plant effect would be indicated if the radioactive material detected in a sample was significantly larger than the background level.

The REMP measures the aquatic, terrestrial, and atmospheric environment for radioactivity, as well as the ambient radiation. In addition, the REMP measures background radiations (i.e., cosmic sources, global fallout, and naturally occurring radioactive material, including radon). Ambient radiation pathways include radiation from radioactive material inside buildings and plant structures and airborne material that may be released from the plants. Thermoluminescent dosimeters (TLDs) are used to measure ambient radiation. The atmospheric environmental monitoring consists of sampling and analyzing the air for radioactive particulates and radioiodine. The aquatic pathways include fish, surface water, fish, crabs, and sediment. The terrestrial environmental monitoring consists of analyzing locally grown vegetables and fodder crops, drinking water, groundwater, meat, and milk. During 2009, analyses performed on samples of environmental media showed no significant or measurable radiological impact above background levels from Salem and HCGS site operations (PSEG, 2010b). The 2009 Salem and Hope Creek REMP report is incorporated by reference in this SEIS.

Previously, PSEG had also tested muskrat populations in the area. Muskrats are trapped and consumed by the local population (PSEG, 2006c). As of 2006, no muskrat samples have been available for testing as the trappers who were supplying PSEG with samples were no longer operating (PSEG, 2007c). The last muskrat data was collected in 2005; only one sample detectable levels of potassium-40; no other radionuclides were detected (PSEG, 2006c).

The results of the 2009 REMP sampling and previous REMP reports (including the consideration of 2005 REMP muskrat data) demonstrate that the routine operation at Salem and HCGS has had no significant or measurable radiological impact on the environment. No elevated radiation levels have been detected in the offsite environment as a result of plant operations and the storage of radioactive waste.

The NJDEP’s Bureau of Nuclear Engineering performs an independent Environmental Surveillance and Monitoring Program (ESMP) in the environment around the Salem and Hope Creek Nuclear Generating Stations. The ESMP provides a comprehensive monitoring strategy that ensures that New Jersey citizens are aware of and, if necessary, protected from harmful exposure to radioactive effluent discharges from New Jersey’s nuclear power plants during normal or accident operations.

The specific objectives of the ESMP are to monitor pathways for entry of radioactivity into the environment in order to identify potential exposures to the population from routine and accidental releases of radioactive effluent, and to provide a summary and interpretation of this information to members of the public and government agencies.

The NRC reviewed the NJDEP’s 2008 report (the most recent report available at the time this draft SEIS was prepared) which contains information on the environmental sampling conducted during the time period of January 1, 2008 through December 31, 2008. The State reported the following: “Overall, the data collected by the NJDEP’s ESMP throughout 2008 indicate that residents living in the area around Oyster Creek and Salem/Hope Creek nuclear power plants have not received measurable exposures of radiation above normal background” (NJDEP, 2009a).

Additionally, NJDEP BNE monitors the groundwater on site at Artificial Island in conjunction with the remedial action being undertaken by PSEG to address tritium contamination detected in shallow groundwater near Salem Unit 1. There is no evidence that the tritium has reached any areas outside of the PSEG property. Analyses of fish, shellfish, vegetation, and sediment samples contained only potassium-40, a naturally-occurring radionuclide. Trace amounts of strontium-90 were detected in all milk samples, at levels consistent with what is expected as a result of past atmospheric nuclear weapons testing (NJDEP, 2009b).

Based on these and previous monitoring results, concentrations of radioactive contaminants in native leafy vegetation, sediments, surface water, and fish and game animals in areas surrounding Salem and HCGS have been low. Consequently, no disproportionately high and adverse human health impacts would be expected in special pathway receptor populations in the region as a result of subsistence consumption of fish and wildlife.

4.10 Evaluation of Potential New and Significant Information

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.

The new and significant assessment that PSEG conducted during preparation of this license renewal application included: (1) interviews with PSEG subject matter experts on the validity of the conclusions in the GEIS as they relate to Salem and HCGS, (2) an extensive review of documents related to environmental issues at Salem and HCGS and within the Delaware Estuary, (3) correspondence with state and federal agencies to determine if the agencies had concerns relevant to their resource areas that had not been addressed in the GEIS, (4) credit for PSEG environmental monitoring and reporting required by regulations and oversight of station facilities and operations by state and federal regulatory agencies (permanent activities that would bring significant issues to PSEG's attention), and (5) review of previous license renewal applications for issues relevant to the Salem and HCGS license renewal applications.

The NRC also has a process for identifying new and significant information. That process is described in NUREG-1555, Supplement 1, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal* (NRC, 1999b). 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 an issue that are not affected by the new information.

The Staff has not identified any new and significant information on environmental issues listed in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, related to the operation of Salem and HCGS during the period of license renewal. PSEG stated in its Environmental Reports for Salem and HCGS that it is not aware of any new and significant information regarding the environment or plant operations. However, as part of its investigation for new and significant information, PSEG evaluated information about tritium in the groundwater beneath the Salem site. Based on that evaluation, PSEG has concluded that changes in groundwater quality due to the tritium are not significant at Salem and would not preclude current or future uses of the groundwater. The Staff evaluated the applicant's information in section 4.8.2 and agrees that the tritium in the groundwater is not new and significant information. The Staff also determined that information provided during the public comment period did not identify any new issues that require site-specific assessment. The Staff reviewed the discussion of environmental impacts in the GEIS (NRC, 1996) and conducted its own independent review (including two public scoping meetings held in November 2009) to identify new and significant information. The Staff concludes that there are no new and significant information related to the environmental impacts of the Salem and HCGS license renewal.

4.11 Cumulative Impacts

The Staff considered potential cumulative impacts in the environmental analysis of continued operation of Salem and HCGS. For the purposes of this analysis, past actions are those related to the resources at the time of the power plants licensing and construction; present actions are those related to the resources at the time of current operation of the power plants; and future actions are considered to be those that are reasonably foreseeable through the end of plant operations including the period of extended operation. Therefore, the analysis considers potential impacts through the end of the current license terms as well as the 20-year renewal license renewal terms. The geographic area over which past, present, and future actions would occur depend on the type of action considered and is described below for each impact area.

4.11.1 Cumulative Impact on Water Resources

For the purposes of this cumulative impact assessment, the spatial boundary of the groundwater system is the PRM Aquifer, which is a large aquifer of regional importance for municipal and domestic water supply. Although other aquifers (the shallow water-bearing zone, Vincentown Aquifer, and Mt. Laurel-Wenonah Aquifer) underlie the Salem and HCGS facilities, almost all groundwater use by the facilities is from the PRM Aquifer. The spatial boundary for potential cumulative surface water impacts is the Delaware River Basin.

Actions that can impact groundwater and surface water resources in the region include overuse of groundwater resources, unregulated use of water resources, drought impacts, and the need for flow compensation in the Delaware River for consumptive water use.

Within the Salem and HCGS local area, groundwater is not accessed for public or domestic water supply within 1 mi (1.6 km) of the Salem and HCGS facilities (PSEG, 2009a; 2009b). However, groundwater is the primary source of municipal water supply within Salem and the surrounding counties, and groundwater within the PRM Aquifer is an important resource for water supply in a region extending from Mercer and Middlesex counties in New Jersey to the north, and towards Maryland to the southwest. Groundwater withdrawal from the early part of the twentieth century through the 1970s resulted in the development of large-scale cones of depression in the elevation of the piezometric surface, and therefore had a cumulative adverse impact on the availability of groundwater within the aquifer (Walker, 1983). In reaction to this impact, NJDEP implemented water management measures, including limitations on pumping. As of 1998, NJDEP-mandated decreases in water withdrawals had resulted in general recovery of water level elevations in both the Upper and Middle PRM Aquifers in the Salem County area

(USGS, 2009). Therefore, the use of groundwater by the facilities is not contributing to a cumulative effect on local groundwater users or larger regional users. Based on these observations, the Staff concludes that, when added to the groundwater usage from other past, present, and reasonably foreseeable future actions, the cumulative impact on groundwater use is SMALL.

Although the Salem and HCGS facilities use surface water from the Delaware River for cooling purposes, the Delaware River is a tidal estuary at the facility location. Therefore, there is no potential for cumulative surface water use conflicts, and the cumulative impact on surface water use is SMALL.

4.11.2 Cumulative Impacts on Estuarine Aquatic Resources

This section addresses past, present, and future actions that have created or could result in cumulative adverse impacts on the aquatic resources of the Delaware Estuary, the geographic area of interest for this analysis. Cumulative impacts on freshwater aquatic resources other than the Delaware River are discussed with terrestrial resources in Section 4.11.3. A wide variety of historical events have cumulatively affected the Delaware Estuary and its resources (Delaware Estuary Program 1995). Europeans began settling the estuary region early in the 17th century. By 1660 the English had established multiple small settlements, and major changes in the environment began. Philadelphia had 5,000 inhabitants by 1700 and became the predominant city and port in America. Agriculture grew throughout the region, and the clearing of forest led to erosion. Dredging, diking, and filling gradually altered extensive areas of shoreline and tidal marsh. By the late 1800s, industrialization had altered much of the watershed of the upper estuary, and fisheries were declining due to overfishing as well as pollution from ships, sewers, and industry. By the 1940s, anadromous fish were blocked from migrating upstream to spawn due to a barrier of low oxygen levels in the Philadelphia area. This barrier combined with small dams on tributaries nearly destroyed the herring and shad fisheries. A large increase in industrial pollution during and after World War II resulted in the Delaware River near Philadelphia becoming one of the most polluted river reaches in the world. Major improvements in water quality began in the 1960s through the 1980s as a result of State, multi-State, and Federal action, including the Clean Water Act and the activities of the Delaware River Basin Commission. (Delaware Estuary Program, 1995)

In addition to past events, a variety of current and likely future activities and processes also have cumulative impacts on the aquatic resources of the Delaware Estuary to which the proposed action may contribute. Stressors associated with the proposed action and other activities or processes that may contribute to cumulative impacts on the aquatic resources of the estuary include the following:

- continued operation of the once-through cooling system for Salem Units 1 and 2
- continued operation of the closed-cycle cooling system for HCGS
- construction and operation of proposed additional unit at Salem/HCGS site
- continued withdrawal and discharge of water to support power generation, industry, and municipal water suppliers
- fishing pressure

- habitat loss and restoration
- changes in water quality
- climate change.

Each of these stressors may influence the structure and function of estuarine food webs and result in observable changes to the aquatic resources in the Delaware Estuary. In most cases, it is not possible to determine quantitatively the impact of individual stressors or groups of stressors on aquatic resources. The stressors affect the estuary simultaneously, and their effects are cumulative. A discussion follows of how the stressors listed above may contribute to cumulative impacts on aquatic resources of the Delaware Estuary.

Continued Operation of the Salem Once-Through Cooling System

Based on the assessment presented in Section 4.5 of this draft SEIS, the Staff concluded that entrainment, impingement, and thermal discharge impacts on aquatic resources from the operation of Salem Units 1 and 2 collectively have not had a noticeable adverse effect on the balanced indigenous community of the Delaware Estuary in the vicinity of Salem. The continued operation of Salem during the renewal term would continue to contribute to cumulative impacts on the estuarine community of fish and shellfish. As discussed in Sections 4.5.2 through 4.5.5, there has been extensive, long-term monitoring of fish and invertebrate populations of the Delaware Estuary. The data collected by these studies reflect the cumulative effects of multiple stressors acting on the estuarine community. For example, data from 1970 through 2004 were analyzed using commonly accepted techniques for assessing species richness (the average number of species in the community) and species density (the average number of species per unit volume or area). This analysis found that in the vicinity of Salem and HCGS since 1978, when Salem began operation, finfish species richness has not changed, and species density has increased (PSEG, 2006c). Operation of Salem during the relicensing period likely would continue to contribute substantially to cumulative impacts on aquatic resources in conjunction with HCGS and other facilities that withdraw water from or discharge to the Delaware Estuary. However, given the long-term improvements in the estuarine community during recent decades while these facilities were operating, NRC expects their cumulative impacts are expected to be limited, with effects on individual species populations potentially ranging from negligible to noticeable.

Continued Operation of the HCGS Closed-Cycle Cooling System

As discussed in Section 4.5.1, the closed-cycle cooling system used by HCGS substantially reduces the volume of water withdrawn by the facility and substantially reduces entrainment, impingement, and thermal discharge effects compared to the Salem once-through cooling system. Accordingly, the impacts of these effects from operation of the HCGS cooling system during the relicensing period would be limited, and the incremental contribution of HCGS to cumulative impacts on the estuarine community would be minimal. HCGS has operated in conjunction with Salem since 1986 and the community has been simultaneously affected by both facilities. Therefore, the analysis of Salem's effects on the aquatic community discussed above incorporates the cumulative effects of both HCGS and Salem. Operation of HCGS during the relicensing period would continue to contribute to cumulative impacts in conjunction with Salem and other facilities that withdraw water from or discharge to the Delaware Estuary. As described above for Salem, NRC expects these cumulative impacts are expected to be limited, with effects on individual species populations potentially ranging from negligible to noticeable.

Construction and Operation of Proposed Additional Unit at Salem/HCGS Site

On May 25, 2010, PSEG submitted to NRC an application for an Early Site Permit for the possible construction and operation of a new nuclear facility with two reactor units on Artificial Island adjacent to Salem and HCGS (PSEG, 2010a). The projected start of construction would be in 2016 (NRC, 2010). If PSEG decides to proceed and construct a new nuclear power facililty at the Salem/HCGS site, it would contribute to cumulative impacts on aquatic resources during construction and operation. The impacts of this action on aquatic resources during the construction period may be substantial in the immediate vicinity of the construction activities, but would be limited in extent and unlikely to significantly contribute to cumulative impacts on the estuarine community in conjunction with the ongoing operation of Salem and HCGS. Given the planned use of a closed-cycle cooling system for the new facility, the impacts on aquatic resources from its operation likely would be similar to those of HCGS and substantially smaller than those of Salem. Nevertheless, the long-term operation of the new facility would add to the cumulative impacts on the estuarine community from Salem and HCGS during the period in which their operations overlap.

NRC concluded in the GEIS that impacts on aquatic ecology are Category 1 issues at individual power plants with closed-cycle cooling systems, such as the system at HCGS and the system planned for the new facility. The Staff concludes in this SEIS (see Section 4.5.5) that impacts on aquatic ecology from the collective effects of entrainment, impingement, and heat shock at Salem during the renewal term would be SMALL. Thus, the incremental contributions of each of the three facilities to impacts on aquatic resources would be minor. However, it is possible that, depending on the characteristics of the new facility, their cumulative impacts could alter an important attribute of the Delaware Estuary, such as certain fish populations, to a noticeable degree.

The specific impacts of this action ultimately would depend on the actual design, operating characteristics, and construction practices proposed by the applicant. Such details are not available at this time. However, if a combined license application is submitted to NRC, the detailed impacts of this additional unit adjacent to the site of the existing Salem and HCGS units then would be analyzed and addressed in a separate NEPA document prepared by NRC.

Continued Water Withdrawals and Discharges

No large industrial facilities lie downstream of Artificial Island on either side of the estuary south to the mouth of Delaware Bay. An oil refinery lies upstream of Artificial Island in Delaware approximately 8 mi (13 km) to the north, and many industrial facilities are upstream from there (PSEG, 2009a). Many of these facilities are permitted to withdraw water from the river and to discharge effluents to the river. In addition, water is withdrawn from the nontidal, freshwater reaches of the river to supply municipal water throughout New Jersey, Pennsylvania, and New York (DRBC, 2010). In the tidal portion of the river, water is used for power plant cooling systems as well as industrial operations. DRBC-approved water users in this reach include 22 industrial facilities and 14 power plants in Delaware, New Jersey, and Pennsylvania (DRBC, 2005). Of these facilities, Salem uses by far the largest volume of water, with a reported water withdrawal volume in 2005 of 1,067,892 million gallons (4,042 million m^3) (DRBC, 2005). This volume exceeds the combined total withdrawal for all other industrial, power, and public water supply purposes in the tidal portion of the river. The volume of water withdrawn by HCGS in 2005 was much lower, at 19,561 million gallons (74 million m^3) (DRBC, 2005).

These activities will likely continue into the future, and water supply withdrawals likely will increase in the future in conjunction with population growth. Because water withdrawals from the Delaware River will continue, and are likely to increase, during the relicensing term, this activity will continue to contribute to cumulative effects in the estuary. Similarly, ongoing discharges of effluents to the river and estuary will continue to have cumulative effects. Withdrawals and discharges are regulated by Federal and State agencies as well as by the DRBC, and such regulation should limit the magnitude of their effects. Permit requirements are expected to limit adverse effects from withdrawals and discharges, and cumulative impacts from these activities on the aquatic resources of the Delaware Estuary are expected to be minimal.

Fishing Pressure

The majority of the RS and EFH species at Salem are commercially or recreationally important and, thus, are subject to effects from the harvesting of fish stocks. Losses from fish populations due to fishing pressure are cumulative in conjunction with losses due to entrainment and impingement at Salem and HCGS as well as other water intakes. In most cases, Federal or State agencies regulate the commercial or recreational catches of RS are regulated by Federal or State agencies, but losses of some RS continue to occur as bycatch caught unintentionally when fishing for other species. The extent and magnitude of fishing pressure and its relationship to cumulative impacts on fish populations and the overall aquatic community of the Delaware Estuary are difficult to determine because of the large geographic scale of the fisheries and the natural variability that occurs in fish populations and the ecosystem. Fishing pressure (and protection of fisheries through catch restrictions) has the potential to influence the food web of the Delaware Estuary by affecting fish and invertebrate populations in areas extending from the Atlantic Ocean and Delaware Bay through the estuary and upriver.

Habitat Loss and Restoration

As described above, alterations to terrestrial, wetland, shoreline, and aquatic habitats have occurred in the Delaware Estuary since colonial times. Development, agriculture, and other upland habitat alterations in the watershed have affected water quality. The creation of dams and the filling or isolation of wetlands to support industrial and agricultural activities has dramatically changed patterns of nutrient and sediment loading to the estuary. Such activities also have reduced productive marsh habitats and limited access of anadromous fish to upstream spawning habitats. In addition, historic dredging and deposition activities have altered estuarine environments and affected flow patterns, and future activities, such as dredging to deepen the shipping channel through the estuary, may continue to influence estuarine habitats. Development along the shores of the estuary in some places also has resulted in the loss of shoreline habitat.

Although habitat loss in the vicinity of the Delaware Estuary continues to occur currently and is likely in the future, habitat restoration activities have had a beneficial effect on the estuary and are expected to continue as a requirement of the Salem NJPDES permit during the license renewal term (see Section 4.5.5). In addition, NRC expects wetland permitting regulations to limit future losses of wetland habitat from development in the watershed. Thus, the net cumulative impacts on aquatic habitats associated with the estuary are likely to be minimal in the future, and restoration activities are expected to provide ongoing habitat improvements.

Water Quality

In general, there is evidence that water quality in the Delaware River Basin, including the estuary, is improving. Upgrades to wastewater treatment facilities and improved agricultural practices during the past 25 years have reduced the amount of untreated sewage, manure, and fertilizer entering the river and contributed to reductions in nutrients and an apparent increase in dissolved oxygen. Chemical contaminants persist in sediments and the tissues of fish and invertebrates, and nonpoint discharges of chemicals still occur (Kauffmann et al, 2008). Water quality in the Delaware Estuary likely will continue to be adversely affected by human activities; however, improvement may continue in many water quality parameters, and the incremental contribution of Salem and HCGS to adverse effects on water quality is expected to be minimal.

Climate Change

The potential cumulative effects of climate change on the Delaware Estuary, whether from natural cycles or related to anthropogenic activities, could result in a variety of environmental alterations that would affect aquatic resources. The environmental changes that could affect estuarine systems include sea level rise, temperature increases, salinity changes, and wind and water circulation changes. Changes in sea level could result in dramatic effects on tidal wetlands and other shoreline communities. Water temperature increases could affect spawning patterns or success, or influence species distributions when cold-water species move northward while warm-water species become established in new habitats. Changes in estuarine salinity patterns could influence the spawning and distribution of RS and the ranges of exotic or nuisance species. Changes in precipitation patterns could have major effects on water circulation and alter the nature of sediment and nutrient inputs to the system. This could result in changes to primary production and influence the estuarine food web on many levels. Thus, the extent and magnitude of climate change impacts may make this process an important contributor to cumulative impacts on the aquatic resources of the Delaware Estuary, and these impacts could be substantial over the long term.

Final Assessment of Cumulative Impacts on Aquatic Resources

Aquatic resources of the Delaware Estuary are cumulatively affected to varying degrees by multiple activities and processes that have occurred in the past, are occurring currently, and are likely to occur in the future. The food web and the abundance of RS and other species have been substantially affected by these stressors historically. The impacts of some of these stressors associated with human activities have been and can be addressed by management actions (e.g., cooling system operation, fishing pressure, water quality, and habitat restoration). Other stressors, such as climate change and increased human population and associated development in the Delaware River Basin, cannot be directly managed and their effects are more difficult to quantify and predict. It is likely, however, that future anthropogenic and natural environmental stressors would cumulatively affect the aquatic community of the Delaware Estuary sufficiently that they would noticeably alter important attributes, such as species ranges, populations, diversity, habitats, and ecosystem processes, just as they have in the past. Based on this assessment, the Staff concludes that cumulative impacts during the relicensing period from past, present, and future stressors affecting aquatic resources in the Delaware Estuary would range from MODERATE to LARGE. The incremental contributions specifically from the continued operation of Salem and HCGS to impacts on aquatic resources of the estuary would be SMALL for most impacts.

4.11.3 Cumulative Impacts on Terrestrial and Freshwater Resources

This section addresses past, present, and future actions that could result in adverse cumulative impacts on terrestrial resources, including resources associated with uplands, wetlands, and bodies of freshwater other than the Delaware River (discussed in Section 4.11.2). For the purpose of this analysis, the geographic area of interest includes the Salem and HCGS site on Artificial Island and the associated transmission line ROWs identified in Section 2.1.5.

Impacts on terrestrial and freshwater resources in the area began with historical settlement and development by Europeans, which involved clearing of forests and filling and draining of wetlands for agriculture. Colonial settlement of the Delaware River area of southern New Jersey began in 1638. During the 1640s, a fortification, Fort Elfsborg, was built in an area that previously was mostly swampland between Salem and Alloway Creek. As settlement progressed, forested regions in this part of southern New Jersey were further cleared for towns, farming, and lumber (Morris Land Conservancy, 2006). Tidal marshes along the margins of the Delaware Estuary were managed for salt hay farms and other agricultural uses, the hydrology of marshes was altered for mosquito control, and marshes were filled for disposal of dredged material and for development (Philipp, 2005). Industrial development in the area began with the glassmaking industry in the early 1700s and continued through the 1800s (Morris Land Conservancy, 2006). The Industrial Revolution and other historical trends continued the changes in land use and the loss of terrestrial communities of native vegetation and wildlife.

The Salem and HCGS facilities are located within 740 ac (300 ha) of PSEG property on 1,500-ac (600 ha) Artificial Island. Construction of Salem and HCGS converted 373 ac (151 ha) in the southwest corner of Artificial Island to facilities and industrial uses. Artificial Island was originally created by deposition of hydraulic dredge material in the early 20th century, and all terrestrial resources on the island have become established since then. Before development of the land on the Salem and HCGS sites, the vegetative communities of the island consisted mainly of typical coastal tidal marsh species, including salt-tolerant grasses such as cordgrass (*Spartina* spp.) and common reed (*Phragmites australis)*, which could survive in the brackish habitats. There was no known previous development or use of Artificial Island prior to the construction of Salem and HCGS. Currently, the Salem and HCGS sites are developed and maintained for operation of the facilites. The remainder of Artificial Island consists mainly of undeveloped areas of tidal marsh with poor quality soils and very few trees. Non-wetland areas are vegetated mainly with grasses, small shrubs, and planted trees in developed areas (PSEG, 2009a; 2009b).

Construction of the transmission line ROWs maintained by PSEG for Salem and HCGS resulted in subsequent changes to the wildlife and plant species present within the vicinity of Artificial Island and along the length of the transmission line ROWs. The transmission lines ROWs have a total length of approximately 149 mi (240 km) and occupy approximately 4,376 ac (1,771 ha). The three ROWs for the Salem and HCGS power transmission system pass through a variety of habitat types, including marshes and other wetlands, agricultural or forested land, and some urban and residential areas (PSEG, 2009a; 2009b). Fragmentation of the previously contiguous forested, agricultural, and swamp areas that the transmission ROWs traverse likely resulted in edge effects such as changes in light, wind, and temperature; changes in abundance and distribution of interior species; reduced habitat ranges for certain species; and an increased susceptibility to invasive species, such as multiflora rose (*Rosa multiflora*) in uplands, purple loosestrife (*Lythrum salicaria*) in wetlands, and Japanese stiltgrass (*Microstegium vimineum*) in both habitat types (NJDEP, 2004a). ROW maintenance is likely to continue to have future impacts on terrestrial habitat, such as prevention of natural succession stages within the ROWs, increases in edge species, and decreases in interior species.

Land use data provide an indication of the impacts on terrestrial resources that have resulted from historical and ongoing development. Current land uses in the region are discussed by county in Section 2.2.8.3 of this draft SEIS. In Salem County, based on 2008 data, farmland under active cultivation is the predominant type of land cover (42 percent), followed by tidal and freshwater wetlands (30 percent), forests (12 percent), residential/commercial/industrial uses (13 percent), and other undeveloped natural areas (3 percent) (Morris Land Conservancy, 2006). In the two adjacent counties in New Jersey (Cumberland and Gloucester), agriculture accounts for 19 and 26 percent of the land cover, and urban land use in the two counties was 12 percent and 26 percent, respectively (DVRPC, 2009; Gloucester County, 2009). Thus, commercial and industrial facilities, including the Salem and HCGS site and ROWs, have had a smaller impact on the loss of native terrestrial forest and wetland habitats in the region compared to agricultural development.

Although development of PSEG property on Artificial Island has had minimal impact on terrestrial resources as compared to historical and ongoing development in the region, portions of both PSEG land and the island have been protected from development. Approximately 25 percent (100 ac [40 ha]) of PSEG property and approximately 80 percent (1,200 ac [485 ha]) of Artificial Island remain undeveloped. These areas consist predominantly of estuarine marsh and freshwater emergent marsh, wetlands, and ponds. The U.S. government owns the portions of the island adjacent to Salem and HCGS (to the north and east), while the State of New Jersey owns the rest of the island as well as much nearby inland property (LACT,1988a; 1988b; PSEG 2009a; 2009b). In conjunction with the Artificial Island wetlands, public lands in the region also preserve forest and wetland habitat and have a beneficial cumulative impact on terrestrial resources. In compliance with Salem's 1994 and 2001 NJPDES permits, PSEG implemented the EEP, which has preserved and/or restored more than 20,000 ac (8,000 ha) of wetland and adjoining upland buffers around the Delaware Estuary. In particular, the program restored 4,400 ac (1,780 ha) of formerly diked salt hay farms to reestablish conditions suitable for the growth of low marsh vegetation such as saltmarsh cord grass (*Spartina alterniflora*) and provide for tidal exchange with the estuary (PSEG, 2009a).

PSEG has indicated the possibility of constructing one or two new reactor units at the Salem and HCGS site on Artificial Island (PSEG, 2010b) which would be primarily located on previously disturbed land adjacent to the existing Salem and HCGS units. It is not know at this time whether new transmission lines would be constructed. If additional ROW needs to be cleared, terrestrial habitats and the wildlife they support could potentially be affected in the areas it would traverse.

The Staff concluded in Sections 4.6 and 4.7 that the the continued operation of Salem and HCGS, including the operation and maintenance of the transmission line ROWs, would have minimal impacts and would not contribute to the overall decline in the condition of terrestrial resources. However, while the level of impact due to direct and indirect impacts of Salem and HCGS on terrestrial communities is SMALL, the cumulative impacts of historical, ongoing, and future developments in the region combined, as discussed above, would be MODERATE.

4.11.4 Cumulative Human Health Impacts

The radiological dose limits for protection of the public and workers have been developed by the NRC and EPA to address the cumulative impact of acute and long-term exposure to radiation and radioactive material. These dose limits are codified in 10 CFR Part 20 and 40 CFR Part 190. For the purpose of this analysis, the area within a 50-mi (80.4-km) radius of the Salem and HCGS site was included. The radiological environmental monitoring program conducted by PSEG in the vicinity of the Salem and HCGS site measures radiation and radioactive materials from all sources (i.e., hospitals and other licensed users of radioactive material); therefore, the monitoring program measures cumulative radiological impacts. Within the 50-mi (80-km) radius of the Salem and HCGS site, there are no other nuclear power reactors or uranium fuel cycle facilities.

On May 25, 2010 PSEG submitted an application for an Early Site Permit (ESP) for the possible construction of one or two reactor units at the Salem and HCGS site (PSEG 2010a). A specific reactor design has not been selected; therefore, the application uses a plant parameter envelope approach to evaluate the suitability of the site based on the potential environmental impacts from a blend of reactor types. This approach uses surrogate values as upper and lower bounds for issues such as power level, radioactive effluents, public dose estimates, thermal discharges, air quality, and accident consequences, for each of the potential reactor designs being considered. This is a conservative approach allowed by the NRC for the analysis of the environmental impacts from an unspecified reactor design at a specific location. A final decision by the applicant on the reactor design will be deferred until the submission of an application for either a construction permit or a combined construction permit and operating license.

The NRC will evaluate the ESP application in accordance with its regulations to ensure the application meets the NRC requirements for adequate protection and safety of the public and the environment. As discussed above, any new potential source of radioactive emissions from such a facility will be evaluated during its licensing process to address the cumulative impact of acute and long-term exposure to radiation and radioactive material.

The applicant constructed an independent spent fuel storage installation (ISFSI) on the Salem and HCGS site in 2007 for the storage of its spent fuel. Currently, only spent fuel from HCGS is being stored in the ISFSI. The installation and monitoring of this facility is governed by NRC requirements in 10 CFR Part 72, “Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste.” Radiation from this facility as well as from the operation of Salem and HCGS are required to be within the radiation dose limits in 10 CFR Part 20, 40 CFR Part 190, and 10 CFR Part 72. The NRC performs periodic inspections of the ISFSI and Salem and HCGS to verify their compliance with licensing and regulatory requirements.

Radioactive effluent and environmental monitoring data for the five-year period from 2005 to 2009 were reviewed as part of the cumulative impacts assessment. These reports show that past and current annual radiological doses to a maximally exposed member of the public at the site boundary are well below regulatory dose limits. In Section 4.8 the Staff concluded that impacts of radiation exposure to the public and workers from operation of Salem and HCGS during the renewal term are SMALL. The possible addition of one or two reactor units to the three-reactor site is not expected to result in any substantial increases in doses that would cause the cumulative dose impact to approach regulatory limits. This is because the reactor would be required to maintain its radiological release within NRC's dose limits for individual reactor units and the cumulative dose from all reactor units and the ISFSI on the site. Also, the NRC and the State of New Jersey would regulate any future actions in the vicinity of the Salem and HCGS site that could contribute to cumulative radiological impacts. Therefore, the staff concludes that the cumulative radiological impact to the public and workers from continued operation of Salem and HCGS, its associated ISFSI, and two potential additional reactor units would be SMALL.

In addition to health impact from radiological sources, the Staff also evaluated and determined that the electric-field-induced currents from the Salem and HCGS transmission lines are below the NESC criteria for preventing electric shock from induced currents. Therefore, the Salem and HCGS transmission lines do not significantly affect the overall potential for electric shock from induced currents within the areac of analysis area and the human health impact from such source is SMALL. The potential effect from future and chronic exposure to these electric fields continues to be studied and is not known at this time. The Staff considers the GEIS finding of "Uncertain" still appropriate and will continue to follow developments on this issue.

4.11.5 Cumulative Air Quality Impacts

The Salem and HCGS facilities are located in Salem County, which is included with the Metropolitan Philadelphia Interstate Air Quality Control Region (AQCR), which encompasses the area geographically located in five counties of New Jersey, including Salem and Gloucester Counties, New Castle County Delaware, and five counties of Pennsylvania (40 CFR 81.15). Salem County is designated as in attainment/unclassified area with respect to the National Ambient Air Quality Standards (NAAQSs) for Particulate Matter less than 2.5 microns in diameter ($PM_{2.5}$), sulfur dioxide (SO_2), nitrogen oxides (NOx), carbon monoxide (CO), and lead. The county, along with all of southern New Jersey, is a nonattainment area with respect to the 1-hour primary ozone standard and the 8-hour ozone standard. For the 1-hour ozone standard, Salem County is located within the multi-state Philadelphia-Wilmington-Trenton non-attainment area, and for the 8-hour ozone standard, it is located in the Philadelphia-Wilmington-Atlantic City (PA-NJ-DE-MD) nonattainment area. Of the adjacent counties, Gloucester County in New Jersey is in non-attainment for the 1-hour and 8-hour ozone standards, as well as the annual and daily $PM_{2.5}$ standard (NJDEP, 2010b). New Castle County, Delaware is considered to be in moderate non-attainment for the ozone standards, and non-attainment for $PM_{2.5}$ (40 CFR 81.315).

The State of New Jersey has implemented several measures to address greenhouse gas (GHG) emissions within the state. In February 2007, the governor signed EO 54 calling for a reduction in GHG emissions to 1990 levels by 2020, and to 80 percent below 2006 levels by 2050. These objectives became mandatory in July 2007, with passage of the Global Warming Response Act. New Jersey also joined with nine other northeastern and mid-Atlantic states in the Regional Greenhouse Gas Initiative (RGGI) through Assembly Bill 4559 in January 2008. The RGGI caps carbon dioxide (CO_2) emissions from power plants, and requires utilities to purchase emissions credits, with the funds used to finance energy efficiency and renewable energy programs.

Potential cumulative effects of climate change on the State of New Jersey, whether or not from natural cycles of anthropogenic (man-induced) activities, could result in a variety of changes to the air quality of the area. As projected in the “Global Climate Change Impacts in the United States” report by the United States Global Change Research Program (USGCRP, 2009), the temperatures in the mid-Atlantic have already risen up to 1°F (0.6°C) since the 1961-1979 baseline, and are projected to increase by 3 to 6°F (1.7 to 3.3°C) more by 2090. Increases in average annual temperatures, higher probability of extreme heat events, higher occurrences of extreme weather events (intense rainfall or drought) and changes in the wind patterns could affect concentrations of the air pollutants and their long-range transport, because their formation partially depends on temperature and humidity and is a result of the interactions between hourly changes in the physical and dynamic properties of the atmosphere, atmospheric circulation features, wind, topography, and energy use (IPCC, 2010).

Consistent with the findings in the GEIS, the Staff concludes that the impacts from continued operation of the Salem and HCGS facilities on air quality are SMALL. As no refurbishment is planned at the facilities during the license renewal period, no additional air emissions would result from refurbishment activities (PSEG, 2009a; 2009b). In comparison with construction and operation of a comparable fossil-fueled power plant, license renewal would result in a new cumulative deferral of GHG emissions, which would otherwise be produced if a new gas or coal-fired plant were instead constructed. When compared with the alternative of a new fossil-fuel power plant, the option of license renewal also results in a substantial new cumulative deferral in toxic air emissions.

For the purpose of this cumulative air impact assessment, the spatial bounds include the Metropolitan Philadelphia Interstate AQCR, which encompasses the area geographically located in five counties of New Jersey, including Salem and Gloucester Counties, New Castle County Delaware, and five counties of Pennsylvania. The Staff concludes that, combined with the emissions from other past, present, and reasonably foreseeable future actions, cumulative hazardous and criteria air pollutant emission impacts on air quality from Salem and HCGS-related actions would be SMALL.

4.11.6 Cumulative Socioeconomic Impacts

As discussed in Section 4.9 of this draft SEIS, continued operation of Salem and HCGS during the license renewal term would have no impact on socioeconomic conditions in the region beyond those already being experienced. Since PSEG has indicated that there would be no major plant refurbishment, overall expenditures and employment levels at Salem and HCGS would remain relatively constant with no additional demand for housing, public utilities, and public services. In addition, since employment levels and the value of Salem and HCGS would not change, there would be no population and tax revenue-related land use impacts. There would also be no disproportionately high and adverse health or environmental impacts on minority and low-income populations in the region. Based on this and other information presented in this draft SEIS, there would be no cumulative socioeconomic impacts from Salem and HCGS operations during the license renewal term.

If PSEG decides to proceed and construct a new nuclear power plant unit at the Salem and HCGS site, the cumulative short-term construction-related socioeconomic impacts of this action could be MODERATE to LARGE in counties located in the immediate vicinity of Salem and HCGS. These impacts would be caused by the short-term increased demand for rental housing and other commercial and public services used by construction workers during the years of power plant construction. During peak construction periods there would be a noticeable increase in the number and volume of construction vehicles on roads in the immediate vicinity of the Salem and HCGS site.

The cumulative long-term operations-related socioeconomic impacts of this action during the operation of the new power plant unit would likely be SMALL to MODERATE. These impacts would be caused by the increased demand for permanent housing and other commercial and public services, such as schools, police and fire, and public water and electric services, from the addition of operations workers at the Salem and HCGS site during the years of new plant operations. During shift changes there would be a noticeable increase in the number of commuter vehicles on roads in the immediate vicinity of the Salem and HCGS site.

Since Salem County has less housing and public services available to handle the influx of construction workers in comparison to New Castle, Gloucester, and Cumberland Counties, the cumulative short-term construction-related socioeconomic impacts on Salem County would likely be MODERATE to LARGE. Over the long-term, cumulative operations impacts on Salem County would likely be SMALL to MODERATE since new operations workers would likely reside in the same counties and in the same pattern as the current Salem and HCGS workforce. Many of the operations workers would be expected to settle in Salem County where nearly 40 percent of the current workforce reside.

Because New Castle, Gloucester, and Cumberland Counties each has a larger available housing supply than Salem County, and the current number of Salem and HCGS workers residing in these three counties combined (43 percent) is the same as those residing in Salem County (40 percent), the cumulative construction- and operations-related socioeconomic impacts are likely to be SMALL in these three counties. If PSEG decides to construct a new nuclear power plant unit at the Salem and HCGS site, the cumulative impacts of this action would likely be SMALL on the four-county socioeconomic region of influence.

The specific impact of this action would ultimately depend on the actual design, characteristics, and construction practices proposed by the applicant. Such details are not available at this time, but if the combined license application is submitted to NRC, the detailed socioeconomic impacts of this action at the Salem and HCGS site would be analyzed and addressed in a separate NEPA document that would be prepared by NRC.

4.11.7 Summary of Cumulative Impacts

The Staff considered the potential impacts resulting from operation of Salem and HCGS during the period of extended operation and other past, present, and reasonably foreseeable future actions in the vicinity of Salem and HCGS. The preliminary determination is that the potential cumulative impacts resulting from Salem and HCGS operation during the period of extended operation would range from SMALL to LARGE. Table 4-24 summarizes the cumulative impact by resource area.

1 **Table 4-24. Summary of Cumulative Impacts on Resource Areas**

Resource Area	Impact	Summary
Land Use	SMALL	With respect to the Salem and HCGS facilities, no measureable changes in land use would occur over the proposed license renewal term. When combined with other past, present, and reasonable foreseeable future activities, impacts from continued operation of Salem and HCGS would constitute a SMALL cumulative impact on land use.
Air Quality	SMALL	Impacts of air emissions over the proposed license renewal term would be SMALL. When combined with other past, present, and reasonably foreseeable future activities, impacts to air resources from the Salem and HCGS facilities would constitute a SMALL cumulative impact on air quality. In comparison with the alternative of constructing and operating a comparable gas or coal-fired power plant, license renewal would result in a new cumulative deferral in both GHG and other toxic air emissions, which would otherwise be produced by a fossil-fueled plant.
Ground Water	SMALL	Groundwater consumption constitutes a SMALL cumulative impact on the resource. When this consumption is added to other past, present, and reasonably foreseeable future withdrawals, cumulative impact on groundwater resources is SMALL.
Surface Water	SMALL	Impacts on surface water over the proposed license term would be SMALL. When combined with other past, present, and reasonably foreseeable future activities, impacts to surface water from the Salem and HCGS facilities would constitute a SMALL cumulative impact.
Aquatic Resources	SMALL to MODERATE	Past and present operations have impacted aquatic resources in the vicinity of Salem and HCGS and would likely continue to in the future. Such impacts would continue to be SMALL. When combined with other past, present, and reasonable foreseeable future activities, impacts from continued operation of Salem and HCGS would constitute a SMALL to MODERATE cumulative impact on aquatic resources.
Terrestrial Resources	MODERATE	Past and present operations have impacted terrestrial habitat and species in the vicinity of Salem and HCGS. Continued impacts associated with the proposed license renewal term would be SMALL. When combined with other past, present, and reasonable foreseeable future activities, impacts from continued operation of Salem and HCGS would constitute a MODERATE cumulative impact on terrestrial resources.

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Resource Area	Impact	Summary
Threatened or Endangered Species	SMALL	Past and present operations have impacted threatened or endangered species in the vicinity of Salem and HCGS and would likely continue to in the future. Such impacts would continue to be SMALL. When combined with other past, present, and reasonable foreseeable future activities, impacts from continued operation of Salem and HCGS would constitute a SMALL cumulative impact on threatened or endangered species.
Human Health	SMALL	When combined with the other past, present, and reasonably foreseeable future activities, the cumulative human health impacts of continued operation of Salem and HCGS from radiation exposure to the public, and electric-field-induced currents from the Salem and HCGS transmission lines would all be SMALL.
Socioeconomics	SMALL to LARGE	Impacts on socioeconomics over the proposed license term would be SMALL depending on the alternative selected. When combined with other past, present, and reasonably foreseeable future activities, impacts to socioeconomics from the Salem and HCGS facilities would constitute a SMALL to LARGE cumulative impact.

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5.0 ENVIRONMENTAL IMPACTS OF ACCIDENTS

Environmental Issues associated with the postulated accidents are discussed in NUREG-1437, Volumes 1 and 2, "Generice Environmental Impact Statement for License Renewal of Postulated Nuclear Plants" (hereafter referred to as the GEIS) (NRC 1996, 1999).(1) The GEIS includes 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 tehn 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 specific type of cooling system or other specificied plant or site characteristics.

(2) A single significance level (i.e, SMALL, MODERATE, or LARGE) has been assigned to the impacts (except for collective offsite radiological impacts from the fuel cylcle and from the 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.

Catergory 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 describes the environmental impacts from postulated accidents that might occur during the license renewal term. Two classes of accidents are evaluated in the GEIs. These are design-basis accidents (DBA) and severe accidents, as discussed below.

5.1 DESIGN-BASIS ACCIDENTS

In order to receive NRC approval for an operating license, an applicant for an initial operating license must submit a final safety analysis report (FSAR) as part of its application. The FSAR presents the design criteria and design information for the proposed reactor and comprehensive data on the proposed site. The FSAR 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 or not the plant

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

design meets the NRC's regulations and requirements and includes, in part, the nuclear plant design and its anticipated response to an accident.

DBAs are those accidents that both the licensee and the NRC staff evaluate to ensure that the plant can withstand normal and abnormal transients, as well as 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, Part 50, "Domestic Licensing of Production and Uitilization Facilities," of the *Code of Federal Regulations* (10 CFR Part 50) and 10 CFR Part 100, "Reactor Site Criteria."

The environmental impacts of postulated accidents were evaluated for the license renewal period in Chapter 5 of the GEIS. Section 5.5.1 states:

> All plants have had a previous evaluation of the environmental impacts of design-basis accidents. In addition, the licensee will be required to maintain acceptable design and performance criteria throughout the renewal period. Therefore, the calculated releases from design-basis accidents would not be expected to change. Since the consequences of these events are evaluated for the hypothetical maximally exposed individual at the time of licensing, changes in the plant environment will not affect these evaluations. Therefore, the staff concludes that the environmental impacts of design-basis accidents are of small significance for all plants. Because the environmental impacts of design basis accidents are of small significance and because additional measures to reduce such impacts would be costly, the staff concludes that no mitigation measures beyond those implemented during the current term license would be warranted. This is a Category 1 issue.

This issue, applicable to Salem Nuclear Generating Station Units, 1 and 2 (SGS) and Hope Creek Generating Station (HCGS), is listed in Table 5-1.

Table 5-1. Issues Applicable to Postulated Accidents during the Renewal Term

Issue	GEIS Section	Category
DBAs	5.3.2; 5.5.1	1

No new and significant information related to DBAs was identified during the review of PSEG's environmental report (ER), site audit, scoping process, or evaluation of other available information. Therefore, there are no impacts related to DBA beyond those discussed in the GEIS.

5.2 SEVERE ACCIDENTS

Severe nuclear accidents are those that are more severe than DBAs because they could result in substantial damage to the reactor core, whether or not there are serious offsite consequences. In the GEIS, the staff assessed the impacts of severe accidents during the license renewal period, using the results of existing analyses and information from various sites to predict the environmental impacts of severe accidents for plants during the renewal period.

Severe accidents initiated by external phenomena such as tornadoes, floods, earthquakes, fires, and sabotage have not traditionally been discussed in quantitative terms in the final environmental impact statements and were not specifically considered for the Salem Generating Station, Units 1 and 2 (SGS) and Hope Creek Generating Station (HCGS) sites in the GEIS (NRC, 1996). The GEIS, however, did evaluate existing impact assessments performed by the NRC staff and by the industry at 44 nuclear plants in the United States and segregated all sites into six general categories and then estimated that the risk consequences calculated in existing analyses bound the risks for all other plants within each category. The GEIS further concluded that the risk from beyond design-basis earthquakes at existing nuclear power plants is designated as SMALL. The GEIS for license renewal documents and concluded that the core damage and radiological release from such acts would be no worse than the damage and release to be expected from internally initiated events.

In the GEIS, the NRC staff concludes that the risk from sabotage and beyond design-basis earthquakes at existing nuclear power plants is designated as SMALL, and additionally, that the risks from other external events are adequately addressed by a generic consideration of internally initiated severe accidents (NRC, 1996).

Based on information in the GEIS, the staff found that:

> The generic analysis…applies to all plants and that the probability-weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to ground water, and societal and economic impacts of severe accidents are of small significance for all plants. However, not all plants have performed a site-specific analysis of measures that could mitigate severe accidents. Consequently, severe accidents are a Category 2 issue for plants that have not performed a site-specific consideration of severe accident mitigation and submitted that analysis for Commission review.

This issue, applicable to SGS, and HCGS, is listed in Table 5-2.

Table 5-2. Issues Applicable to Postulated Accidents during the Renewal Term

Issue	GEIS Section	Category
Severe accidents	5.3.3; 5.3.3.2; 5.3.3.3; 5.3.3.4; 5.3.3.5; 5.4; 5.5.2	2

The staff identified no new and significant information related to postulated accidents during the review of PSEG's environmental report, the site audit, the scoping process, or evaluation of other available information. Therefore, there are no impacts related to postulated accidents beyond those discussed in the GEIS. In accordance with 10 CFR

51.53(c)(3)(ii)(L), however, the NRC staff has reviewed severe accident mitigation alternatives (SAMAs) for SGS and HGCS. Review results are discussed in Section 5.3 of this draft SEIS.

5.3 SEVERE ACCIDENT MITIGATION ALTERNATIVES

As required by 10 CFR 51.53(c)(3)(ii)(L), license renewal applicants much 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), related supplement, or in an environmental assessment. The purpose of this consideration is to ensure that plant changesl (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 SGC and HCGS; therefore, the remainder of chapter 5 addresses those alternatives.

5.3.1 Introduction

This section presents a summary of the SAMA evaluation for SGS and HCGS conducted by PSEG and the NRC staff's reviews of those evaluations. The NRC staff performed its review with contract assistance from Pacific Northwest National Laboratory. The NRC staff's reviews are available in greater detail in Appendices F and G; the SAMA evaluations are available in PSEG's ERs and subsequent submittals.

The SAMA evaluations for SGS and HCGS were conducted with a four-step approach. In the first step, PSEG quantified the level of risk associated with potential reactor accidents using the plant specific probabilistic risk assessment (PRA) and other risk models.

In the second step, PSEG examined the major risk contributors and identified possible ways (SAMAs) of reducing that risk. Common ways of reducing risk are changes to components, systems, procedures, and training. PSEG identified 27 potential SAMAs for SGS, and 23 for HCGS. PSEG performed an initial screening to determine if any SAMAs could be eliminated because they are not applicable to SGS or HCGS due to design differences, or have estimated implementation costs that would exceed the dollar-value associated with completely eliminating all severe accident risk at SGS and HCGS. Four SAMAs were eliminated based on this screening, leaving 25 for SGS and 21 for HCGS for further evaluation.

In the third step, PSEG estimated the benefits and the costs associated with each of the 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). PSEG concluded in its ERs that several of the SAMAs evaluated are potentially cost-beneficial (PSEG 2009a, PSEG 2009b).

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. PSEG's SAMA analysis and the NRC staff's review are discussed in more detail below.

5.3.2 Estimate of Risk

PSEG submitted an assessment of SAMAs for SGS and HCGS as part of the ERs (PSEG 2009a, PSEG 2009b). For each, two distinct analyses are combined to form the basis for the risk estimates used in the SAMA analysis: (1) the plant-specific Level-1 and Level-2 PSA models, which are updated versions of the IPEs (PSEG 1993, PSEG 1994, PSEG 1995); (2) a supplemental analysis of offsite consequences and economic impacts (essentially a Level-3 PSA model) developed specifically for the SAMA analysis. The most recent plant-specific Level-1 and Level 2 PSA models consisted of the following Internal Events PSAs: (1) for SGS, Salem PRA, Revision 4.1, September 2008, model of record (MOR); (2) for HCGS, the HC108B update. Neither of these analyses accounted for external events.

The SGS CDF is approximately 4.8×10^{-5} per year for internal events as determined from quantification of the Level 1 PRA model at a truncation of 1×10^{-11} per year. When determined from the sum of the containment event tree (CET) sequences, or Level 2 PRA model, the release frequency (from all release categories, which consist of intact containment, late release, and early release) is approximately 5.0×10^{-5} per year, also at a truncation of 1×10^{-11} per year. 5.0×10^{-5} per year was used as the baseline CDF in the SAMA evaluations (PSEG 2009a). The CDF is based on the risk assessment for internally initiated events, which includes internal flooding. PSEG did not explicitly include the contribution from external events within the SGS risk estimates; however, it did account for the potential risk reduction benefits associated with external events by multiplying the estimated benefits for internal events by a factor of 2. The breakdown of CDF by initiating event provided in Table 5-2

Table 5-3. Salem Nuclear Station Core Damage Frequency for Internal Events

Initiating Event	CDF (per year)	% Contribution to CDF
Loss of Control Area Ventilatioln	1.8×10^{-6}	37
Loss of Offsite Power (LOOP)	8.1×10^{-6}	17
Loss of Service water	6.6×10^{-6}	14
Internal Floods	4.5×10^{-6}	9
Transients	4.0×10^{-6}	8
Steam Generator Tupe Rupture (SGTR)	2.7×10^{-6}	6

Initiating Event	CDF (per year)	% Contribution to CDF
Loss of Component Cooling Water (CCW)	1.0×10^{-6}	2
Anticipated Transient Without Scram (ATWS)	7.4 × 10–7	2
Loss of 125 V DC Bus A	6.9×10^{-7}	1
Others (less than 1 percent)[3]	1.8×10^{-6}	4
Total CDF (Internal Events)	**4.8×10^{-5}**	**100**

As shown in Table 5-3, events initiated by losses of control area ventilation, offsite power, or service water are the dominant contributors to the CDF. PSEG identified that Station Blackout (SBO) contributes to 8 x 10^{-6} per year (PSEG 2010a).

PSEG estimated the dose to the population within 50 miles (80 km) of the SGS site to be approximately 0.78 person-sievert (person-Sv) (78 person-rem) per year. The breakdown of the total population dose by containment release mode is summarized in Table 5-2. Containment bypass events (such as SGTR-initiated large early release frequency (LERF) accidents) and late containment failures without feedwater dominate the population dose risk at SGS.

Table 5-4 Breakdown of Population Dose by Containment Release Mode For SGS

Containment Release Mode	Population Dose (Person-Rem[1] Per Year)	% Contribution[2]
Containment over-pressure (late)	42.9	55
Steam Generator Rupturs	31.9	41
Containment Isolation Failure	2.3	3
Inact Containment	0.2	<1
Interface system LOCA	0.6	<1
Catastrophic Islaotion Failue	0.4	<1
Basemat melt-through (late)	negligible	negligilbe
Total	**78.2**	**100**

[1]One person-rem = 0.01 person-Sv

[2]Derived from Table E.3-7 of the ER

[3]Column totals may be different due to round off

The HCGS CDF is approximately 5.1x10^{-6} per year as determined from quantification of the Level 1 PRA at a truncation of 1 x 10^{-12} per year. When determing from the sum of the containment event tree (CET) sequences, or Level 2 PRA modeled, using a higher truncation of 5 x 10^{-11}per a year used and the resulting release frequency (from all release categories, which consist of intact containment, late release, and early release) is approximately 4.4 x 10^{-6} per year. 4.4 x 10^{-6} per year was used as the baseline CDF in the SAMA evaluations (PSEG 2009b). Although this is about 16% less that the internal events CDF of 5.1 x 10^{-6} per year obtained from the Level-1 model, the NRC staff considers that its use will have a negligible impact on the results of the SAMA evaluation because the external event multiplier and uncertainty multiplier used in the SAMA analysis have a much greater impact on the SAMA evaluation results than the small difference arising from the model quantification approach. PSEG did not explicity include the contribution from external events within the HCGS risk estimates; however, it did account for the potential risk reduction benefits associated with external events by multiplying the estimated benefits for internal events by a factor of 6.3. The breakdown of CDF by initiating event is provided in Table 5-4.

Table 5-5. Hope Creek Nuclear Station Core Damage Frequency for Internal Events

Initiating Event	CDF (per year)	% Contribution to CDF
Loss of Offsite Power	9.3 x 10-7	18
Loss of Service Water (SW)	8.1×10^{-7}	15
Manual Shutdown	7.7×10^{-7}	15
Turbine Trip with Bypass	6.2×10^{-7}	12
Small Loss of Coolant Accident (LOCA)-Water (Below Top of Active Fuel)	2.8×10^{-7}	5
Small LOCA-Steam (Above Top of Active Fuel	2.3×10^{-7}	4
Loss of Condenser Vacuum	2.0×10^{-7}	4
Fire Protection System Rupture Outside Control Room	1.9×10^{-7}	4
Isolation LOCA in Emergency Core Cooling System (ECCS) Discharge Paths	1.1×10^{-7}	2
Main Steam Isolation Valve (MSIV) Closure	1.1×10^{-7}	2
Internal Flood Outside Lower Relay Room	9.7×10^{-8}	2
Loss of Feedwater	8.8×10^{-8}	2
Loss of Safety Auxilaries Cooling System	$7.9. \times 10^{-8}$	2
Reactor Auxilaries Cooling System (RACS) Common Header Unisolable Rupture	7.6×10^{-8}	1
Unisolable SW A Pipe Rupture in RACS Room	5.7×10^{-8}	1

Initiating Event	CDF (per year)	% Contribution to CDF
Unisolable SWA B Pipe Rupture in RACS Room	5.7×10^{-8}	1
Others (less than 1% each)	4.1×10^{-6}	8
Total CDF (Internal Events)	$\mathbf{5.1 \times 10^{-6}}$	**100**

As shown in Table 5-5, events initiated by loss of offsite power, loss of service water and other transients (manual shutdown and turbine trip with bypass) are the dominant contributors to the CDF. Anticipated transient without scram (ATWS) sequences account for 3 percent of the CDF, station blackout accounts for 12 percent of the CDF (PSEG 2010b).

PSEG estimated the dose to the population within 50 miles (80 km) of the HCGS site to be approximately 0.23 person-sievert (person-Sv) (22.9 person-rem) per year. The breakdown of the total population dose by containment release mode is summarized in Table 5-4. Releases from the containment within the early time frame (0 to less than 4 hours following event initiaton) and intermediate time frame (4 to less that 24 hours following event initiation) dominate the population dose risk at HCGS.

Table 5-6 Breakdown of Population Dose by Containment Release Mode For HCGS

Containment Release Mode	Population Dose (Person-Rem[1] Per Year)	% Contribution[2]
Early Releases (< 4hrs)	11.9	52
Intermediate Releases(4 to< 24 hrs)	9.9	43
Late Releases (≥ 24hrs)	1.1	5
Inact Containment	<0.1	negligible
Total	**22.9**	**100**

[1]One person-rem = 0.01 person-Sv

The NRC staff has reviewed PSEG'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 offsite risk on the CDFs and offsite doses reported by PSEG. .

5.3.3 Potential Plant Improvements

Once the dominant contributors to plant risk were identified, PSEG searched for ways to reduce that risk. In identifying and evaluating potential SAMAs, PSEG considered insights from the plant-specific PRA, and SAMA analyses performed for other operating plants that have submitted license renewal applications. PSEG identified 27 potential risk-reducing improvements (SAMAS) to plant components, systems, procedures, and training for SGS. PSEG identified 23 potential risk-reducing improvements (SAMAs) to plant components, systems, procedures and training for HCGS.

PSEG removed two candidates SAMAS from further consideration for SGS because they are not applicable at SGS due to design differences, have already been implemented at SGS ,or were estimated to have implementation costs that would exceed the dollar value associated with completely eliminating all severe accident risk at SGS. A detail cost-benefit analysis was performed for the SAMAs for SGS, as well as, four additional SAMAs that were analyzed for SGS in response to a NRC staff request for additional information.

PSEG removed two candidates SAMAS from further consideration for HCGS because they are not applicable at HCGS due to design differences, have already been implemented at HCGS, or were estimated to have implementation costs that would exceed the dollar value associated with completely eliminating all severe accident risk at HCGS. A detail cost-benefit analysis was performed for the 21 remaining SAMAs HCGS.

The staff concludes that PSEG used a systematic and comprehensive process for identifying potential plant improvements for SGS and HCGS, and that the set of potential plant improvements identified by PSEG is reasonably comprehensive and, therefore, acceptable.

5.3.4 Evaluation of Risk Reduction and Costs of Improvements

PSEG evaluated the risk-reduction potential of the remaining 25 SAMAs for SGS,as well as four additional SAMAs that were added in response to an NRC staff reguest for additional information. PSEG evaluated the risk-reduction potential for the remaining 21 SAMAs for HCGS. 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.

PSEG estimated the costs for implementing the candidate SAMAs through the development of site-specific cost estimates. 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 cost for unforeseen difficulties.

The staff reviewed PSEG’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 generally conservative (i.e., the estimated risk reduction is higher than what would actually be realized). Accordingly, the staff based its estimates of averted risk for the various SAMAs on PSEG’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 licensee’s analyses of SAMAs for operating reactors. The staff found the cost estimates to be reasonable, and generally consistent with estimates provided in support of other plants’ analyses.

The staff concludes that the risk reduction and the cost estimates provided by PSEG are sufficient and appropriate for use in the SAMA evaluation.

5.3.5 Cost-Benefit Comparison

The cost-benefit analysis performed by PSEG 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 3 percent and the other at 7 percent (NRC, 2004). PSEG provided both sets of estimates for SGS and HCGS (PSEG 2009a, 2009b).

For SGS, PSEG identified eleven potentially cost-beneficial SAMAs in the baseline analysis contained in the ER. The potentially cost-beneficial SAMAs are:

- SAMA 1 – Enhance procedures and provide additional equipment to respond to loss of control area ventilation.
- SAMA 2 – Re-configure Salem 3 to provide a more expedient backup to AC power source for Salem 1 and 2.
- SAMA 4 – Install fuel oil transfer pump on "C" emergency diesel generator (EDG) and provide procedural guidance for using "C" EDG to power selected "A" and "B" loads.
- SAMA 6 – Enhance flood detection for 84' auxiliary building and enhance procedural guidance for responding to service water flooding
- SAMA 9 – Connect Hope Creek cooling tower basin to Salem service water system as alternate service water supply.
- SAMA 10 – Provide procedural guidance for faster cooldown on loss of reactor coolant pump (RCP) Seal
- SAMA 11 – Modify plant procedures to make use of other Unit's PDP for RCP seal.
- SAMA 12 – Improve flood barriers outside 220/440VAC switchgear rooms.
- SAMA 14 – Expand anticipated transients without trip mitigation system actuation circuitry (AMSAC) function to include backup breaker trip on RPS failure.

- SAMA 17 – Enhance procedures and provide additional equipment to respond to loss of EDG control room ventilation.

- SAMA 24 – Provide procedural guidance to cross-tie Salem 1 and 2 service water systems.

PSEG performed additional analyses to evaluate the impact of parameter choices and uncertainties on the results of the SAMA assessment (PSEG, 2009a). If the benefits are increased by an additional factor of 2.5 to account for uncertainties, five additional SAMA candidates were determined to be potentially cost-beneficial. The ER also showed that the sentivity case SAMA (SAMA 5A) was potentially cost-benificial:

- SAMA 3 – Install limited emergency diesel generator (EDG) cross-tie capability between Salem 1 and 2.

- SAMA 5 – Install portable diesel generators to charge station battery and circulating water batteries and replace PDP with air-cooled pump.

- SAMA 5A – Install portable diesel generators to charge station battery and circulating water batteries.

- SAMA 7 – Install “B” Train auxiliary feedwater storage tank (AFWST) makeup including alternative water source.

- SAMA 8 – Install high pressure pump powered with portable diesel generator and long-term suction source to supply the AFW Header.

- SAMA 27 – In addition to the equipment installed for SAMA 5, install permanently piped seismically qualified connections to alternative AFW water sources.

PSEG indicated that all 17 potentially cost-beneficial SAMAs will be considered for implementation through the established Salem Plant Health Committee process.

For HCGS, PSEG identified nine potentially cost-beneficial SAMAs in the baseline analysis contained in the ER. The potentially cost-beneficial SAMAs are:

- SAMA 1 – Remove automatic depressurization system (ADS) inhibit from non-ATWS emergency operating procedures.

- SAMA 3 – Install backup air compressor to supply air-operated valves.

- SAMA 4 – Provide procedural guidance to cross-tie residual heat removal (RHR) trains.
- SAMA 10 – Provide procedural guidance to use B.5.b low pressure pump for non-security events.
- SAMA 17 – Replace a supply fan with a different design in service water pump room.
- SAMA 18 – Replace a return fan with a different design in service water pump room.
- SAMA 30 – Provide procedural guidance for partial transfer function of control functions from the control room to the remote shutdown panel.
- SAMA 35 – Relocate, minimize, and/or eliminate electrical heaters in electrical access room.
- SAMA 39 – Provide procedural guidance to bypass reactor core isolation cooling turbine exhaust pressure trip.

PSEG performed additional analyses to evaluate the impact of parameter choices and uncertainties on the results of the SAMA assessment (PSEG, 2009b). If the benefits are increased by an additional factor of 2.84 to account for uncertainties, four additional SAMA candidates were determined to be potentially cost-beneficial:

- SAMA 8 – Convert selected fire protection piping from wet to dry pipe system.
- SAMA 32 – Install additional physical barriers to limit dispersion of fuel oil from DG rooms.
- SAMA 7 – Provide procedural guidance for loss of all 1E 120V AC power.
- SAMA 37 – Reinforce 1E 120V AC distribution panels.

PSEG indicated that all 13 potentially cost-beneificial SAMAs will be considered for implementation through the established HCGS Plant Health Committee process.

Based on the staff's review, 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.

5.3.6 Conclusions

The staff reviewed PSEG'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 PSEG are reasonable and sufficient for the license renewal submittal.

Based on its review of the SAMA analysis, the staff concurs with PSEG's identification of areas in which risk can be further reduced at both SGS and HCGS 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 consideration of these SAMAs by PSEG is warranted. However, none of the potentially cost-beneficial SAMAs relate to adequately managing the effects of aging during the period of extended operation for SGS or HCGS. Therefore, they need not be implemented as part of the license renewal pursuant to 10 CFR Part 54.

5.4 REFERENCES

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6.0 ENVIRONMENTAL IMPACTS OF THE URANIUM FUEL CYCLE AND SOLID WASTE MANAGEMENT, AND GREENHOUSE GAS EMISSIONS

6.1 THE URANIUM FUEL CYCLE

This section addresses issues related to the uranium fuel cycle, solid waste management during the period of extended operation. The uranium cycle includes uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transportation of radioactive materials, and management of low-level wastes and high-level wastes related to uranium fuel cycle activities. The generic environmental impact statement (GEIS; NRC, 1996, 1999)[1] details the potential generic impacts of the radiological and non-radiological environmental impacts of the uranium fuel cycle and transportation of nuclear fuel and wastes, as listed in Table 6-1 below. The GEIS is based, in part, on the generic impacts provided in Table S-3, "Table of Uranium Fuel Cycle Environmental Data," in Title 10, Section 51.51(b), of the *Code of Federal Regulations* (10 CFR 51.51(b)), and in Table S-4, "Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor," in 10 CFR 51.52(c). The GEIS also addresses the impacts from radon-222 and technetium-99.

The staff of the U.S. Nuclear Regulatory Commission (NRC) did not identify any new and significant information related to the uranium fuel cycle during the review of the PSEG Nuclear LLC (PSEG) environmental reports (ERs) for Salem Nuclear Generating Station, Units 1 and 2 (Salem) and Hope Creek Generating Station (HCGS) (PSEG, 2009a; 2009b), the site audit, and the scoping process. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS. For these Category 1 issues, the GEIS concludes that the impacts are SMALL, except for the collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal, which the Commission has concluded to be acceptable.

Table 6-1. Issues Related to the Uranium Fuel Cycle and Solid Waste Management. *Nine generic issues are related to the fuel cycle and solid waste management. There are no site-specific issues.*

Issues	GEIS Section	Category
Offsite radiological impacts (individual effects from other than the disposal of spent fuel and high-level waste)	6.1, 6.2.1, 6.2.2.1, 6.2.2.3, 6.2.3, 6.2.4, 6.6	1
Offsite radiological impacts (collective effects)	6.1, 6.2.2.1, 6.2.3, 6.2.4, 6.6	1
Offsite radiological impacts (spent fuel and	6.1, 6.2.2.1, 6.2.3, 6.2.4, 6.6	1

[1] The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the GEIS include the GEIS and Addendum 1.

Issues	GEIS Section	Category
high-level waste disposal)		
Nonradiological impacts of the uranium fuel cycle	6.1, 6.2.2.6, 6.2.2.7, 6.2.2.8, 6.2.2.9, 6.2.3, 6.2.4, 6.6	1
Low-level waste storage and disposal	6.1, 6.2.2.2, 6.4.2, 6.4.3, 6.4.3.1, 6.4.3.2, 6.4.3.3, 6.4.4, 6.4.4.1, 6.4.4.2, 6.4.4.3, 6.4.4.4, 6.4.4.5, 6.4.4.5.1, 6.4.4.5.2, 6.4.4.5.3, 6.4.4.5.4, 6.4.4.6, 6.6	1
Mixed waste storage and disposal	6.4.5.1, 6.4.5.2, 6.4.5.3, 6.4.5.4, 6.4.5.5, 6.4.5.6, 6.4.5.6.1, 6.4.5.6.2, 6.4.5.6.3, 6.4.5.6.4, 6.6	1
Onsite spent fuel	6.1, 6.4.6, 6.4.6.1, 6.4.6.2, 6.4.6.3, 6.4.6.4, 6.4.6.5, 6.4.6.6, 6.4.6.7, 6.6	1
Nonradiological waste	6.1, 6.5, 6.5.1, 6.5.2, 6.5.3, 6.6	1
Transportation	6.1, 6.3.1, 6.3.2.3, 6.3.3, 6.3.4, 6.6, Addendum 1	1

6.2 GREENHOUSE GAS EMISSIONS

This section provides a discussion of potential impacts from greenhouse gases (GHGs) emitted from the nuclear fuel cycle. The GEIS does not directly address these emissions, and its discussion is limited to an inference that substantial carbon dioxide (CO_2) emissions may occur if coal- or oil-fired alternatives to license renewal are implemented.

6.2.1 Existing Studies

Since the development of the GEIS, the relative volumes of GHGs emitted by nuclear and other electricity generating methods have been widely studied. However, estimates and projections of the carbon footprint of the nuclear fuel cycle vary depending on the type of study conducted. Additionally, considerable debate also exists among researchers regarding the relative impacts of nuclear and other forms of electricity generation on GHG emissions. Existing studies on GHG emissions from nuclear power plants generally take two different forms:

(1) Qualitative discussions of the potential to use nuclear power to reduce GHG emissions and mitigate global warming; and

(2) Technical analyses and quantitative estimates of the actual amount of GHGs generated by the nuclear fuel cycle or entire nuclear power plant life cycle and comparisons to the operational or life cycle emissions from other energy generation alternatives.

Some of these studies are summarized below to give the reader an overview of the current state of these assessments.

6.2.1.1 Qualitative Studies

The qualitative studies consist primarily of broad, large-scale public policy or investment evaluations of whether an expansion of nuclear power is likely to be a technically, economically, and/or politically feasible means of achieving global GHG reductions. Examples of the studies include:

- Evaluations to determine whether investments in nuclear power in developing countries should be accepted as a flexibility mechanism to assist industrialized nations in achieving their GHG reduction goals under the Kyoto Protocols (Schneider, 2000; IAEA, 2000; NEA and OECD, 2002; NIRS/WISE, 2005). Ultimately, the parties to the Kyoto Protocol did not approve nuclear power as a component under the Clean Development Mechanism (CDM) due to safety and waste disposal concerns (NEA and OECD, 2002).

- Analyses developed to assist governments, including the United States, in making long-term investment and public policy decisions in nuclear power (Keepin, 1988; Hagen et al., 2001; MIT, 2003).

Although the qualitative studies sometimes reference and critique the existing quantitative estimates of GHGs produced by the nuclear fuel cycle, their conclusions generally rely heavily on discussions of other aspects of nuclear policy decisions and investment such as safety, cost, waste generation, and political acceptability. Therefore, these studies are typically not directly applicable to an evaluation of GHG emissions associated with the proposed license renewal for a given nuclear power plant.

6.2.1.2 Quantitative Studies

A large number of technical studies, including calculations and estimates of the amount of GHGs emitted by nuclear and other power generation options, are available in the literature and were useful to the NRC staff's efforts in addressing relative GHG emission levels. Examples of these studies include – but are not limited to – Mortimer (1990), Andseta et al. (1998), Spadaro et al. (2000), Storm van Leeuwen and Smith (2008), Fritsche (2006), Parliamentary Office of Science and Technology (POST) (2006), Atomic Energy Authority (AEA) (2006), Weisser (2006), Fthenakis and Kim (2007), and Dones (2007).

Comparing these studies and others like them is difficult because the assumptions and components of the lifecycles the authors evaluate vary widely. Examples of areas in which differing assumptions make comparing the studies difficult include:

- Energy sources that may be used to mine uranium deposits in the future;

- Reprocessing or disposal of spent nuclear fuel;

- Current and potential future processes to enrich uranium and the energy sources that will power them;

- Estimated grades and quantities of recoverable uranium resources;
- Estimated grades and quantities of recoverable fossil fuel resources;
- Estimated GHG emissions other than CO_2, including the conversion to CO_2 equivalents per unit of electric energy produced;
- Performance of future fossil fuel power systems;
- Projected capacity factors for alternatives means of generation; and
- Current and potential future reactor technologies.

In addition, studies may vary with respect to whether all or parts of a power plant's fuel cycle are analyzed, i.e., a full lifecycle analysis will typically address plant construction, operations, resource extraction (for fuel and construction materials), and decommissioning, whereas, a partial lifecycle analysis primarily focuses on operational differences.

In the case of license renewal, a GHG analysis for that portion of the plant's lifecycle (operation for an additional 20 years) would not involve GHG emissions associated with construction because construction activities have already been completed at the time of relicensing. In addition, the proposed action of license renewal would also not involve additional GHG emissions associated with facility decommissioning, because that decommissioning must occur whether the facility is relicensed or not. However, in some of the aforementioned studies, the specific contribution of GHG emissions from construction, decommissioning, or other portions of a plant's lifecycle cannot be clearly separated from one another. In such cases, an analysis of GHG emissions would overestimate the GHG emissions attributed to a specific portion of a plant's lifecycle. Nonetheless, these studies provide some meaningful information with respect to the potential GHG cumulative impacts associated with license renewal as well as the relative magnitude of the emissions among nuclear power plants and other forms of electric generation, as discussed in the following sections.

In Tables 6-2, 6-3, and 6-4, the NRC staff presents the results of the aforementioned quantitative studies to provide an evaluation of the relative GHG emissions that may result from the proposed license renewal as compared to the potential alternative use of coal-fired, natural gas-fired, and renewable generation. Most studies from Mortimer (1990) onward suggest that uranium ore grades and uranium enrichment processes are leading determinants in the ultimate GHG emissions attributable to nuclear power generation. These studies indicate that the relatively lower order of magnitude of GHG emissions from nuclear power when compared to fossil-fueled alternatives (especially natural gas) could potentially disappear if available uranium ore grades drop sufficiently while enrichment processes continued to rely on the same technologies.

Summary of Nuclear Greenhouse Gas Emissions Compared to Coal

Considering that coal fuels the largest share of electricity generation in the United States and that its burning results in the largest GHG emissions for any of the likely alternatives to nuclear power generation, including Salem and HCGS, most of the available quantitative studies focused on comparisons of the relative GHG emissions of nuclear to coal-fired generation. The quantitative estimates of the GHG emissions associated with the nuclear fuel cycle (and, in some cases, the nuclear lifecycle), as compared to an equivalent coal-fired plant, are presented in Table 6-2. The following chart does not include all existing studies, but provides an illustrative range of estimates developed by various sources.

Table 6-2. Nuclear Greenhouse Gas Emissions Compared to Coal

Source	GHG Emission Results
Mortimer (1990)	Nuclear—230,000 tons CO_2 Coal—5,912,000 tons CO_2 Note: Future GHG emissions from nuclear to increase because of declining ore grade.
Andseta et al. (1998)	Nuclear energy produces 1.4 percent of the GHG emissions compared to coal. Note: Future reprocessing and use of nuclear-generated electrical power in the mining and enrichment steps are likely to change the projections of earlier authors, such as Mortimer (1990).
Spadaro et al. (2000)	Nuclear—2.5 to 5.7 g Ceq/kWh Coal—264 to 357 g Ceq/kWh
Storm van Leeuwen and Smith (2008)	Authors did not evaluate nuclear versus coal.
Fritsche (2006) (Values estimated from graph in Figure 4)	Nuclear—33 g Ceq/kWh Coal—950 g Ceq/kWh
POST (2006) (Nuclear calculations from AEA, 2006)	Nuclear—5 g Ceq/kWh Coal—>1000 g Ceq/kWh Note: Decrease of uranium ore grade to 0.03 percent would raise nuclear to 6.8 g Ceq /kWh. Future improved technology and carbon capture and storage could reduce coal-fired GHG emissions by 90 percent.
Weisser (2006) (Compilation of results from other studies)	Nuclear—2.8 to 24 g Ceq/kWh Coal—950 to 1250 g Ceq/kWh
Fthenakis and Kim (2007)	Authors did not evaluate nuclear versus coal.
Dones (2007)	Author did not evaluate nuclear versus coal.

Summary of Nuclear Greenhouse Gas Emissions Compared to Natural Gas

The quantitative estimates of the GHG emissions associated with the nuclear fuel cycle (and, in some cases, the nuclear lifecycle), as compared to an equivalent natural gas-fired plant, are presented in Table 6-3. The following chart does not include all existing studies, but provides an illustrative range of estimates developed by various sources.

Table 6-3. Nuclear Greenhouse Gas Emissions Compared to Natural Gas

Source	GHG Emission Results
Mortimer (1990)	Author did not evaluate nuclear versus natural gas.
Andseta (1998)	Author did not evaluate nuclear versus natural gas.
Spadaro et al. (2000)	Nuclear—2.5 to 5.7 g Ceq/kWh Natural Gas—120 to 188 g Ceq/kWh
Storm van Leeuwen and Smith (2008)	Nuclear fuel cycle produces 20 to 33 percent of the GHG emissions compared to natural gas (at high ore grades). Note: Future nuclear GHG emissions to increase because of declining ore grade.
Fritsche (2006) (Values estimated from graph in Figure 4)	Nuclear—33 g Ceq/kWh Cogeneration Combined Cycle Natural Gas—150 g Ceq/kWh
POST (2006) (Nuclear calculations from AEA, 2006)	Nuclear—5 g Ceq/kWh Natural Gas—500 g Ceq/kWh Note: Decrease of uranium ore grade to 0.03 percent would raise nuclear to 6.8 g Ceq/kWh. Future improved technology and carbon capture and storage could reduce natural gas GHG emissions by 90 percent.
Weisser (2006) (Compilation of results from other studies)	Nuclear—2.8 to 24 g Ceq/kWh Natural Gas—440 to 780 g Ceq/kWh
Fthenakis and Kim (2007)	Authors did not evaluate nuclear versus natural gas.
Dones (2007)	Author critiqued methods and assumptions of Storm van Leeuwen and Smith (2008), and concluded that the nuclear fuel cycle produces 15 to 27 percent of the GHG emissions of natural gas.

Summary of Nuclear Greenhouse Gas Emissions Compared to Renewable Energy Sources

The quantitative estimates of the GHG emissions associated with the nuclear fuel cycle, as compared to equivalent renewable energy sources, are presented in Table 6-4. Calculation of GHG emissions associated with these sources is more difficult than the calculations for nuclear energy and fossil fuels because of the large variation in efficiencies due to their different sources and locations. For example, the efficiency of solar and wind energy is highly dependent on the location in which the power generation facility is installed. Similarly, the range of GHG emissions estimates for hydropower varies greatly depending on the type of dam or reservoir involved (if used at all). Therefore, the GHG emissions estimates for these energy sources have a greater range of variability than the estimates for nuclear and fossil fuel sources. The following chart does not include all existing studies, but provides an illustrative range of estimates developed by various sources.

Table 6-4. Nuclear Greenhouse Gas Emissions Compared to Renewable Energy Sources

Source	GHG Emission Results
Mortimer (1990)	Nuclear—230,000 tons CO_2 Hydropower—78,000 tons CO_2 Wind power—54,000 tons CO_2 Tidal power—52,500 tons CO_2 Note: Future GHG emissions from nuclear to increase because of declining ore grade.
Andseta (1998)	Author did not evaluate nuclear versus renewable energy sources.
Spadaro et al. (2000)	Nuclear—2.5 to 5.7 g Ceq/kWh Solar PV—27.3 to 76.4 g Ceq/kWh Hydroelectric—1.1 to 64.6 g Ceq/kWh Biomass—8.4 to 16.6 g Ceq/kWh Wind—2.5 to 13.1 g Ceq/kWh
Storm van Leeuwen and Smith (2008)	Author did not evaluate nuclear versus renewable energy sources.
Fritsche (2006) (Values estimated from graph in Figure 4)	Nuclear—33 g Ceq/kWh Solar PV—125 g Ceq/kWh Hydroelectric—50 g Ceq/kWh Wind—20 g Ceq/kWh
POST (2006) (Nuclear calculations from AEA, 2006)	Nuclear—5 g Ceq/kWh Biomass—25 to 93 g Ceq/kWh Solar PV—35 to 58 g Ceq/kWh Wave/Tidal—25 to 50 g Ceq/kWh Hydroelectric—5 to 30 g Ceq/kWh Wind—4.64 to 5.25 g Ceq/kWh Note: Decrease of uranium ore grade to 0.03 percent would raise nuclear to 6.8 g Ceq/kWh.
Weisser (2006) (Compilation of results from other studies)	Nuclear—2.8 to 24 g Ceq/kWh Solar PV—43 to 73 g Ceq/kWh Hydroelectric—1 to 34 g Ceq/kWh Biomass—35 to 99 g Ceq/kWh Wind—8 to 30 g Ceq/kWh
Fthenakis and Kim (2007)	Nuclear—16 to 55 g Ceq/kWh Solar PV—17 to 49 g Ceq/kWh
Dones (2007)	Author did not evaluate nuclear versus renewable energy sources.

6.2.2 Conclusions: Relative GHG Emissions

The sampling of data presented in Tables 6-2, 6-3, and 6-4 above demonstrates the challenges of any attempt to determine the specific amount of GHG emission attributable to nuclear energy production sources, as different assumptions and calculation methodology will yield differing results. The differences and complexities in these assumptions and analyses will further increase when they're used to project future GHG emissions. Nevertheless, several conclusions can be drawn from the information presented.

First, the various studies indicate a general consensus that nuclear power currently produces fewer GHG emissions than fossil-fuel-based electrical generation, e.g., the GHG emissions from a complete nuclear fuel cycle currently range from 2.5 to 55 g C_{eq}/kWh, as compared to the use of coal plants (264 to 1250 g C_{eq}/kWh) and natural gas plants (120 to 780 g C_{eq}/kWh). The studies also provide estimates of GHG emissions from five renewable energy sources based on current technology. These estimates included solar-photovoltaic (17 to 125 g C_{eq}/kWh), hydroelectric (1 to 64.6 g C_{eq}/kWh), biomass (8.4 to 99 g C_{eq}/kWh), wind (2.5 to 30 g C_{eq}/kWh), and tidal (25 to 50 g C_{eq}/kWh). The range of these estimates is wide, but the general conclusion is that current GHG emissions from the nuclear fuel cycle are of the same order of magnitude as from these renewable energy sources.

Second, the studies indicate no consensus on future relative GHG emissions from nuclear power and other sources of electricity. There is substantial disagreement among the various authors regarding the GHG emissions associated with declining uranium ore concentrations, future uranium enrichment methods, and other factors, including changes in technology. Similar disagreement exists regarding future GHG emissions associated with coal and natural gas for electricity generation. Even the most conservative studies conclude that the nuclear fuel cycle currently produces fewer GHG emissions than fossil-fuel-based sources, and is expected to continue to do so in the near future. The primary difference between the authors is the projected cross-over date (the time at which GHG emissions from the nuclear fuel cycle exceed those of fossil-fuel-based sources) or whether cross-over will actually occur.

Considering the current estimates and future uncertainties, it appears that GHG emissions associated with the proposed Salem and HCGS relicensing action are likely to be lower than those associated with fossil-fuel-based energy sources. The NRC staff bases this conclusion on the following rationale:

1. As shown in Tables 6-2 and 6-3, the current estimates of GHG emissions from the nuclear fuel cycle are far below those for fossil-fuel-based energy sources;

2. Salem and HCGS license renewal will involve continued GHG emissions due to uranium mining, processing, and enrichment, but will not result in increased GHG emissions associated with plant construction or decommissioning (as the plant will have to be decommissioned at some point whether or not the license is renewed); and

3. Few studies predict that nuclear fuel cycle emissions will exceed those of fossil fuels within a timeframe that includes the Salem and HCGS period of extended operation. Several studies suggest that future extraction and enrichment methods, the potential for

higher grade resource discovery, and technology improvements could extend this timeframe.

With respect to a comparison of GHG emissions among the proposed Salem and HCGS license renewal action and renewable energy sources, it appears likely that there will be future technology improvements and changes in the type of energy used for mining, processing, and constructing facilities of all types. Currently, the GHG emissions associated with the nuclear fuel cycle and renewable energy sources are comparable i.e., within the same order of magnitude. Because nuclear fuel production is the most significant contributor to possible future increases in GHG emissions from nuclear power, and because most renewable energy sources lack a fuel component, it is likely that GHG emissions from renewable energy sources would be lower than those associated with Salem and HCGS at some point during the period of extended operation.

The NRC staff also provides an additional discussion about the contribution of GHG to cumulative air quality impacts in Section 4.11.2 of this SEIS.

6.3 REFERENCES

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7.0 ENVIRONMENTAL IMPACTS OF DECOMMISSIONING

Decommissioning is defined as the safe removal of a nuclear facility from service and the reduction of residual radioactivity to a level that permits release of the property for unrestricted use and termination of the license. The U.S. Nuclear Regulatory Commission (NRC) issued a generic environmental impact statement (GEIS) for decommissioning (NRC, 2002) that evaluated the environmental impacts from the activities associated with the decommissioning of any reactor before or at the end of an initial or renewed license.

The NRC staff has not identified any new and significant information during the review of the PSEG Nuclear, LLC (PSEG) environmental reports (ERs) for Salem Nuclear Generating Station, Units 1 and 2 (Salem) and Hope Creek Generating Station (HCGS) (PSEG, 2009a; PSEG, 2009b), the site audit, or the scoping process. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS (NRC, 1996; NRC, 1999). For the issues listed in Table 7-1 below, the GEIS concluded that the impacts are SMALL.

Table 7-1. Issues Related to Decommissioning. *Decommissioning would occur regardless of whether the Salem and HCGS units were shut down at the end of their currect operating licenses or at the end of the extended operation periods. There are no site-specific issues related to decommissioning.*

Issues	GEIS Section	Category
Radiation doses	7.3.1; 7.4	1
Waste management	7.3.2; 7.4	1
Air quality	7.3.3; 7.4	1
Water quality	7.3.4; 7.4	1
Ecological resources	7.3.5; 7.4	1
Socioeconomic impacts	7.3.7; 7.4	1

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8.0 ENVIRONMENTAL IMPACTS OF ALTERNATIVES

The National Environmental Policy Act (NEPA) mandates that each environmental impact statement (EIS) consider alternatives to any proposed major Federal action significantly affecting the quality of the human environment. U.S. Nuclear Regulatory Commission (NRC) regulations implementing NEPA for license renewal require that a supplemental environmental impact statement (SEIS) consider and weigh "the environmental effects of the proposed action (license renewal); the environmental impacts of alternatives to the proposed action; and alternatives available for reducing or avoiding adverse environmental impacts" (Title 10 of the *Code of Federal Regulations* (CFR) 51.71(d)).

This SEIS considers the proposed Federal action of issuing a renewed license for the Salem Nuclear Generating Stations, Units 1 and 2 (Salem) and Hope Creek Generating Station (HCGS), which would allow the plants to operate for 20 years beyond the current license expiration dates. In this chapter, the NRC staff (Staff) examines the potential environmental impacts of alternatives to issuing a renewed operating license for Salem and HCGS, as well as alternatives that may reduce or avoid adverse environmental impacts from license renewal, when and where these alternatives are applicable.

While the *Generic Environmental Impact Statement (GEIS) for License Renewal of Nuclear Plants*, NUREG-1437 (NRC, 1996; NRC, 1999), reached generic conclusions regarding many environmental issues associated with license renewal, it did not determine which alternatives are reasonable or reach conclusions about site-specific environmental impact levels. As such, the Staff must evaluate environmental impacts of alternatives on a site-specific basis.

Alternatives to the proposed action of issuing renewed Salem and HCGS operating licenses must meet the purpose and need for issuing a renewed license. They must:

> 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. (NRC, 1996)

The Staff ultimately makes no decision as to which alternative (or the proposed action) to implement, since that decision falls to energy-planning decision-makers. If NRC decides not to renew the licenses (or takes no action at all), then energy-planning decision-makers may no longer elect to continue operating Salem and HCGS and will have to resort to another alternative—which may or may not be one of the alternatives considered in this section—to meet their energy needs.

In evaluating alternatives to license renewal, the Staff first selects energy technologies or options currently in commercial operation, as well as some technologies not currently in commercial operation but likely to be commercially available by the time the current Salem and HCGS operating licenses expire. The current Salem operating licenses will expire on August 13, 2016, for Unit 1 and April 18, 2020, for Unit 2. The current HCGS operating license will expire on April 11, 2026. An alternative must be available (constructed, permitted, and connected to the grid) by the time the current Salem and HCGS licenses expire.

Second, the Staff screens the alternatives to remove those that cannot meet future system needs, and then screens the remaining options to remove those with costs or benefits that do not justify their inclusion in the range of reasonable alternatives. Any alternatives remaining, then, constitute alternatives to the proposed action that the Staff evaluates in detail throughout this section. In Section 8.2, the SEIS briefly addresses each alternative that the Staff removed during screening and explains why each alternative was removed.

The Staff initially considered 17 discrete alternatives to the proposed action, and then narrowed the list to two discrete alternatives and a combination of alternatives considered in Section 8.1.

Once the Staff identifies alternatives for in-depth review, the Staff refers to generic environmental impact evaluations in the GEIS. The GEIS provides overviews of some energy technologies available at the time of its publishing in 1996, though it does not reach any conclusions regarding which alternatives are most appropriate, nor does it categorize impacts for each site. In addition, since 1996, many energy technologies have evolved significantly in capability and cost, while regulatory structures have changed to either promote or impede development of particular alternatives.

As a result, the Staff's analysis starts with the GEIS and then includes updated information from sources like the Energy Information Administration (EIA), other organizations within the Department of Energy (DOE), the Environmental Protection Agency (EPA), industry sources and publications, and information submitted in the PSEG Nuclear, LLC (PSEG, the applicant) environmental report (ER).

For each in-depth analysis, the Staff analyzes environmental impacts across seven impact categories: (1) air quality, (2) groundwater use and quality, (3) surface water use and quality, (4) aquatic and terrestrial ecology, (5) human health, (6) socioeconomics, and (7) waste management. As in earlier chapters of this draft SEIS, the Staff uses the NRC's three-level standard of significance—SMALL, MODERATE, or LARGE—to indicate the degree of the environmental effect on each of the seven aforementioned categories that have been evaluated.

In-Depth Alternatives:

- **Supercritical coal-fired**
- **Natural gas-fired combined-cycle**
- **Combination**

Other Alternatives Considered:

- **Offsite Coal-Fired and Natural Gas-Fired**
- **New nuclear**
- **Conservation/ Efficiency**
- **Purchased power**
- **Solar power**
- **Wood-fired**
- **Wind (onshore/offshore)**
- **Hydroelectric power**
- **Wave and ocean energy**
- **Geothermal power**
- **Municipal solid waste**
- **Biofuels**
- **Oil-fired power**
- **Fuel cells**
- **Delayed retirement**

The in-depth alternatives that the Staff considered include (1) a supercritical coal-fired plant in Section 8.1.1, (2) a natural gas-fired combined-cycle power plant in Section 8.1.2, and (3) a combination of alternatives in Section 8.1.3 that includes natural gas-fired combined-cycle generation, energy conservation, and a wind power component. In Section 8.2, the Staff explains why it dismissed many other alternatives from in-depth consideration. In Section 8.3, the Staff considers the environmental effects that may occur if NRC takes no action and does not issue renewed licenses for Salem and HCGS. Finally, in Section 8.4, the impacts of all alternatives are summarized.

> **Energy Outlook:** Each year the Energy Information Administration (EIA), part of the U.S. Department of Energy (DOE), issues its updated *Annual Energy Outlook (AEO)*. *AEO 2009* indicates that natural gas, coal, and renewable are likely to fuel most new electrical capacity through 2030, with some growth in nuclear capacity (EIA, 2009a), though all projections are subject to future developments in fuel price or electricity demand:
>
> "Natural-gas-fired plants account for 53 percent of capacity additions in the reference case, as compared with 22 percent for renewable, 18 percent for coal-fired plants, and 5 percent for nuclear. Capacity expansion decisions consider capital, operating, and transmission costs. Typically, coal-fired, nuclear, and renewable plants are capital-intensive, whereas operating (fuel) expenditures account for most of the costs associated with natural-gas-fired capacity."

In addition, for each of the alternatives mentioned above, the Staff took the general approach of evaluating each as a potential alternative to completely replace the power production capacity of all three units currently at Salem and HCGS. However, during the preparation of this SEIS, the Staff also considered the possible scenarios of license renewal for Salem but not HCGS and vice versa, as the application for each plant was submitted separately. The Staff has determined that such scenarios would present various combinations of alternatives that would essentially equate to different variations of alternatives (1), (2), and (3) above (e.g., a supercritical coal-fired plant that replaces Salem alongside a renewed HCGS, or a natural gas-fired combined-cycle plant that replaces HCGS alongside a renewed Salem). Given the large number of combinations that this would create, the Staff evaluated the alternatives using a bounding approach, as provided in Section 8.1 below, which can be scaled down for a qualitative representation of what the impacts would be for combinations such as a supercritical coal-fired plant replacing Salem alongside a renewed HCGS. For example, the Staff estimates that the resource impacts for that combination would fall between those of the continued operation at Salem and HCGS and those of the impacts from a supercritical coal-fired plant as described in Section 8.1.1, where impacts for air quality, human health, socioeconomics, and waste management would range from SMALL to MODERATE.

8.1 Alternative Energy Sources

8.1.1 Supercritical Coal-Fired Generation

The GEIS indicates that a 3,656 megawatt-electric (MW[e]) supercritical coal-fired power plant (a plant equivalent in capacity to each individual Salem Unit 1, Salem Unit 2, and HCGS plants) could require 6,200 ac (2,600 ha) of available land area, and thus would not fit on the existing 1,480 ac (599 ha) owned by PSEG at the Salem and HCGS sites; however, the Staff notes that many coal-fired power plants with larger capacities have been located on smaller sites. In the ERs, PSEG assumed that a coal-fired alternative would be developed on the existing Salem and HCGS sites. The Staff believes this to be reasonable and, as such, will consider a coal-fired alternative located on the current Salem and HCGS sites.

Coal-fired generation accounts for 48.2 percent of U.S. electrical power generation, a greater share than any other fuel (EIA, 2010a). Furthermore, the EIA projects that coal-fired power plants will account for the greatest share of added capacity through 2030—more than natural gas, nuclear or renewable generation options (EIA, 2009a). While coal-fired power plants are widely used and likely to remain widely used, the Staff notes that future coal capacity additions may be affected by perceived or actual efforts to limit greenhouse gas (GHG) emissions. For now, the Staff considers a coal-fired alternative to be a feasible, commercially available option that could provide electrical generating capacity after the Salem and HCGS current licenses expire.

Supercritical technologies are increasingly common in new coal-fired plants. Supercritical plants operate at higher temperatures and pressures than most existing coal-fired plants (beyond water's "critical point", where boiling no longer occurs and no clear phase change occurs between steam and liquid water). Operating at higher temperatures and pressures allows this coal-fired alternative to function at a higher thermal efficiency than many existing coal-fired power plants do. While supercritical facilities are more expensive to construct, they consume less fuel for a given output, reducing environmental impacts. Based on technology forecasts from EIA, the Staff expects that a new, supercritical coal-fired plant beginning operation in 2014 would operate at a heat rate of 9069 British thermal units/kilowatt hour (Btu/kWh), or approximately 38 percent thermal efficiency (EIA, 2009a).

In a supercritical coal-fired power plant, burning coal heats pressurized water. As the supercritical steam/water mixture moves through plant pipes to a turbine generator, the pressure drops and the mixture flashes to steam. The heated steam expands across the turbine stages, which then spin and turn the generator to produce electricity. After passing through the turbine, any remaining steam is condensed back to water in the plant's condenser.

In most modern U.S. facilities, condenser cooling water circulates through cooling towers or a cooling pond system (either of which are closed-cycle cooling systems). Older plants often withdraw cooling water directly from existing rivers or lakes and discharge heated water directly to the same body of water (called open-cycle cooling). Salem operates open-cycle cooling water using once-through cooling at both of their units, while HCGS operates a closed-cycle cooling system with a natural draft cooling tower. Although nuclear plants require more cooling capacity than an equivalently sized coal-fired plant, the existing cooling tower at HCGS, by itself, is not expected to be adequate to support a coal-fired alternative that would have the capacity to replace both Salem and HCGS. Therefore, implementation of a coal-fired alternative would require the construction of additional cooling towers to provide the necessary cooling capacity to support the replacement of both Salem and HCGS. Under the coal-fired alternative, the facility would withdraw makeup water from and discharge blowdown (water containing concentrated dissolved solids and biocides) from cooling towers back to the Delaware River, similar to the manner in which the current HCGS cooling tower operates. However, additional cooling towers would be required, so the volume of water managed in cooling towers would increase. At the same time, the once-through cooling system associated with the Salem Units 1 and 2 would cease operation.

In order to replace the 3,656 net MW(e) that Salem and HCGS currently supply, the coal-fired alternative would need to produce roughly 3889 gross MW(e), using about 6 percent of power output for onsite power usage (PSEG, 2009a; PSEG, 2009b). Onsite electricity demands include scrubbers, cooling towers, coal-handling equipment, lights, communication, and other onsite needs. A supercritical coal-fired plant equivalent in capacity to Salem and HCGS would require less cooling water than Salem and HCGS because the alternative operates at a higher thermal efficiency. The 3,889 gross MW(e) would be achieved using standard-sized units, which are assumed to be approximately equivalent to six units of 630 MW(e) each.

The 3,656 net MW(e) power plants would consume approximately 12.2 million tons (11.1 million metric tons [MT]) of coal annually (EPA, 2006). EIA reports that most coal consumed in New Jersey originates in West Virginia or Pennsylvania (EIA, 2010b). Given current coal mining operations in this area, the coal used in this alternative would likely be mined by a combination of strip (mountaintop-removal) mining and underground mining. The coal would be mechanically processed and washed, and transported by barge to the Salem and HCGS facility. Limestone for scrubbers would also likely be delivered by barge. This coal-fired alternative would produce roughly 753,960 tons (684,440 MT) of ash annually (EIA, 2010b), and roughly 245,300 tons (222,700 MT) of scrubber sludge annually (PSEG, 2009a; PSEG, 2009b). Much of the coal ash and scrubbed sludge could be reused depending on local recycling and reuse markets.

The coal-fired alternative would also include construction impacts such as clearing the plant site of vegetation, excavation, and preparing the site surface before other crews begin actual construction of the plant and any associated infrastructure. Because this alternative would be constructed at the Salem and HCGS site, it is unlikely that new transmission lines would be necessary. Because coal would be supplied by barge, no construction of a new rail line would be necessary.

8.1.1.1 Air Quality

Air quality impacts from coal-fired generation can increase substantially as compared to license renewal because these power plants emit significant quantities of sulfur oxides (SO_x), nitrogen oxides (NO_x), particulates, carbon monoxide (CO), and hazardous air pollutants such as mercury. However, many of these pollutants can be reduced using various pollution control technologies.

As previously discussed in Section 4.1.1.5, Salem and HCGS are located in Salem County, New Jersey. Salem County is designated as an attainment/unclassified area with respect to the National Ambient Air Quality Standards (NAAQSs) for particulate matter 2.5 microns or less in diameter ($PM_{2.5}$), sulfur dioxide (SO_2), NO_x, CO, and lead. The county, along with all of southern New Jersey, is a nonattainment area with respect to the 1-hour primary ozone standard and the 8-hour ozone standard. For the 1-hour ozone standard, Salem County is located within the multi-state Philadelphia-Wilmington-Trenton non-attainment area, and for the 8-hour ozone standard, it is located in the Philadelphia-Wilmington-Atlantic City (PA-NJ-DE-MD) non attainment area.

A new coal-fired generating plant would qualify as a new major-emitting industrial facility and would be subject to Prevention of Significant Deterioration of Air Quality Review under requirements of Clean Air Act (CAA), adopted by the New Jersey Department of Environmental Protection (NJDEP) Bureau of Air Quality Permitting. A new coal-fired generating plant would need to comply with the new source performance standards for coal-fired plants set forth in 40 CFR 60 Subpart Da. The standards establish limits for particulate matter and opacity (40 CFR 60.42(a)), SO_2 (40 CFR 60.43(a)), and NO_x (40 CFR 60.44(a)). Regulations issued by NJDEP adopt the EPA's CAA rules (with modifications) to limit power plant emissions of SO_x, NO_x, particulate matter, and hazardous air pollutants. The new coal-fired generating plant would qualify as a major facility as defined in Section 7:27-22.1 of the New Jersey Administrative Code, and would be required to obtain a major source permit from NJDEP.

Section 169A of the CAA (42 *United States Code* (U.S.C.) 7401) establishes a national goal of preventing future and remedying existing impairment of visibility in mandatory Class I Federal areas when impairment results from man-made air pollution. The EPA issued a new regional haze rule in 1999 (64 *Federal Register* (FR) 35714). 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 through developing and implementing air quality protection plans to reduce the pollution that causes visibility impairment. The reasonable progress goals must provide an improvement in visibility for the most-impaired days over the period of implementation plan and ensure no degradation in visibility for the least-impaired days over the same period (40 CFR 51.308(d)(1)). Five regional planning organizations (RPO) collaborate on the visibility impairment issue, developing the technical basis for these plans. The State of New Jersey is among eleven member states (Maryland, Delaware, New Jersey, Pennsylvania, New York, Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, and Maine) of the Mid-Atlantic/Northeast Visibility Union (MANE-VU), along with tribes, Federal agencies, and other interested parties that identifies regional haze and visibility issues and develops strategies to address them (NJDEP, 2009a). The visibility protection regulatory requirements, contained in 40 CFR Part 51, Subpart P, include the review of the new sources that would be constructed in the attainment or unclassified areas and may affect visibility in any Federal Class I area (40 CFR Part 51, Subpart P, §51.307). If a coal-fired plant were located close to a mandatory Class I area, additional air pollution control requirements would be imposed. There is one mandatory Class I Federal area in the State of New Jersey, which is the Brigantine National Wildlife Refuge (40 CFR 81.420), located approximately 58 miles (mi; 93 kilometers [km]) southeast of the Salem and HCGS facilities. There are no Class I Federal areas in Delaware, and no other areas located within 100 mi (161 km) of the facilities (40 CFR 81.400). New Jersey is also subject to the Clean Air Interstate Rule (CAIR), which has outlined emissions reduction goals for both SO_2 and NO_x for the year 2015. CAIR will aid New Jersey sources in reducing SO_2 emissions by 25,000 tons (23,000 MT, or 49 percent), and NO_x emissions by 11,000 tons (10,000 MT, or 48 percent; EPA, 2010).

The Staff projects that the coal-fired alternative at the Salem and HCGS site would have the following emissions for criteria and other significant emissions based on published EIA data, EPA emission factors and on performance characteristics for this alternative and likely emission controls:

- Sulfur oxides (SO_x) – 12,566 tons (11,407 MT) per year
- Nitrogen oxides (NO_x) – 3,050 tons (769 MT) per year
- Particulate matter (PM) PM_{10} – 85.4 tons (77.5 MT) per year
- Particulate matter (PM) $PM_{2.5}$ – 22.6 tons (20.5 MT) per year
- Carbon monoxide (CO) – 3,050 tons (2,769 MT) per year

Sulfur Oxides

The coal-fired alternative at the Salem and HCGS site would likely use wet, limestone-based scrubbers to remove SO_x. The EPA indicates that this technology can remove more than 95 percent of SO_x from flue gases. The Staff projects total SO_x emissions after scrubbing would be 12,566 tons (11,407 MT) per year. SO_x emissions from a new coal-fired power plant would be subject to the requirements of Title IV of the CAA. Title IV was enacted to reduce emissions of SO_2 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_2 emissions and imposes controls on SO_2 emissions through a system of marketable allowances. The EPA issues one allowance for each ton of SO_2 that a unit is allowed to emit. New units do not receive allowances, but are required to have allowances to cover their SO_2 emissions. Owners of new units must therefore purchase allowances from owners of other power plants or reduce SO_2 emissions at other power plants they own. Allowances can be banked for use in future years. Thus, provided a new coal-fired power plant is able to purchase sufficient allowances to operate, it would not add to net regional SO_2 emissions, although it might do so locally.

Nitrogen Oxides

A coal-fired alternative at the Salem and HCGS site would most likely employ various available NO_x-control technologies, which can be grouped into two main categories: combustion modifications and post-combustion processes. Combustion modifications include low-NO_x burners, over fire air, and operational modifications. Post-combustion processes include selective catalytic reduction and selective non-catalytic reduction. An effective combination of the combustion modifications and post-combustion processes allow the reduction of NO_x emissions by up to 95 percent (EPA, 1998). PSEG indicated in its ER that the technology would use low NO_x burners, overfire air, and selective catalytic reduction to reduce NO_x emissions by approximately 95 percent from uncontrolled emissions. As a result, the NO_x emissions associated with a coal-fired alternative at the Salem and HCGS site would be approximately 3,050 tons (2,769 MT) per year.

Section 407 of the CAA establishes technology-based emission limitations for NO_x emissions. A new coal-fired power plant would be subject to the new source performance standards for such plants as indicated in 40 CFR 60.44a(d)(1). This regulation, issued on September 16, 1998 (63 FR 49442), limits the discharge of any gases that contain nitrogen oxides (NO_2) to 1.6 pounds per megawatt hour (lb/MWh) of NO_x per joule (J) of gross energy output (equivalent to

200 nanograms [ng]), based on a 30-day rolling average. Based on the projected emissions, the proposed alternative would easily meet this regulation.

Particulates

The new coal-fired power plant would use baghouse-based fabric filters to remove particulates from flue gases. PSEG indicated that this technology would remove 99.9 percent of particulate matter. The EPA notes that filters are capable of removing in excess of 99 percent of particulate matter, and that SO_2 scrubbers further reduce particulate matter emissions (EPA, 2008a). Based on EPA emission factors, the new supercritical coal-fired plant would emit 85.4 tons (77.5 MT) per year of particulate matter having an aerodynamic diameter less than or equal to 10 microns (PM_{10}) annually (EPA, 1998; EIA, 2010b). In addition, coal burning would also result in approximately 22.6 tons (20.5 MT) per year of $PM_{2.5}$. Coal-handling equipment would introduce fugitive dust emissions when fuel is being transferred to onsite storage and then reclaimed from storage for use in the plant. During the construction of a coal-fired plant, onsite activities would also generate fugitive dust. Vehicles and motorized equipment would create exhaust emissions during the construction process. These impacts would be intermittent and short-lived, however, and to minimize dust generation construction crews would use applicable dust-control measures.

Carbon Monoxide

Based on EPA emission factors and assumed plant characteristics, the Staff computed that the total CO emissions would be approximately 3,050 tons (2,769 MT) per year (EPA, 1998).

Hazardous Air Pollutants

Consistent with the D.C. Circuit Court's February 8, 2008 ruling that vacated its Clean Air Mercury Rule (CAMR), the EPA is in the process of developing mercury emissions standards for power plants under the CAA (Section 112) (EPA, 2009a). Before CAMR, the EPA determined that coal-and oil-fired electric utility steam-generating units are significant emitters of hazardous air pollutants (HAPs; 65 FR 79825). The EPA determined that coal plants emit arsenic, beryllium, cadmium, chromium, dioxins, hydrogen chloride, hydrogen fluoride, lead, manganese, and mercury (65 FR 79825). The EPA concluded that mercury is the HAP of greatest concern; it further concluded that:

(1) a link exists between coal combustion 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 resulting from mercury exposures caused by the consumption of contaminated fish (65 FR 79825).

On February 6, 2009, the Supreme Court dismissed the EPA's request to review the 2008 Circuit Court's decision, and also denied a similar request by the Utility Air Regulatory Group later that month (EPA, 2009a).

Carbon Dioxide

A coal-fired plant would also have unregulated carbon dioxide (CO_2) emissions during operations as well as during mining, processing, and transportation, which the GEIS indicates could contribute to global warming. The coal-fired plant would emit approximately 33,611,000 tons (30,512,000 MT) per year of CO_2.

Construction Impacts

Activities associated with the construction of a new coal-fired plant at the Salem and HCGS site would cause some additional air effects as a result of equipment emissions and fugitive dust from operation of the earth-moving and material handling equipment. Workers' vehicles and motorized construction equipment would generate temporary exhaust emissions. The construction crews would employ dust-control practices in order to control and reduce fugitive dust, which would be temporary in nature. The staff concludes that the impact of vehicle exhaust emissions and fugitive dust from operation of earth-moving and material handling equipment would be SMALL.

Summary of Air Quality

While the GEIS analysis mentions global warming from unregulated CO_2 emissions and acid rain from SO_x and NO_x emissions as potential impacts, it does not quantify emissions from coal-fired power plants. However, the GEIS analysis does imply that air impacts would be substantial (NRC, 1996). The above analysis shows that emissions of air pollutants, including SO_x, NO_x, CO, and particulates, exceed those produced by the existing nuclear power plant, as well as those of the other alternatives considered in this section. Operational emissions of CO_2 are also much greater under the coal-fired alternative, as reviewed by the Staff in Section 6.2 and in the previous sections. Adverse human health effects such as cancer and emphysema have also been associated with air emissions from coal combustion, and are discussed further in Section 8.1.1.5.

The NRC analysis for a coal-fired alternative at the Salem and HCGS site indicates that impacts from the coal-fired alternative would have clearly noticeable effects, but given existing regulatory regimes, permit requirements, and emissions controls, the coal-fired alternative would not destabilize air quality. Therefore, the appropriate characterization of air quality impacts from operation of a coal-fired plant located at the Salem and HCGS site would be MODERATE. Existing air quality would result in varying needs for pollution control equipment to meet applicable local requirements, or varying degrees of participation in emissions trading schemes.

8.1.1.2 Groundwater Use and Quality

If the onsite coal-fired alternative continued to use groundwater for drinking water and service water, the need for groundwater at the plant would be minor. Total usage would likely be less than Salem and HCGS because many fewer workers would be onsite, and because the coal-fired unit would have fewer auxiliary systems requiring service water. No effect on groundwater quality would be apparent.

Construction of a coal-fired plant could have a localized effect on groundwater due to temporary dewatering and run-off control measures. Because of the temporary nature of construction and the likelihood of reduced groundwater usage during operation, the impact of the coal-fired alternative would be SMALL.

8.1.1.3 Surface Water Use and Quality

The alternative would require a consumptive use of water from the Delaware River for cooling purposes. Because this consumptive loss would be from an estuary, the NRC concludes the impact of surface water use would be SMALL. A new coal-fired plant would be required to obtain a National Pollutant Discharge and Elimination System (NPDES) permit from the NJDEP for regulation of industrial wastewater, storm water, and other discharges. Assuming the plant operates within the limits of this permit, the impact from any cooling tower blowdown, site runoff, and other effluent discharges on surface water quality would be SMALL.

8.1.1.4 Aquatic and Terrestrial Ecology

Aquatic Ecology

Impacts to aquatic ecology resources from a coal-fired alternative at the Salem and HCGS site could result from effects on water bodies both adjacent to and distant from the site. Temporary effects on some aquatic organisms likely would result from construction that could occur in the water near the shoreline at the facility. Longer-term, more extensive effects on aquatic organisms likely would occur during the period of operation of the facility due to the intake of cooling water and discharge of effluents to the estuary. The numbers of fish and other aquatic organisms affected by impingement, entrainment, and thermal impacts would be substantially smaller than those associated with license renewal. Water consumption from and discharge of blowdown to the Delaware Estuary would be lower due to the higher thermal efficiency of the coal-fired facility and its use of only closed-cycle cooling. In addition, the intake and discharge would be monitored and regulated by the NJDEP under the facility's NPDES permit, including requirements under Clean Water Act (CWA) Section 316(a) and 316(b) for thermal discharges and cooling water intakes, respectively. Assuming the use of closed-cycle cooling and adherence to regulatory requirements, the impact on ecological resources of the Delaware Estuary from operation of the intake and discharge facilities would be minimal for this alternative.

Thus, impacts to aquatic ecology as a result of the effects of facility operations may occur on the adjacent Delaware Estuary. The coal-fired alternative potentially would have noticeable effects on aquatic resources in multiple areas. Given existing regulatory regimes, permit requirements, and emissions controls, these effects would be limited and unlikely to destabilize aquatic communities. Therefore, the impacts to aquatic resources from a coal-fired plant located at the Salem and HCGS site would be SMALL for the Delaware Estuary.

Terrestrial Ecology

Constructing the coal-fired alternative onsite would require approximately 505 ac (204 ha) of land for construction of the power block with an additional 193–386 ac (56–78 ha) for waste disposal, which PSEG indicated could be accommodated on the existing site (see Section 8.1.1.6) (PSEG, 2009a; PSEG, 2009b). Onsite impacts to terrestrial ecology may occur if additional land requirements result in the encroachment into or filling of the adjacent tidal marsh. In addition, if additional roads would need to be constructed through less disturbed areas, impacts could occur as these construction activities may fragment or destroy local ecological communities. Land disturbances could affect habitats of native wildlife; however, these impacts are not expected to be extensive. Cooling tower operation would produce drift that could result in some deposition of dissolved solids on surrounding vegetation and soils onsite and offsite.

Onsite or offsite waste disposal by landfilling also would affect terrestrial ecology at least until the time when the disposal area is reclaimed. Deposition of acid rain resulting from NO_x and SO_x emissions, as well as the deposition of other pollutants, also could affect terrestrial ecology. Air deposition impacts may be noticeable but, given the emission controls discussed in Section 8.1.1.1, are unlikely to be destabilizing. Thus, the impacts to terrestrial resources from a coal-fired plant located at the Salem and HCGS site would be SMALL to MODERATE.

8.1.1.5 Human Health

Coal-fired power plants introduce worker risks from new plant construction, coal and limestone mining, from coal and limestone transportation, and from disposal of coal combustion and scrubber wastes. In addition, there are public risks from inhalation of stack emissions (as addressed in Section 8.1.1.1) and the secondary effects of eating foods grown in areas subject to deposition from plant stacks.

Human health risks of coal-fired power plants are described, in general, in Table 8-2 of the GEIS (NRC, 1996). Cancer and emphysema as a result of the inhalation of toxins and particulates are identified as potential health risks to occupational workers and members of the public (NRC, 1996). The human health risks of coal-fired power plants, both to occupational workers and to members of the public, are greater than those of the current Salem and HCGS facilities due to exposures to chemicals such as mercury; SO_x; NO_x; radioactive elements such as uranium and thorium contained in coal and coal ash; and polycyclic aromatic hydrocarbon (PAH) compounds, including benzo(a)pyrene.

During construction activities there would be also risk to workers from typical industrial incidents and accidents. Accidental injuries are not uncommon in the construction industry and accidents resulting in fatalities do occur. However, the occurrence of such events is mitigated by the use of proper industrial hygiene practices, worker safety requirements, and training. Occupational and public health impacts during construction are expected to be controlled by continued application of accepted industrial hygiene and occupational health and safety practices.

Regulations restricting emissions—enforced by EPA or State agencies—have acted to significantly reduce potential health effects but have not entirely eliminated them. These agencies also impose site-specific emission limits as needed to protect human health. Even if the coal-fired alternative were located in a nonattainment area, emission controls and trading or offset mechanisms could prevent further regional degradation; however, local effects could be visible. Many of the byproducts of coal combustion responsible for health effects are largely controlled, captured, or converted in modern power plants (as described in Section 8.1.1.1), although some level of health effects may remain.

Aside from emission impacts, the coal-fired alternative introduces the risk of coal pile fires and, for those plants that use coal combustion liquid and sludge waste impoundments, the release of the waste due to a failure of the impoundment. Although there have been several instances of this occurring in recent years, these types of events are still relatively rare.

Based on the cumulative potential impacts of construction activities, emissions, and materials management on human health, the NRC staff considers the overall impact of constructing and operating a new coal-fired facility to be MODERATE.

8.1.1.6 Socioeconomics

Land Use

The GEIS generically evaluates the impacts of nuclear power plant operations on land use both on and off each power plant site. The analysis of land use impacts focuses on the amount of land area that would be affected by the construction and operation of a new supercritical coal-fired power plant on the Salem and HCGS site.

The GEIS indicates that an estimated 1,700 ac (700 ha) would be required for constructing a 1,000-MW(e) coal plant. Scaling from the GEIS estimate, approximately 6,200 ac (2,500 ha) would be required to replace the 3,656 MW(e) provided by Salem and HCGS. PSEG indicated that approximately 505 ac (204 ha) of land would be needed to support a coal-fired alternative capable of replacing the Salem and HCGS facilities (PSEG, 2009a; PSEG, 2009b). This amount of land use includes power plant structures and associated coal delivery and waste disposal infrastructure. However, many coal-fired power plants with larger capacities have been located on smaller sites, and the PSEG estimate is considered reasonable. PSEG indicated that an additional 193 ac (78 ha) of land area may be needed for waste disposal over the 20-year license renewal term, or 386 ac (156 ha) over the 40-year operational life of a coal-fired alternative, which PSEG indicated could be accommodated onsite (PSEG, 2009a; PSEG, 2009b).

Offsite land use impacts would occur from coal mining, in addition to land use impacts from the construction and operation of the new power plant. According to the GEIS, supplying coal to a 1,000-MW(e) plant would disturb approximately 22,000 ac (8,900 ha) of land for the mining of coal and disposing of wastes during the 40-year operational life. Scaling from GEIS estimates, approximately 80,500 ac (32,580 ha) of land would be required for a coal-fired alternative to replace Salem and HCGS. However, most of the land in existing coal-mining areas has already experienced some level of disturbance. The elimination of the need for uranium mining to supply fuel for the Salem and HCGS facilities would partially offset this offsite land use impact. Scaling from GEIS estimates, approximately 3,660 ac (1,480 ha) of land used for uranium mining and processing would no longer be needed.

Based on this information and the need for additional land at Salem and HCGS, land use impacts would range from SMALL to MODERATE.

Socioeconomics

Socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics and social conditions of a region. For example, the number of jobs created by the construction and operation of a new coal-fired power plant could affect regional employment, income, and expenditures. Two types of job creation result from this alternative: (1) construction-related jobs, and (2) operation-related jobs in support of power plant operations, which have the greater potential for permanent, long-term socioeconomic impacts. The Staff estimated workforce requirements during power plant construction and operation for the coal-fired alternative in order to measure their possible effect on current socioeconomic conditions.

According to the GEIS, a peak construction workforce of 1,200 to 2,500 would be required for a 1,000 MW(e) plant. Scaling from GEIS estimates, this would require a lower-end workforce of approximately 4,400 for a 3,660-MW(e) plant). PSEG projected a peak workforce of about 5,660 would be required to construct the coal-fired alternative at the Salem and HCGS site (PSEG, 2009a; PSEG, 2009b). During the construction period, the communities surrounding the plant site would experience increased demand for rental housing and public services. The relative economic contributions of these workers to local business and tax revenues would vary.

After construction, local communities could be temporarily affected by the loss of construction jobs and associated loss in demand for business services. In addition, the rental housing market could experience increased vacancies and decreased prices. As noted in the GEIS, the socioeconomic impacts at a rural construction site could be larger than at an urban site, because the workforce would need to relocate closer to the construction site. Although the ER indicates that Salem and HCGS is a rural site (PSEG, 2009a; PSEG, 2009b), it is located near the Philadelphia and Wilmington metropolitan areas. Therefore, these effects may be somewhat lessened because workers are likely to commute to the site from these areas instead of relocating closer to the construction site. Based on the site's proximity to these metropolitan areas, construction impacts would be SMALL.

PSEG estimated an operational workforce of approximately 500 workers for the 3,660 MW(e) supercritical coal-fired power plant alternative (PSEG, 2009a; PSEG 2009b). This would result in a loss of approximately 1,100 relatively high-paying jobs (based on a current Salem and HCGS workforce of 1,614), with a corresponding reduction in purchasing activity and tax contributions to the regional economy. The impact of the job loss, however, may not be noticeable given the amount of time that would be required for the construction of a new power plant and the decommissioning of the existing facilities and the relatively large region from which Salem and HCGS personnel are currently drawn. The size of property tax payments under the coal-fired alternative may increase if additional land is required at Salem and HCGS to support this alternative. Operational impacts would therefore range from SMALL to MODERATE.

Transportation

During periods of peak construction activity, up to 5,660 workers could be commuting daily to the site, as well as the current 1,614 workers already at Salem and HCGS. In addition to commuting workers, trucks would be transporting construction materials and equipment to the worksite, thereby increasing the amount of traffic on local roads. The increase in vehicular traffic on roads would peak during shift changes resulting in temporary level of service impacts and delays at intersections. Barges would likely be used to deliver large components to the Salem and HCGS site. Transportation impacts would likely be MODERATE during construction.

Transportation traffic-related impacts would be greatly reduced after construction, but would not disappear during plant operations. The maximum number of plant operating personnel commuting to the Salem and HCGS site would be approximately 500 workers. This is much smaller than the number of operations workers commuting to Salem and HCGS today. Deliveries of coal and limestone would be by barge. The coal-fired alternative transportation impacts would likely be SMALL during plant operations.

Aesthetics

The aesthetics impact analysis focuses on the degree of contrast between the coal-fired alternative and the surrounding landscape and the visibility of the coal plant.

The coal-fired power plant would be up to 200 feet (61 meters [m]) tall with exhaust stacks up to 500 feet (152 m). The facility would be visible offsite during daylight hours. The supercritical coal-fired power plant would be similar in height to the current Salem and HCGS reactor containment buildings (190 to 200 feet, or 58 to 61 m, tall) and the HCGS cooling tower, which stands at 514 feet (157 m). The coal-fired alternative would require more than one cooling tower, thus increasing the size of the plume. Lighting on plant structures would be visible offsite at night. Overall, aesthetic impacts associated with the supercritical coal-fired alternative would range from SMALL to MODERATE.

Coal-fired generation would introduce new sources of noise that would be audible offsite. Sources contributing to noise produced by coal-fired power plant operations would be classified as continuous or intermittent. Continuous noise sources include the mechanical equipment associated with normal plant operations. Intermittent noise sources include the equipment related to coal handling, solid-waste disposal, use of outside loudspeakers, and the commuting of plant employees. The impact of plant noise emissions are expected to be SMALL due to the distance from the Salem and HCGS site to the nearest receptors.

Historic and Archaeological Resources

Cultural resources are the indications of human occupation and use of the landscape as defined and protected by a series of Federal laws, regulations, and guidelines. Prehistoric resources are physical remains of human activities that predate written records; they generally consist of artifacts that may alone or collectively yield information about the past. Historic resources consist of physical remains that postdate the emergence of written records; in the United States, they are architectural structures or districts, archaeological objects, and archaeological features dating from 1492 and later. Ordinarily, sites less than 50 years old are not considered historic, but exceptions can be made for such properties if they are of particular importance, such as structures associated with the development of nuclear power (e.g., Shippingport Atomic Power Station) or Cold War themes. American Indian resources are sites, areas, and materials important to American Indians for religious or heritage reasons. Such resources may include geographic features, plants, animals, cemeteries, battlefields, trails, and environmental features. The cultural resource analysis encompassed the power plant site and adjacent areas that could potentially be disturbed by the construction and operation of alternative power plants.

The potential for historic and archaeological resources can vary greatly depending on the location of the proposed site. To consider a project's effects on historic and archaeological resources, any affected areas would need to be surveyed to identify and record historic and archaeological resources, identify cultural resources (e.g., traditional cultural properties), and develop possible mitigation measures to address any adverse effects from ground disturbing activities.

Before construction at the Salem and HCGS site studies would likely be needed to identify, evaluate, and address mitigation of potential impacts of new plant construction on cultural resources. Studies would be needed for all areas of potential disturbance at the proposed plant site and along associated corridors where construction would occur (e.g., roads, transmission corridors, rail lines, or other Right-of-Ways [ROWs]). Areas with the greatest sensitivity should be avoided.

As noted in Section 4.9.6, there is little potential for historic and archaeological resources to be present on most of the Salem and HCGS site; therefore, the impact for a coal-fired alternative at the Salem and HCGS site would likely be SMALL.

Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from the construction and operation of a new supercritical coal-fired power plant. Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant and exceeds the risk or exposure rate for the general population or for another appropriate comparison group. Disproportionately high environmental effects refer to impacts or risk of impact on the natural or physical environment in a minority or low-income community that are significant and appreciably exceed the environmental impact on the larger community. Such effects may include biological, cultural, economic, or social impacts. Some of these potential effects have been identified in resource areas discussed in this SEIS. For example, increased demand for rental housing during power plant construction could disproportionately affect low-income populations. Minority and low-income populations are subsets of the general public residing around Salem and HCGS, and all are exposed to the same hazards generated from constructing and operating a new coal-fired power plant. For socioeconomic data regarding the analysis of environmental justice issues, the reader is referred to Section 4.9.7, Environmental Justice.

Potential impacts to minority and low-income populations from the construction and operation of a new supercritical coal-fired power plant at Salem and HCGS would mostly consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts from construction would be short-term and primarily limited to onsite activities. Minority and low-income populations residing along site access roads would also be affected by increased commuter vehicle traffic during shift changes and truck traffic. However, these effects would be temporary during certain hours of the day and not likely to be high and adverse. Increased demand for rental housing in the vicinity of Salem and HCGS during construction could affect low-income populations. Given the close proximity to the Philadelphia and Wilmington metropolitan areas, most construction workers would likely commute to the site, thereby reducing the potential demand for rental housing.

Based on this information and the analysis of human health and environmental impacts presented in this SEIS, the construction and operation of a new supercritical coal-fired power plant would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations residing in the vicinity of Salem and HCGS.

8.1.1.7 Waste Management

Coal combustion generates several waste streams including ash (a dry solid) and sludge (a semi-solid byproduct of emission control system operation). The Staff estimates that an approximately 3,656 MW(e) power plant comprised of six units of approximately 630 MW(e) each would generate annually a total of approximately 684,440 MT (753,960 tons) of ash (EIA, 2010b), and 245,300 tons (222,700 MT) of scrubber sludge (PSEG, 2009a; PSEG, 2009b) About 340,000 tons (309,000 MT) or 45 percent of the ash waste and 193,800 tons (176,000 MT) or 79 percent of scrubber sludge would be recycled, based on industry-average recycling rates (ACAA, 2007). Therefore, approximately 414,000 tons (375,000 MT) of ash and 51,500 tons (46,700 MT) of scrubber sludge would remain annually for disposal. Disposal of the remaining waste could noticeably affect land use and groundwater quality, but would require proper citing in accordance with the describe local ordinance and the implementation of the required monitoring and management practices in order to minimize these impacts (state reference). After closure of the waste site 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) stating that it would issue regulations for disposal of coal combustion waste under Subtitle D of the Resource Conservation and Recovery Act. The EPA has not yet issued these regulations.

The impacts from waste generated during operation of this coal-fired alternative would be clearly visible, but would not destabilize any important resource.

The amount of the construction waste would be small compared to the amount of waste generated during operational stage and much of it could be recycled. Overall, the impacts from waste generated during construction stage would be minor.

Therefore, the Staff concludes that the overall impacts from construction and operation of this alternative would be MODERATE.

Table 8-1. Summary of the Direct and Indirect Environmental Impacts of the Supercritical Coal-Fired Alternative Compared to Continued Operation of Salem and HCGS

	Supercritical Coal-Fired Generation	Continued Salem and HCGS Operation
Air Quality	MODERATE	SMALL
Groundwater	SMALL	SMALL
Surface Water	SMALL	SMALL
Aquatic and Terrestrial Resources	SMALL to MODERATE	SMALL
Human Health	MODERATE	SMALL
Socioeconomics	SMALL to MODERATE	SMALL to LARGE
Waste Management	MODERATE	SMALL

8.1.2 Natural Gas-fired Combined-Cycle Generation

In this section, the Staff evaluates the environmental impacts of a natural gas-fired combined-cycle generation plant at the Salem and HCGS site.

Natural gas fueled 21.4 percent of electric generation in the US in 2008 (the most recent year for which data are available); this accounted for the second greatest share of electrical power after coal (EIA, 2010a). Like coal-fired power plants, natural gas-fired plants may be affected by perceived or actual actions to limit GHG emissions; they produce markedly lower GHG emissions per unit of electrical output than coal-fired plants. Natural gas-fired power plants are feasible and provide commercially available options for providing electrical generating capacity beyond Salem and HCGS's current license expiration dates.

Combined-cycle power plants differ significantly from coal-fired and existing nuclear power plants. They derive the majority of their electrical output from a gas-turbine cycle, and then generate additional power—without burning any additional fuel—through a second, steam-turbine cycle. The first, gas turbine stage (similar to a large jet engine) burns natural gas that turns a driveshaft that powers an electric generator. The exhaust gas from the gas turbine is still hot enough, however, to boil water into steam. Ducts carry the hot exhaust to a heat recovery steam generator, which produces steam to drive a steam turbine and produce additional electrical power. The combined-cycle approach is significantly more efficient than any one cycle on its own; thermal efficiency can exceed 60 percent. Since the natural gas-fired alternative derives much of its power from a gas turbine cycle, and because it wastes less heat than either the coal-fired alternative or the existing Salem and HCGS, it requires significantly less cooling.

In order to replace the 3,656 MW(e) that Salem and HCGS currently supply, the Staff selected a gas-fired alternative that uses nine GE STAG 107H combined-cycle generating units. While any number of commercially available combined-cycle units could be installed in a variety of combinations to replace the power currently produced by Salem and HCGS, the STAG 107H is a highly efficient model that would help minimize environmental impacts (GE, 2001). Other manufacturers, like Siemens, offer similarly high efficiency models. This gas-fired alternative produces a net 400 MW(e) per unit. Nine units would produce a total of 3,600 MW(e), or nearly the same output as the existing Salem and HCGS plants.

The combined-cycle alternative operates at a heat rate of 5,687 btu/kWh, or about 60 percent thermal efficiency (GE, 2001). Allowing for onsite power usage, including cooling towers and site lighting, the gross output of these units would be roughly 3,744 MW(e). As noted above, this gas-fired alternative would require much less cooling water than Salem and HCGS because it operates at a higher thermal efficiency and because it requires much less water for steam cycle condenser cooling. This alternative would likely make use of the site's existing natural draft cooling tower, but may require the construction of an additional tower.

In addition to the already existing natural draft cooling tower, other visible structures onsite would include the turbine buildings, two exhaust stacks, an electrical switchyard, and, possibly, equipment associated with a natural gas pipeline, like a compressor station. The GEIS estimates indicate that this 3,600 MW(e) plant would require 400 ac (165 ha), which would be feasible on the 1,480 ac (599 ha) PSEG site.

This 3600 MW(e) power plant would consume 161.65 billion cubic feet (ft^3; 4,578 million cubic meters [m^3]) of natural gas annually assuming an average heat content of 1,029 btu/ft^3 (EIA, 2009b). Natural gas would be extracted from the ground through wells, then treated to remove impurities (like hydrogen sulfide), and blended to meet pipeline gas standards, before being piped through the interstate pipeline system to the power plant site. This gas-fired alternative would produce relatively little waste, primarily in the form of spent catalysts used for emissions controls.

Environmental impacts from the gas-fired alternative would be greatest during construction. The closest natural gas pipeline that could serve as a source of natural gas for the plant is located in Logan Township, approximately 25 mi (40 km) from the Salem and HCGS facilities (PSEG, 2010). Site crews would clear vegetation from the site, prepare the site surface, and begin excavation before other crews begin actual construction on the plant and any associated infrastructure, including the 25-mi (40 km) pipeline spur to serve the plant and electricity transmission infrastructure connecting the plant to existing transmission lines. Constructing the gas-fired alternative on the Salem and HCGS site would allow the gas-fired alternative to make use of the existing electric transmission system.

8.1.2.1 Air Quality

Salem and HCGS are located in Salem County, New Jersey. The general air quality regulatory status of the Salem County region is as described in Section 8.1.1.1 for the coal-fired generation alternative. A new gas-fired generating plant would qualify as a new major-emitting industrial facility and would be subject to Prevention of Significant Deterioration of Air Quality Review under requirements of CAA, adopted by the NJDEP Bureau of Air Quality Permitting. The natural gas-fired plant would need to comply with the standards of performance for stationary gas turbines set forth in 40 CFR Part 60 Subpart GG. Regulations issued by NJDEP adopt the EPA's CAA rules (with modifications) to limit power plant emissions of SO_x, NO_x, particulate matter, and hazardous air pollutants. The new gas-fired generating plant would qualify as a major facility as defined in Section 7:27-22.1 of the New Jersey Administrative Code, and would be required to obtain a major source permit from NJDEP.

As previously discussed in Section 8.1.1.1, Section 169A of the CAA (42 U.S.C. 7401) establishes a national goal of preventing future and remedying existing impairment of visibility in mandatory Class I Federal areas when impairment results from man-made air pollution. If a gas-fired plant were located close to a mandatory Class I area, additional air pollution control requirements would be imposed. There is one mandatory Class I Federal area in the State of New Jersey, which is the Brigantine National Wildlife Refuge (40 CFR 81.420), located approximately 58 mi (93 km) southeast of the Salem and HCGS facilities. There are no Class I Federal areas in Delaware, and no other area located within 100 mi (161 km) of the facilities (40 CFR 81.400). New Jersey is also subject to the CAIR, which has outlined emissions reduction goals for both SO_2 and NO_x for the year 2015 (See Section 8.1.1.1). The Staff projects the following emissions for a gas-fired alternative based on data published by the EIA, the EPA, and on performance characteristics for this alternative and its emissions controls:

- Sulfur oxides (SO_x) – 53 tons (48 MT) per year
- Nitrogen oxides (NO_x) – 932 tons (846 MT) per year
- Carbon monoxide (CO) – 193 tons (175 MT) per year
- Total suspended particles (TSP) – 162 tons (147 MT) per year
- Particulate matter (PM) PM_{10} – 162 tons (147 MT) per year
- Carbon dioxide (CO_2) – 9,400,000 tons (8,500,000 MT) per year

Sulfur and Nitrogen Oxides

As stated above, the new natural gas-fired alternative would produce 53 tons (48 MT) per year of SO_x (assumed to be all SO_2) (EPA, 2000; INGAA, 2000) and 932 tons (846 MT) per year of NO_x based on the use of the dry low NO_x combustion technology and use of the selective catalytic reduction (SCR) in order to significantly reduce NO_x emissions (INGAA, 2000). The new plant would be subjected to the continuous monitoring requirements for SO_2, NO_x and CO_2 as specified in 40 CFR Part 75. A new natural gas-fired plant would have to comply with Title IV of the CAA reduction requirements for SO_2 and NO_x, which are the main precursors of acid rain and the major cause of reduced visibility. Title IV establishes maximum SO_2 and NO_x emission rate from the existing plants and a system of the SO_2 emission allowances that can be used, sold or saved for future use by new plants.

Particulates

Based on EPA emission factors (EPA, 2000), the new natural gas-fired alternative would produce 162 tons (147 MT) per year of TSP, all of which would be emitted as $PM_{10.}$

Carbon Monoxide

Based on EPA emission factors (EPA, 2000), the Staff estimates that the total CO emissions would be approximately 193 tons (175 MT) per year.

Hazardous Air Pollutants

The EPA issued in December 2000 regulatory findings (65 FR 79825) on emissions of hazardous air pollutants from electric utility steam-generating units, which identified that natural gas-fired plants emit hazardous air pollutants such as arsenic, formaldehyde and nickel and stated that

> . . . the impacts due to HAP emissions from natural gas-fired electric utility steam generating units were negligible based on the results of the study. The Administrator finds that regulation of HAP emissions from natural gas-fired electric utility steam generating units is not appropriate or necessary.

Carbon Dioxide

The new plant would be subjected to the continuous monitoring requirements for SO_2, NO_x and CO_2 specified in 40 CFR Part 75. The Staff computed that the natural gas-fired plant would emit approximately 9.4 million tons (8.5 million MT) per year of unregulated CO_2 emissions. In response to the Consolidated Appropriations Act of 2008, the EPA has proposed a rule that requires mandatory reporting of GHG emissions from large sources that would allow collection of accurate and comprehensive emissions data to inform future policy decisions (EPA, 2009b). The EPA proposes that suppliers of fossil fuels or industrial GHGs, manufacturers of vehicles and engines, and facilities that emit 25,000 MT or more per year of GHG emissions submit annual reports to the EPA. The gases covered by the proposed rule are CO_2, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulfur hexafluoride (SF_6), and other fluorinated gases including nitrogen trifluoride (NF_3) and hydrofluorinated ethers (HFE).

Construction Impacts

Activities associated with the construction of the new natural gas-fired plant at the Salem and HCGS site would cause some additional air effects as a result of equipment emissions and fugitive dust from operation of the earth-moving and material handling equipment. Workers' vehicles and motorized construction equipment would generate temporary exhaust emissions. The construction crews would employ dust-control practices in order to control and reduce fugitive dust, which would be temporary in nature. The Staff concludes that the impact of vehicle exhaust emissions and fugitive dust from operation of earth-moving and material handling equipment would be SMALL.

The overall air quality impacts from a new natural gas-fired plant located at the Salem and HCGS site would be SMALL to MODERATE, primarily due to air pollutant emissions from plant operation.

8.1.2.2 Groundwater Use and Quality

The use of groundwater for a natural gas-fired combined-cycle plant would likely be limited to supply wells for drinking water and possibly filtered service water for system cleaning purposes. Total usage would likely be much less than Salem and HCGS because many fewer workers would be onsite, and because the gas-fired alternative would have fewer auxiliary systems requiring service water.

No effects on groundwater quality would be apparent except during the construction phase due to temporary dewatering and run-off control measures. Because of the temporary nature of construction and the likelihood of reduced groundwater usage during operation, the impact of the natural gas-fired alternative would be SMALL.

8.1.2.3 Surface Water Use and Quality

The alternative would require a consumptive use of water from the Delaware River for cooling purposes. Because this consumptive loss would be from an estuary, the NRC concludes the impact of surface water use would be SMALL. A new natural gas-fired plant would be required to obtain an NPDES permit from the NJDEP for regulation of industrial wastewater, storm water, and other discharges. Assuming the plant operates within the limits of this permit, the impact from any cooling tower blowdown, site runoff, and other effluent discharges on surface water quality would be SMALL.

8.1.2.4 Aquatic and Terrestrial Ecology

Aquatic Ecology

Compared to the existing Salem and HCGS facilities, impacts on aquatic ecology from the onsite, gas-fired alternative would be substantially smaller because the combined-cycle plant would inject significantly less heat to the environment and require less water. Also, any new plants (including coal) would fall under EPA's Phase I rules for new plants and would have closed cycle cooling. Adverse effects (impingement and entrainment and thermal effects) would be substantially less than those of the existing Salem and HCGS facilities. The numbers of fish and other aquatic organisms affected by impingement, entrainment, and thermal impacts would be smaller than those associated with license renewal because water consumption and blowdown discharged to the Delaware Estuary would be substantially lower. Some temporary impacts on aquatic organisms may occur due to construction. Longer-term effects could result from effluents discharged to the river. However, NRC assumes that the appropriate agencies would monitor and regulate such activities. The number of organisms affected by impingement, entrainment, and thermal effects of this alternative would be substantially less than for license renewal, so NRC expects that the levels of impact for the natural gas alternative would be SMALL.

Terrestrial Ecology

Constructing the natural gas alternative would require approximately 128 ac (52 ha) of land according to PSEG estimates (PSEG, 2009a; PSEG, 2009b). Scaling from the GEIS estimate, approximately 400 ac (165 ha) would be required to replace the 3,600 MW(e) provided by Salem and HCGS. These land disturbances are the principal means by which this alternative would affect terrestrial ecology.

Onsite impacts to terrestrial ecology may occur if additional land requirements result in the encroachment into or filling of the adjacent tidal marsh. However, based on the anticipated land requirements, the encroachment should be minimal. In addition, if additional roads would need to be constructed through less disturbed areas, impacts could occur as these construction activities may fragment or destroy local ecological communities. Land disturbances could affect habitats of native wildlife; however, these impacts are not expected to be extensive. Gas extraction and collection would also affect terrestrial ecology in offsite gas fields, although much of this land is likely already disturbed by gas extraction, and the incremental effects of this alternative on gas field terrestrial ecology are difficult to gauge.

Construction of the nine natural-gas-fired units could entail some loss of native wildlife habitats; however, these impacts are not expected to be extensive. If new roads and a new cooling tower were required to be constructed through less disturbed areas, these activities could fragment or destroy local ecological communities, thereby increasing impacts. Operation of the cooling tower would cause some deposition of particulates on surrounding vegetation (including wetlands) and soils from cooling tower drift. Overall, impacts to terrestrial resources at the site would be minimal and limited mostly to the construction period. Construction of a 150-ft (46-m), wide 25-mi (40-km) long gas pipeline (to the nearest assumed tie-in) could lead to further disturbance to undeveloped areas. However, PSEG indicated that the pipeline would be routed along existing, previously disturbed rights-of-way and would expect to only temporarily impact terrestrial species. Because of the relatively small potential for undisturbed land to be affected, impacts from construction of the pipeline are expected to be minimal.

Based on this information, impacts to terrestrial resources from the onsite, gas-fired alternative would be SMALL.

8.1.2.5 Human Health

Like the coal-fired alternative discussed above, a gas-fired plant would emit criteria air pollutants, but in smaller quantities (except NO_x, which requires additional controls to reduce emissions). Human health effects of gas-fired generation are generally low, although in Table 8-2 of the GEIS (NRC, 1996), the Staff identified cancer and emphysema as potential health risks from gas-fired plants. NO_x emissions contribute to ozone formation, which in turn contributes to human health risks. Emission controls on this gas-fired alternative maintain NO_x emissions well below air quality standards established for the purposes of protecting human health, and emissions trading or offset requirements mean that overall NO_x in the region would not increase. Health risks to workers may also result from handling spent catalysts from NO_x emission control equipment that may contain heavy metals.

During construction activities there would be a risk to workers from typical industrial incidents and accidents. Accidental injuries are not uncommon in the construction industry, and accidents resulting in fatalities do occur. However, the occurrence of such events is mitigated by the use of proper industrial hygiene practices, worker safety requirements, and training. Occupational and public health impacts during construction are expected to be controlled by continued application of accepted industrial hygiene and occupational health and safety practices. Fewer workers would be on site for a shorter period of time to construct a gas-fired plant that other new power generation alternatives, and so exposure to occupational risks tends to be lower than other alternatives.

Overall, human health risks to occupational workers and to members of the public from gas-fired power plant emissions sited at the Salem and HCGS site would be less than the risks described for coal-fired alternative and therefore, would likely be SMALL.

8.1.2.6 Socioeconomics

Land Use

The analysis of land use impacts focuses on the amount of land area that would be affected by the construction and operation of a nine-unit natural gas-fired combined-cycle power plant at the Salem and HCGS site.

PSEG indicated that approximately 128 ac (52 ha) of land would be needed to support a natural gas-fired alternative to replace Salem and HCGS (PSEG 2009a; PSEG, 2009b). Scaling from the GEIS estimate, approximately 400 ac (165 ha) would be required to replace the 3,600 MW(e) provided by Salem and HCGS. This amount of onsite land use would include other plant structures and associated infrastructure. Onsite land use impacts from construction would be SMALL.

In addition to onsite land requirements, land would be required offsite for natural gas wells and collection stations. Scaling from GEIS estimates, approximately 12,960 ac (5,200 ha) would be required for wells, collection stations, and a 25-mi (40 km) pipeline spur to bring the gas to the plant. Most of this land requirement would occur on land where gas extraction already occurs. In addition, some natural gas could come from outside of the United States and be delivered as liquefied gas.

The elimination of uranium fuel for the Salem and HCGS facilities could partially offset offsite land requirements. Scaling from GEIS estimates, approximately 3,660 ac (1,480 ha) would not be needed for mining and processing uranium during the 40-year operating life of the plant. Based on this information and the need for additional land at Salem and HCGS, overall land use impacts from a gas-fired power plant would be SMALL to MODERATE.

Socioeconomics

Socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics and social conditions of a region. For example, the number of jobs created by the construction and operation of a new natural gas-fired power plant could affect regional employment, income, and expenditures. Two types of job creation would result: (1) construction-related jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact; and (2) operation-related jobs in support of power plant operations, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements for the construction and operation of the natural gas-fired power plant alternative were evaluated in order to measure their possible effect on current socioeconomic conditions.

While the GEIS estimates a peak construction workforce of 4,320, PSEG projected a maximum construction workforce of 2,920 (PSEG 2009a; PSEG, 2009b). During construction, the communities surrounding the power plant site would experience increased demand for rental housing and public services. The relative economic effect of construction workers on local economy and tax revenue would vary.

After construction, local communities could be temporarily affected by the loss of construction jobs and associated loss in demand for business services, and the rental housing market could experience increased vacancies and decreased prices. As noted in the GEIS, the socioeconomic impacts at a rural construction site could be larger than at an urban site, because the workforce would have to move to be closer to the construction site. Although the ER identifies the Salem and HCGS site as a primarily rural site (PSEG, 2009a; PSEG, 2009b), it is located near the Philadelphia and Wilmington metropolitan areas. Therefore, these effects would likely be lessened because workers are likely to commute to the site from these areas instead of relocating closer to the construction site. Because of the site's proximity to these larger population centers, the impact of construction on socioeconomic conditions would be SMALL.

PSEG estimated a power plant operations workforce of approximately 132 (PSEG, 2009a), (PSEG, 2009b). Scaling from GEIS estimates of an operational workforce of 150 employees for a 1,000-MW(e) gas-fired plant, 540 workers would be required to replace the 3600 MW(e) provided by Salem and HCGS. The PSEG estimate appears reasonable and is consistent with trends toward lowering labor costs by reducing the size of power plant operations workforces. This would result in a loss of approximately 1,070 to 1,480 relatively high-paying jobs (based on a current Salem and HCGS workforce of 1,614), with a corresponding reduction in purchasing activity and tax contributions to the regional economy. The impact of the job loss, however, may not be noticeable given the amount of time required for the construction of a new power plant and the decommissioning of the existing facilities and the relatively large region from which Salem and HCGS personnel are currently drawn. The size of property tax payments under the gas-fired alternative may increase if additional land is required at Salem and HCGS to support this alternative. Operational impacts would therefore range from SMALL to MODERATE.

Transportation

Transportation impacts associated with construction and operation of a nine-unit gas-fired power plant would consist of commuting workers and truck deliveries of construction materials to the Salem and HCGS site. During periods of peak construction activity, between 2,900 and 4,300 workers could be commuting daily to the site, as well as the current 1,614 workers already at Salem and HCGS. In addition to commuting workers, trucks would be transporting construction materials and equipment to the worksite thereby increasing the amount of traffic on local roads. The increase in vehicular traffic would peak during shift changes resulting in temporary level of service impacts and delays at intersections. Some large plant components would likely be delivered by barge. Pipeline construction and modification to existing natural gas pipeline systems could also have an impact on local traffic. Traffic-related transportation impacts during construction would likely be MODERATE.

During plant operations, traffic-related transportation impacts would be greatly reduced. According to PSEG, approximately 132 workers would be needed to operate the gas-fired power plant. Fuel for the plant would be transported by pipeline. The transportation infrastructure would experience little to no increased traffic from plant operations. Overall, the gas-fired alternative transportation impacts would be SMALL during plant operations.

Aesthetics

The aesthetics impact analysis focuses on the degree of contrast between the natural gas-fired alternative and the surrounding landscape and the visibility of the gas-fired plant.

The nine gas-fired units would be approximately 100 foot (30 m) tall, with an exhaust stack up to 200 feet (61 m). The facility would be visible offsite during daylight hours. However, the gas-fired power plant would be shorter than the existing HCGS cooling tower, which stands at 514 feet (157 m). This alternative would likely make use of the site's existing natural draft cooling tower. The condensate plume that would be generated would be no more noticeable than the existing plume from HCGS. Noise from plant operations, as well as lighting on plant structures, would be detectable offsite. Pipelines delivering natural gas fuel could be audible offsite near gas compressors.

In general, aesthetic changes would be limited to the immediate vicinity of Salem and HCGS and would be SMALL.

Historic and Archaeological Resources

Cultural resources are the indications of human occupation and use of the landscape as defined and protected by a series of Federal laws, regulations, and guidelines. Prehistoric resources are physical remains of human activities that predate written records; they generally consist of artifacts that may alone or collectively yield information about the past. Historic resources consist of physical remains that postdate the emergence of written records; in the United States, they are architectural structures or districts, archaeological objects, and archaeological features dating from 1492 and later. Ordinarily, sites less than 50 years old are not considered historic, but exceptions can be made for such properties if they are of particular importance, such as structures associated with the development of nuclear power (e.g., Shippingport Atomic Power Station) or Cold War themes. American Indian resources are sites, areas, and materials important to American Indians for religious or heritage reasons. Such resources may include geographic features, plants, animals, cemeteries, battlefields, trails, and environmental features. The cultural resource analysis encompassed the power plant site and adjacent areas that could potentially be disturbed by the construction and operation of alternative power plants.

The potential for historic and archaeological resources can vary greatly depending on the location of the proposed site. To consider a project's effects on historic and archaeological resources, any affected areas would need to be surveyed to identify and record historic and archaeological resources, identify cultural resources (e.g., traditional cultural properties), and develop possible mitigation measures to address any adverse effects from ground disturbing activities.

Before construction at the Salem and HCGS site, studies would likely be needed to identify, evaluate, and address mitigation of potential impacts of new plant construction on cultural resources. Studies would be needed for all areas of potential disturbance at the proposed plant site and along associated corridors where construction would occur (e.g., roads, transmission corridors, rail lines, or other ROWs). Areas with the greatest sensitivity should be avoided.

As noted in Section 4.9.6, there is little potential for historic and archaeological resources to be present on most of the Salem and HCGS site; therefore, the impact for a natural gas-fired alternative at the Salem and HCGS site would likely be SMALL.

Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from the construction and operation of a new natural gas-fired combined-cycle power plant. Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant and exceed the risk or exposure rate for the general population or for another appropriate comparison group. Disproportionately high environmental effects refer to impacts or risk of impact on the natural or physical environment in a minority or low-income community that are significant and appreciably exceeds the environmental impact on the larger community. Such effects may include biological, cultural, economic, or social impacts. Some of these potential effects have been identified in resource areas discussed in this SEIS. For example, increased demand for rental housing during power plant construction could disproportionately affect low-income populations. Minority and low-income populations are subsets of the general public residing around Salem and HCGS, and all are exposed to the same hazards generated from constructing and operating a new natural gas-fired combined-cycle power plant. For socioeconomic data regarding the analysis of environmental justice issues, the reader is referred to Section 4.9.7, Environmental Justice.

Potential impacts to minority and low-income populations from the construction and operation of a new natural gas-fired combined-cycle power plant at Salem and HCGS would mostly consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts from construction would be short-term and primarily limited to onsite activities. Minority and low-income populations residing along site access roads would also be affected by increased commuter vehicle traffic during shift changes and truck traffic. However, these effects would be temporary during certain hours of the day and not likely to be high and adverse. Increased demand for rental housing in the vicinity of Salem and HCGS during construction could affect low-income populations. Given the close proximity to the Philadelphia and Wilmington metropolitan areas, most construction workers would likely commute to the site, thereby reducing the potential demand for rental housing.

Based on this information and the analysis of human health and environmental impacts presented in this SEIS, the construction and operation of a new natural gas-fired combined-cycle power plant would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations residing in the vicinity of Salem and HCGS.

8.1.2.7 Waste Management

During the construction phase of this alternative, land clearing and other construction activities would generate waste that can be recycled, disposed onsite or shipped to an offsite waste disposal facility. Because the alternative would be constructed on the previously disturbed Salem and HCGS site, the amounts of wastes produced during land clearing would be reduced.

During the operational stage, spent SCR catalysts used to control NOx emissions from the natural gas-fired plants would make up the majority of the waste generated by this alternative. This waste would be disposed of according to applicable Federal and state regulations.

The Staff concluded in the GEIS (NRC, 1996), that a natural gas-fired plant would generate minimal waste and the waste impacts would be SMALL for a natural gas-fired alternative located at the Salem and HCGS site.

Table 8-2. Summary of the Direct and Indirect Environmental Impacts of the Natural Gas Combined-Cycle Generation Alternative Compared to Continued Operation of Salem and HCGS

	Natural Gas Combined-Cycle Generation	Continued Salem and HCGS Operation
Air Quality	SMALL to MODERATE	SMALL
Groundwater	SMALL	SMALL
Surface Water	SMALL	SMALL
Aquatic and Terrestrial Resources	SMALL	SMALL
Human Health	SMALL	SMALL
Socioeconomics	SMALL to MODERATE	SMALL to LARGE
Waste Management	SMALL	SMALL

8.1.3 Combination Alternative

Even though individual alternatives to license renewal might not be sufficient on their own to replace the 3,656 MW(e) total capacity of Salem and HCGS because of the lack of resource availability, technical maturity, or regulatory barriers, it is conceivable that a combination of alternatives might be sufficient.

There are many possible combinations of alternatives that could be considered to replace the power generated by Salem and HCGS. In the GEIS, NRC staff indicated that consideration of alternatives would be limited to single, discrete generating options, given the virtually unlimited number of combinations available. In this section, the NRC staff examines a possible combination of alternatives. Under this alternative, both Salem and HCGS would be retired and a combination of other alternatives would be considered, as follows:

- Denying the re-license application for Salem and HCGS
- Constructing five 400 MW(e) natural gas-fired combined-cycle plants at Salem
- Obtaining 878 MW(e) from renewable energy sources (primarily offshore wind)
- Implementing 731 MW(e) of efficiency and conservation programs, from among the 3,300 MW of energy efficiency and conservation goals identified by the New Jersey Energy Master Plan (State of New Jersey, 2008) and the Northeast Energy Efficiency Partnerships, Inc. (NEEP, 2009).

The potential contributions of efficiency and conservation programs and renewable energy are based on achievement of the goals of the New Jersey Energy Master Plan (State of New Jersey, 2008). Goal #1 of this Plan is to reduce energy consumption by 20 percent through efficiency and conservation programs. Based on the current generating capacity of 3656 MW(e) of Salem and HCGS, achievement of the 20 percent objective would contribute 731 MW(e) equivalent to this combination alternative. Goal #3 of the New Jersey Energy Master Plan is to increase the current Renewable Portfolio Standard (RPS) to 30 percent. Based on the original generating capacity of 3656 MW(e), with demand reduced by 20 percent to 2925 MW(e) through achievement of Goal #1, a 30 percent renewable energy contribution to this portfolio would comprise 878 MW(e). The remainder of the capacity, or approximately 2000 MW(e), would be generated by the implementation of natural gas generating units.

The following sections analyze the impacts of the alternative outlined above. In some cases, detailed impact analyses for similar actions are described in previous sections of this Chapter. When this occurs, the impacts of the combined alternatives are discussed in a general manner with reference to other sections of this draft SEIS.

Each component of the combination alternative produces different environmental impacts, though several of the options would have impacts similar to—but smaller than—alternatives already addressed in this SEIS. Constructing a total of 2,000 MW(e) of gas-fired capacity on the Salem and HCGS sites would create roughly the same impacts as the on-site combined-cycle natural gas alternative described in Section 8.1.2. This alternative would make use of the existing transmission lines at the sites, but would require construction of a 25-mi (40 km) long natural gas pipeline, the same as would be required under the combined-cycle natural gas alternative evaluated in Section 8.1.2. The amount of air emissions, land use, and water consumption would be reduced due to the smaller number of natural-gas fired units.

The Staff has not yet addressed the impacts of wind power or conservation in this SEIS. A wind installation capable of yielding 878 MW(e) of capacity would likely entail placing wind turbines off of the New Jersey coast. A wind installation capable of delivering 878 MW(e) on average would require approximately 245 turbines with a capacity of 3.6 MW each (MMS, 2010). Because wind power installations do not provide full power all the time, the total installed capacity exceeds the capacity stated here.

Impacts from conservation measures are likely to be negligible, as indicated in the GEIS (NRC, 1996). The primary concerns identified in the GEIS related to indoor air quality and waste disposal. In the GEIS, air quality appeared to become an issue when weatherization initiatives exacerbated existing problems, and were expected not to present significant effects. Waste disposal concerns related to energy-saving measures like fluorescent lighting could be addressed by recycling programs. The overall impact from conservation is considered to be SMALL in all resource areas, though measures that provide weatherization assistance to low-income populations may have positive effects on environmental justice conditions.

8.1.3.1 Air Quality

The combination alternative will have some impact on air quality as a result of emissions from the onsite gas turbines. Because of the size of the units, an individual unit's impacts would be SMALL. Section 8.1.2.1 of this draft SEIS describes the impacts on air quality from the construction and operation of natural gas units as SMALL to MODERATE. The construction and operation of the wind farm would have only minor impacts on air quality.

Overall, the Staff considers that the air quality impacts from the combination alternative would be SMALL.

8.1.3.2 Groundwater Use and Quality

The use of groundwater for a natural gas-fired combined-cycle plant would likely be limited to supply wells for drinking water and possibly filtered service water for system cleaning purposes. Total usage would likely be much less than Salem and HCGS because many fewer workers would be onsite, and because the gas-fired alternative would have fewer auxiliary systems requiring service water.

No effects on groundwater quality would be apparent except during the construction phase due to temporary dewatering and run-off control measures. Because of the temporary nature of construction and the likelihood of reduced groundwater usage during operation, the impact of the natural gas-fired alternative would be SMALL.

8.1.3.3 Surface Water Use and Quality

The primary water use and quality issues from this alternative would be from the gas-fired units at Salem and HCGS. While construction of a wind farm, particularly if located offshore, would result in some impacts to surface water, these impacts are likely to be short lived. An offshore wind farm is unlikely to be located immediately adjacent to any water users. Construction activities may increase turbidity; however, construction of an onshore wind farm could create additional erosion, as would construction of a gas-fired unit on the Salem and HCGS sites. In general, site management practices keep these effects to a small level.

During operations, only the gas-fired plants would require water for cooling. The natural gas would likely use closed-cycle cooling, which would limit the effects on water resources. As the Staff indicated for the coal-fired and gas-fired alternatives, the gas-fired portion of this alternative is likely to rely on surface water for cooling (or, as is the case in some locations, treated sewage effluent).

The Staff considers impacts on water use and quality to be SMALL for the combination alternative. The onsite impacts at the Salem and HCGS facility would be expected to be similar to the impacts described in Sections 8.1.2.2 and 8.1.2.3 of this draft SEIS.

8.1.3.4 Aquatic and Terrestrial Ecology

Impacts on aquatic and terrestrial ecology from the gas-fired power plant component of the combination alternative, which includes seven gas-fired units, would be similar to those described for the gas-fired alternative in Section 8.1.2.4. Therefore, ecological impacts would similarly be SMALL.

Aquatic Ecology

The wind farm component of this alternative, if located offshore, could have temporary impacts on aquatic organisms due to construction activities, which would likely increase turbidity in the area of construction. The Staff assumes that the appropriate agencies would monitor and regulate such activities. Overall, the impacts to aquatic resources would be SMALL to MODERATE.

Based on data in the GEIS, an onshore wind farm component of the combination alternative producing 878 MW(e) of electricity would require approximately 132,000 ac (53,400 ha) spread over several offsite locations, with less than 10 percent of that land area in actual use for turbines and associated infrastructure. The remainder of the land, if located onshore, could remain in use for activities such as agriculture. Additional land would likely be needed for construction of support infrastructure to connect to existing transmission lines. During construction, there would be an increased potential for erosion and adverse effects on adjacent water bodies, though stormwater management practices are expected to minimize such impacts.

Terrestrial Ecology

Impacts to terrestrial ecology from construction of the wind farm portion of the combination alternative and any needed transmission lines could include loss of terrestrial habitat, an increase in habitat fragmentation and corresponding increase in edge habitat. The GEIS notes that habitat fragmentation may lead to declines of migrant bird populations. Once operational, birds would be likely to collide with the turbines, and migration routes would need to be considered during site selection. Based on this information, impacts to terrestrial resources would be MODERATE.

8.1.3.5 Human Health

The primary health concerns under this option would be occupational health and safety risks during the construction of the new gas turbine and the wind farm. As described previously, if the risks are appropriately managed, the human health impacts from construction and operation of a gas-fired power plant are SMALL. Human health impacts from a wind farm would also be associated primarily with the construction of the facility and would also be minimal. Continued operation of HCGS with the existing closed-cycle cooling system would not change the human health impacts designation of SMALL as discussed in Chapter 4.

Therefore, the Staff concludes that the overall human health impact from the combination alternative would be SMALL.

8.1.3.6 Socioeconomics

Land Use

Impacts from this alternative would include the types of impacts discussed for land use in Section 8.1.2.6 of this draft SEIS. Section 8.1.2.6 states that the land use impacts from the construction of nine gas-fired units at the Salem site would be SMALL to MODERATE. The combined alternative includes seven gas-fired units, which would fit on the existing site without purchasing additional land. In addition to onsite land requirements, land would be required offsite for natural gas wells and collection stations. The land use impacts of the gas-fired component of the combination alternative would be similar to the impacts described in Sections 8.1.2.6, SMALL to MODERATE.

Impacts from the wind power component of this alternative would depend largely on whether the wind facility is located onshore or offshore. Onshore wind facilities would require more land than offshore facilities, simply because all towers and supporting infrastructure would be located on land. According to the GEIS, onshore installations could require approximately 60,000 ac (24,400 ha), though turbines and infrastructure would actually occupy only a small percentage (less than 10 percent) of that land area. The wind farm would most likely be located on agricultural cropland, which would be largely unaffected by the wind turbines.

Although the wind farm would require a large amount of land, only a small component of that land would be in actual use. Also, the elimination of uranium fuel for Salem and HCGS could partially offset offsite land requirements.

Land use impacts of an energy efficiency and conservation program would be SMALL. Rapid replacement and disposal of old energy inefficient appliances and other equipment would generate waste material and could potentially increase the size of landfills. However, given time for program development and implementation, the cost of replacements, and the average life of appliances and other equipment, the replacement process would probably be gradual. Older energy inefficient appliances and equipment would likely be replaced by more efficient appliances and equipment as they fail (especially frequently replaced items, like light bulbs). In addition, many items (like home appliances or industrial equipment) have substantial recycling value and would likely not be disposed of in landfills. Based on this information and the need for additional land, overall, land use impacts from the combination alternative could range from SMALL to MODERATE.

Socioeconomics

As previously discussed, socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics and social conditions of a region. For example, the number of jobs created by the construction and operation of a natural gas-fired power plant at Salem and HCGS and wind farm could affect regional employment, income, and expenditures. Two types of jobs would be created: (1) construction-related jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact; and (2) operation-related jobs in support of power generating operations, which have the greater potential for permanent, long-term socioeconomic impacts. The Staff conducted evaluations of construction and operations workforce requirements in order to measure their possible effect on current socioeconomic conditions.

Impacts from this alternative would include the types of impacts discussed for socioeconomics in Section 8.1.2.6 of this draft SEIS. Section 8.1.2.6 states that the socioeconomics impacts from the construction and operation of nine gas-fired units at the Salem site would be SMALL to MODERATE. The combined alternative includes seven gas-fired units. The size of the construction workforce and number of operational workers would be similar. Accordingly, the socioeconomic impacts from the gas-fired component of the combination alternative would be SMALL to MODERATE.

An estimated additional 300 construction workers would be required for the wind farm. These workers could cause a short-term increase in demand for services and temporary (rental) housing in the region around the construction site(s).

After construction, some local communities may be temporarily affected by the loss of the construction jobs and associated loss in demand for business services. The rental housing market could also experience increased vacancies and decreased prices. However, these effects would likely be spread over a larger area, as the wind farms may be constructed in more than one location. The combined effects of these two construction activities would range from SMALL to MODERATE.

Additional estimated operations workforce requirements for this combination alternative would include 50 operations workers for the wind farm. Given the small number of operations workers at these facilities, socioeconomic impacts associated with operation of the natural gas-fired power plant at Salem and HCGS and the wind farm would be SMALL. Socioeconomic effects of an energy efficiency and conservation program would also be SMALL. As noted in the GEIS, the program would likely employ some additional workers.

Transportation

Construction and operation of a natural gas-fired power plant and a wind farm would increase the number of vehicles on roads in the vicinity of these facilities. During construction, cars and trucks would deliver workers, materials, and equipment to the work sites. The increase in vehicular traffic would peak during shift changes resulting in temporary level of service impacts and delays at intersections. Transporting components of wind turbines could have a noticeable impact, but is likely to be spread over a large area. Pipeline construction and modification to existing natural gas pipeline systems could also have an impact on local traffic. Traffic-related transportation impacts during construction could range from SMALL to MODERATE depending on the location of the wind farm site, current road capacities and average daily traffic volumes.

During plant operations, transportation impacts would lessen. Given the small numbers of operations workers at these facilities, levels of service traffic impacts on local roads from operation of the gas-fired power plant at the Salem and HCGS site as well as the wind farm would be SMALL. Transportation impacts at the wind farm site or sites would also depend on current road capacities and average daily traffic volumes, but are likely to be SMALL given the low number of workers employed by that component of the alternative.

Aesthetics

Aesthetic impact analysis focuses on the degree of contrast between the power plant and the surrounding landscape and the visibility of the power plant. In general, aesthetic changes would be limited to the immediate vicinity of Salem and HCGS and the wind farm facilities.

Aesthetic impacts from the gas-fired power plant component of the combination alternative would be essentially the same as those described for the gas-fired alternative in Section 8.1.2.6. Noise during power plant operations would be limited to industrial processes and communications. In addition to the power plant structures, construction of natural gas pipelines would have a short-term impact. Noise from the pipelines could be audible offsite near compressors. In general, aesthetic changes would be limited to the immediate vicinity of Salem and HCGS and would be SMALL.

The wind farm would have the greatest visual impact. Several hundred wind turbines over 300 feet (100 m) in height and spread over 60,000 acres (24,400 ha) would dominate the view and would likely become the major focus of attention. Depending on its location, the aesthetic impacts from the construction and operation of the wind farm would be MODERATE to LARGE.

Historic and Archaeological Resources

Cultural resources are the indications of human occupation and use of the landscape as defined and protected by a series of Federal laws, regulations, and guidelines. Prehistoric resources are physical remains of human activities that predate written records; they generally consist of artifacts that may alone or collectively yield information about the past. Historic resources consist of physical remains that postdate the emergence of written records; in the United States, they are architectural structures or districts, archaeological objects, and archaeological features dating from 1492 and later. Ordinarily, sites less than 50 years old are not considered historic, but exceptions can be made for such properties if they are of particular importance, such as structures associated with the development of nuclear power (e.g., Shippingport Atomic Power Station) or Cold War themes. American Indian resources are sites, areas, and materials important to American Indians for religious or heritage reasons. Such resources may include geographic features, plants, animals, cemeteries, battlefields, trails, and environmental features. The cultural resource analysis encompassed the power plant site and adjacent areas that could potentially be disturbed by the construction and operation of alternative power plants.

The potential for historic and archaeological resources can vary greatly depending on the location of the proposed site. To consider a project's effects on historic and archaeological resources, any affected areas would need to be surveyed to identify and record historic and archaeological resources, identify cultural resources (e.g., traditional cultural properties), and develop possible mitigation measures to address any adverse effects from ground disturbing activities.

Onsite impacts to historical and cultural resources from the construction of a gas turbine plant are expected to be SMALL. Depending on the resource richness of the alternative site ultimately chosen for the wind power alternative, the impacts could range between SMALL to MODERATE. Therefore, the overall impacts on historic and archaeological resources from the combination alternative could range from SMALL to MODERATE.

Impacts to historic and archaeological resources from implementing the energy efficiency and conservation program would be SMALL and would not likely affect land use or historical or cultural resources elsewhere in the State.

Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from the construction and operation of a new natural gas-fired power plant at Salem and HCGS, wind farm, and energy efficiency and conservation programs. Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant and exceeds the risk or exposure rate for the general population or for another appropriate comparison group. Disproportionately high environmental effects refer to impacts or risk of impact on the natural or physical environment in a minority or low-income community that are significant and appreciably exceed the environmental impact on the larger community. Such effects may include biological, cultural, economic, or social impacts. Some of these potential effects have been identified in resource areas discussed in this SEIS. For example, increased demand for rental housing during power plant construction could disproportionately affect low-income populations. Minority and low-income populations are subsets of the general public residing around a power plant, and all are exposed to the same hazards generated from constructing and operating a natural gas-fired combined-cycle power plant and wind farm.

Low-income families could benefit from weatherization and insulation programs. This effect would be greater than the effect for the general population because (according to the Office of Management and Budget [OMB]) low-income households experience home energy burdens more than four times larger than the average household (OMB, 2007). Weatherization programs could target low-income residents as a cost-effective energy efficiency option since low-income populations tend to spend a larger proportion of their incomes paying utility bills (OMB, 2007). Overall impacts to minority and low-income populations from energy efficiency programs would be nominal, depending on program design and enrollment.

Potential impacts to minority and low-income populations from the construction and operation of a new natural gas-fired combined-cycle power plant at Salem and HCGS and wind farm would mostly consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts from construction would be short-term and primarily limited to onsite activities. Minority and low-income populations residing along site access roads would also be affected by increased commuter vehicle traffic during shift changes and truck traffic. However, these effects would be temporary during certain hours of the day and not likely to be high and adverse. Increased demand for rental housing during construction in the vicinity of Salem and HCGS and the wind farm could affect low-income populations. Given the close proximity to the Philadelphia and Wilmington metropolitan areas, most construction workers would likely commute to the site, thereby reducing the potential demand for rental housing.

Based on this information and the analysis of human health and environmental impacts presented in this SEIS, the construction and operation of a natural gas-fired power plant and the wind farm (depending on its location) would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations.

8.1.3.7 Waste Management

The primary source of waste would be associated with the construction of the new gas-fired combined-cycle plant and the wind farm. During the construction phase of this alternative, land clearing and other construction activities would generate waste that can be recycled, disposed onsite, or shipped to an offsite waste disposal facility. Because the gas-fired combined-cycle plant would be constructed on the previously disturbed Salem site, the amounts of waste produced during land clearing would be reduced. Waste impacts could be substantial but likely not noticeably alter or destabilize the resource during construction of the wind farms, depending on how the various sites handle wastes.

The waste contribution from the remaining HCGS unit would be roughly one-third of the waste generated by the current facility (Salem and HCGS) described in Sections 2.1.2 and 2.1.3. If the remaining HCGS unit were to continue operation with the existing closed-cycle cooling system, waste impacts would be minor.

Therefore, the Staff concludes that the overall impact from waste from the combination alternative would be SMALL.

Table 8-3. Summary of the Direct and Indirect Environmental Impacts of the Combination Alternative Compared to Continued Operation of Salem and HCGS

	Combination	Continued Salem and HCGS Operation
Air Quality	SMALL	SMALL
Groundwater	SMALL	SMALL
Surface Water	SMALL	SMALL
Aquatic and Terrestrial Resources	SMALL to MODERATE	SMALL
Human Health	SMALL	SMALL
Socioeconomics	SMALL to LARGE	SMALL to LARGE
Waste Management	SMALL	SMALL

8.2 Alternatives Considered But Dismissed

In the sections below, the Staff presents other alternatives it initially considered for analysis as alternatives to license renewal of Salem and HCGS, but later dismissed due to technical, resource availability, or commercial limitations that currently exist and that the Staff believes are likely to continue to exist when the existing Salem and HCGS licenses expire. Under each of the following technology headings, the Staff indicates why it dismissed each alternative from further consideration.

8.2.1 Offsite Coal- and Natural Gas-Fired

While it is possible that coal- and natural gas-fired alternatives like those considered in 8.1.1 and 8.1.2, respectively, could be constructed at sites other than Salem and HCGS, the Staff determined that they would likely result in greater impacts than alternatives constructed at the Salem and HCGS site. Greater impacts would occur from construction of support infrastructure, like transmission lines, and roads that are already present on the Salem and HCGS site. Further, the community around Salem and HCGS is already familiar with the appearance of a power facility and it is an established part of the region's aesthetic character. Workers skilled in power plant operations would also be available in this area. The availability of these factors are only likely to be available on other recently-industrial sites. In cases where recently-industrial sites exist, other remediation may also be necessary in order to ready the site for redevelopment. In short, an existing power plant site would present the best location for a new power facility.

8.2.2 New Nuclear

In its ER, PSEG indicated that it is unlikely that a nuclear alternative could be sited, constructed and operational by the time the HCGS operating license expires in 2026 (PSEG, 2009b), nor could this be accomplished in a timeframe necessary to replace the generating output of Salem Unit 1, which has a license expiration date of 2016 (PSEG, 2009a). On May 25, 2010, PSEG submitted an application for an early site permit for two reactor units. Given the relatively short time remaining on the current Salem and HCGS licenses, the Staff has not evaluated new nuclear generation as an alternative to license renewal.

8.2.3 Energy Conservation/Energy Efficiency

Though often used interchangeably, energy conservation and energy efficiency are different concepts. Energy efficiency typically means deriving a similar level of services by using less energy, while energy conservation simply indicates a reduction in energy consumption. Both fall into a larger category known as demand-side management (DSM). DSM measures—unlike the energy supply alternatives discussed in previous sections—address energy end uses. DSM can include measures that shift energy consumption to different times of the day to reduce peak loads, measures that can interrupt certain large customers during periods of high demand, measures that interrupt certain appliances during high demand periods, and measures like replacing older, less efficient appliances, lighting, or control systems. DSM also includes measures that utilities use to boost sales, such as encouraging customers to switch from gas to electricity for water heating.

Unlike other alternatives to license renewal, the GEIS notes that conservation is not a discrete power generating source; it represents an option that states and utilities may use to reduce their need for power generation capability (NRC, 1996).

In October 2008, the State of New Jersey published their Energy Master Plan (New Jersey, 2008), which established goals and evaluated potential options for meeting the projected increase in electricity demand in the state through 2020. As part of this Master Plan, actions were identified to maximize energy conservation and energy efficiency, including: transitioning the state's current energy efficiency programs to be implemented by the electric and gas utilities, modifying the statewide building code for new buildings to make new buildings as least 30 percent more energy efficient, increasing energy efficiency standards for new appliances and other equipment, and developing education and outreach programs for the public. An additional goal is to reduce peak electricity demand, primarily by expanding incentives developing technologies to increase participation in regional demand response programs. A separate goal established in the report (not related to energy conservation) included successful accomplishment of the state's Renewable Energy Portfolio Standard by 2020.

The report concluded that the combination of all of these efforts (energy conservation, efficiency, and renewable energy sources) would still not result in meeting the increased demand for electricity in the state, and that additional development of traditional electricity sources would still be required. Therefore, these measures would not be able to replace the output of the Salem and HCGS facilities. Because of this, the Staff has not evaluated energy conservation/efficiency as a discrete alternative to license renewal. It has, however, been considered as a component of the combination alternative.

8.2.4 Purchased Power

In the Salem and HCGS ERs, PSEG indicated that purchased electrical power is a potentially viable option for replacing the generating capacity of the Salem and HCGS facilities. PSEG anticipated that this power could be purchased from other generation sources within the PJM region, but that the source would likely be from new capacity generated using technologies that are evaluated in the GEIS. The technologies that would most likely be used to generate the purchased power would be coal and natural gas, and therefore the impacts associated with the power purchase would be similar to those evaluated in Sections 8.1.1 and 8.1.2. In addition, purchased power would likely require the addition of transmission capacity, which would result in additional land use impacts. Because purchased electrical power would likely be provided by new generation sources evaluated elsewhere in this section, and would also require new transmission capacity, the Staff has not evaluated purchased power as a separate alternative to license renewal.

8.2.5 Solar Power

Solar technologies use the sun's energy to produce electricity. Currently, the Salem and HCGS area receives approximately 4.5 to 5.5 kWh per square meter per day, for solar collectors oriented at an angle equal to the installation's latitude (NREL, 2010). Since flat-plate photovoltaics tend to be roughly 25 percent efficient, a solar-powered alternative would require more than 140,000 ac (57,000 ha) of collectors to provide an amount of electricity equivalent to that generated by Salem and HCGS. Space between parcels and associated infrastructure increase this land requirement. This amount of land, while large, is consistent with the land required for coal and natural gas fuel cycles. In the GEIS, the Staff noted that, by its nature, solar power is intermittent (i.e., it does not work at night and cannot serve baseload when the sun is not shining), and the efficiency of collectors varies greatly with weather conditions. A solar-powered alternative would require energy storage or backup power supply to provide electric power at night. Given the challenges in meeting baseload requirements, the Staff did not evaluate solar power as an alternative to license renewal of Salem and HCGS.

8.2.6 Wood-Fired

The National Renewable Energy Laboratory estimates the amount of biomass fuel resources, including forest, mill, agricultural, and urban residues, available within New Jersey, Delaware, and Pennsylvania to be approximately 5.6 million dry tons per year (5.1 MT; Milbrandt, 2005). Based on an estimate of 9.961 million Btu per dry ton and a thermal conversion efficiency of 25%, conversion of this entire resource would generate the equivalent of less than 500 MW(e). Of the available biomass in the three states, the vast majority (80 percent) is in Pennsylvania, and assumed to be located primarily in the western portion of the state. Therefore, the volume that would be available for fueling a plant in the local area would be much less, and is not likely to be sufficient to substitute for the capacity provided by Salem and HCGS. As a result, the Staff has not considered a wood-fired alternative to Salem and HCGS license renewal.

8.2.7 Wind (Onshore/Offshore)

The American Wind Energy Association indicates that New Jersey currently ranks 33rd among the states in installed wind power capacity (7.5 MW), and 29th among the state in potential capacity. No projects are currently under construction (AWEA, 2010). No wind capacity is installed in Delaware. Although Pennsylvania ranks 15th among the states in installed capacity, with a total of 748 MW, most of this installed capacity is located in the western portion of the state (AWEA, 2010). The Report of the New Jersey Governor's Blue Ribbon Panel on Development of Wind Turbine Facilities in Coastal Waters

(State of New Jersey, 2006) concluded that onshore wind speeds in New Jersey are not viable for commercial wind power development, and that the vast majority of the state's wind generation capacity was offshore. The report also concluded that development of the offshore resources is not commercially viable without significant state and/or federal subsidies. Also, preliminary information evaluated in the report indicated that the timing of peak offshore wind speeds did not coincide with the times of peak energy demand, and that offshore wind alone could not significantly reduce reliance on fossil fuel and domestic nuclear capacity (State of New Jersey, 2006). Finally, the results of a study of potential impacts of large-scale wind turbine siting by NJDEP identified large areas along the New Jersey Coast that would likely be considered to be off limits to large scale wind development due to documented bird concentrations, nesting for resident threatened and endangered bird species, and stopover locations for migratory birds (NJDEP, 2009b).

Given wind power's intermittency, the lack of easily implementable onshore resources in New Jersey, and restrictions on placement of turbines in areas that would otherwise have high resource potential, the Staff will not consider wind power as a stand-alone alternative to license renewal. However, given the potential for development of offshore resources, the Staff will consider wind power as a portion of a combination alternative.

8.2.8 Hydroelectric Power

According to researchers at Idaho National Energy and Environmental Laboratory [INEEL], New Jersey has an estimated 11 MW of technically available, undeveloped hydroelectric resources at 12 sites throughout the State (INEEL, 1996). Given that the available hydroelectric potential in the State of New Jersey constitutes only a small fraction of generating capacity of Salem and HCGS, the Staff did not evaluate hydropower as an alternative to license renewal.

8.2.9 Wave and Ocean Energy

Wave and ocean energy has generated considerable interest in recent years. Ocean waves, currents, and tides are often predictable and reliable. Ocean currents flow consistently, while tides can be predicted months and years in advance with well-known behavior in most coastal areas. Most of these technologies are in relatively early stages of development, and while some results have been promising, they are not likely to be able to replace the capacity of Salem and HCGS by the time their licenses expire. Therefore, the NRC did not consider wave and ocean energy as an alternative to Salem and HCGS license renewal.

8.2.10 Geothermal Power

Geothermal energy has an average capacity factor of 90 percent and can be used for baseload power where available. However, geothermal electric generation is limited by the geographical availability of geothermal resources (NRC, 1996). Although New Jersey has some geothermal potential in a heating capacity, it does not have geothermal electricity potential for electricity generation (GHC, 2008). The Staff concluded that geothermal energy is not a reasonable alternative to license renewal at Salem and HCGS.

8.2.11 Municipal Solid Waste

Municipal solid waste combustors use three types of technologies—mass burn, modular, and refuse-derived fuel. Mass burning is currently the method used most frequently in the United States and involves no (or little) sorting, shredding, or separation. Consequently, toxic or hazardous components present in the waste stream are combusted, and toxic constituents are exhausted to the air or become part of the resulting solid wastes. Currently, approximately 87 waste-to-energy plants operate in the United States. These plants generate approximately 2,531 MW(e), or an average of 29 MW(e) per plant (Energy Recovery Council, 2010). This includes five plants in New Jersey generating a total of 173 MW(e). More than 124 average-sized plants would be necessary to provide the same level of output as the other alternatives to Salem and HCGS license renewal.

Estimates in the GEIS suggest that the overall level of construction impact from a waste-fired plant would be approximately the same as that for a coal-fired power plant. Additionally, waste-fired plants have the same or greater operational impacts than coal-fired technologies (including impacts on the aquatic environment, air, and waste disposal). The initial capital costs for municipal solid-waste plants are greater than for comparable steam-turbine technology at coal-fired facilities or at wood-waste facilities because of the need for specialized waste separation and handling equipment (NRC, 1996).

The decision to burn municipal waste to generate energy is usually driven by the need for an alternative to landfills rather than energy considerations. The use of landfills as a waste disposal option is likely to increase in the near term as energy prices increase; however, it is possible that municipal waste combustion facilities may become attractive again.

Given the small average installed size of municipal solid waste plants and the unfavorable regulatory environment, the Staff does not consider municipal solid waste combustion to be a feasible alternative to Salem and HCGS license renewal.

8.2.12 Biofuels

In addition to wood and municipal solid waste fuels, there are other concepts for biomass-fired electric generators, including direct burning of energy crops, conversion to liquid biofuels, and biomass gasification. In the GEIS, the Staff indicated that none of these technologies had progressed to the point of being competitive on a large scale or of being reliable enough to replace a baseload plant such as Salem and HCGS. After reevaluating current technologies, the Staff finds other biomass-fired alternatives are still unable to reliably replace the Salem and HCGS capacity. For this reason, the Staff does not consider other biomass-derived fuels to be feasible alternatives to Salem and HCGS license renewal.

8.2.13 Oil-Fired Power

EIA projects that oil-fired plants would account for very little of the new generation capacity constructed in the United States during the 2008 to 2030 time period. Further, EIA does not project that oil-fired power would account for any significant additions to capacity (EIA, 2009a).

The variable costs of oil-fired generation tend to be greater than those of the nuclear or coal-fired operations, and oil-fired generation tends to have greater environmental impacts than natural gas-fired generation. In addition, future increases in oil prices are expected to make oil-fired generation increasingly more expensive (EIA, 2009a). The high cost of oil has prompted a steady decline in its use for electricity generation. Thus, the Staff did not consider oil-fired generation as an alternative to Salem and HCGS license renewal.

8.2.14 Fuel Cells

Fuel cells oxidize fuels without combustion and its environmental side effects. Power is produced electrochemically by passing a hydrogen-rich fuel over an anode and air (or oxygen) over a cathode and separating the two by an electrolyte. The only byproducts (depending on fuel characteristics) are heat, water, and CO_2. Hydrogen fuel can come from a variety of hydrocarbon resources by subjecting them to steam under pressure. Natural gas is typically used as the source of hydrogen.

At the present time, fuel cells are not economically or technologically competitive with other alternatives for electricity generation. In addition, fuel cell units are likely to be small in size. While it may be possible to use a distributed array of fuel cells to provide an alternative to Salem and HCGS, it would be extremely costly to do so and would require many units. Accordingly, the Staff does not consider fuel cells to be an alternative to Salem and HCGS license renewal.

8.2.15 Delayed Retirement

The power generating merchants within the PJM region have retired a large number of generation sources since 2003, totaling 5,945 MW retired and 2,629 MW pending retirement. Most of these retirements involve older fossil fuel-powered plants which are retired due to challenges in meeting increasingly stringent air quality standards (PJM, 2009). Although these retirements have caused reliability criteria violations, PJM does not have any authority to compel owners to delay retirement (PJM, 2009), and therefore retirements are likely to continue. Therefore, delayed retirement of non-nuclear plants is not considered as a feasible alternative to Salem and HCGS license renewal.

8.3 No-Action Alternative

This section examines environmental effects that would occur if NRC takes no action. No Action in this case means that NRC does not issue a renewed operating license for Salem and HCGS and the licenses expire at the end of their current license terms. If NRC takes no action, the plants would shutdown at or before the end of the current license. After shutdown, plant operators would initiate decommissioning according to 10 CFR 50.82. Table 8-4 provides a summary of environmental impacts of No Action compared to continued operation of the Salem and HCGS.

The Staff notes that the option of No Action is the only alternative considered in-depth that does not satisfy the purpose and need for this SEIS, as it does not provide power generation capacity nor would it meet the needs currently met by Salem and HCGS or that the alternatives evaluated in Section 8.1 would satisfy. Assuming that a need currently exists for the power generated by Salem and HCGS, the no-action alternative would require that the appropriate energy planning decision-makers rely on an alternative to replace the capacity of Salem and HCGS or reduce the need for power.

This section addresses only those impacts that arise directly as a result of plant shutdown. The environmental impacts from decommissioning and related activities have already been addressed in several other documents, including the *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities*, NUREG-0586, Supplement 1 (NRC, 2002); the license renewal GEIS (chapter 7; NRC, 1996); and Chapter 7 of this SEIS. These analyses either directly address or bound the environmental impacts of decommissioning whenever PSEG ceases operating Salem and HCGS.

The Staff notes that, even with renewed operating licenses, Salem and HCGS would eventually shut down, and the environmental effects addressed in this section would occur at that time. Since these effects have not otherwise been addressed in this SEIS, the impacts will be addressed in this section. As with decommissioning effects, shutdown effects are expected to be similar whether they occur at the end of the current license or at the end of a renewed license.

8.3.1 Air Quality

When the plant stops operating, there would be a reduction in emissions from activities related to plant operation such as use of diesel generators and employees vehicles. In Chapter 4, the Staff determined that these emissions would have a SMALL impact on air quality during the renewal term. Therefore, if the emissions decrease, the impact to air quality would also decrease and would be SMALL.

8.3.2 Groundwater Use and Quality

The use of groundwater would diminish as plant personnel are removed from the site and operations cease. Some consumption of groundwater may continue as a small staff remains onsite to maintain facilities prior to decommissioning. Overall impacts would be smaller than during operations, but would remain SMALL.

8.3.3 Surface Water Use and Quality

The rate of consumptive use of surface water would decrease as the plant is shut down and the reactor cooling system continues to remove the heat of decay. Wastewater discharges would also be reduced considerably. Shutdown would reduce the already SMALL impact on surface water resources and quality.

8.3.4 Aquatic and Terrestrial Resources

Aquatic Ecology

If the plant were to cease operating, operational impacts to aquatic ecology would decrease, as the plant would withdraw and discharge less water than it does during operations. Shutdown would reduce the already SMALL impacts to aquatic ecology.

Terrestrial Ecology

Shutdown would result in no additional land disturbances onsite or offsite, and terrestrial ecology impacts would be SMALL.

8.3.5 Human Health

Human health risks would be smaller following plant shutdown. The plant, which is currently operating within regulatory limits, would emit less gaseous and liquid radioactive material to the environment. In addition, following shutdown, the variety of potential accidents at the plant (radiological or industrial) would be reduced to a limited set associated with shutdown events and fuel handling and storage. In Chapter 4 of this draft SEIS, the Staff concluded that the impacts of continued plant operation on human health would be SMALL. In Chapter 5, the Staff concluded that the impacts of accidents during operation were SMALL. Therefore, as radioactive emissions to the environment decrease, and as the likelihood and variety of accidents decrease following shutdown, the Staff concludes that the risks to human health following plant shutdown would be SMALL.

8.3.6 Socioeconomics

Land Use

Plant shutdown would not affect onsite land use. Plant structures and other facilities would likely remain in place until decommissioning. Most transmission lines connected to Salem and HCGS would remain in service after the facilities stop operating. Maintenance of most existing transmission lines would continue as before. The transmission lines could be used to deliver the output of any new capacity additions made on the Salem and HCGS site. Impacts on land use from plant shutdown would be SMALL.

Socioeconomics

Plant shutdown would have an impact on socioeconomic conditions in the region around Salem and HCGS. Should the plants shut down, there would be immediate socioeconomic impacts from loss of jobs (some, though not all, of the approximately 1,614 employees would begin to leave) and property tax payments may be reduced. These impacts, however, would not be considered significant on a regional basis given the close proximity to the Philadelphia and Wilmington metropolitan areas and because plant workers' residences are not concentrated in a single community or county.

Revenue losses from Salem and HCGS operations would affect Salem County and the communities closest to and most reliant on the plant's tax revenue (like Lower Alloways Creek Township, which receives approximately 57 percent of its property tax revenue from Salem and HCGS).. The socioeconomic impacts of plant shutdown would (depending on the jurisdiction) range from SMALL to LARGE. See Appendix J to NUREG-0586, Supplement 1 (NRC, 2002), for additional discussion of the potential socioeconomic impacts of plant decommissioning.

Transportation

Traffic volumes on the roads in the vicinity of Salem and HCGS would be greatly reduced after plant shutdown due to the loss of jobs. Deliveries of materials and equipment to Salem and

HCGS would also be reduced until decommissioning. Transportation impacts from the termination of plant operations would be SMALL.

Aesthetics

Plant structures and other facilities would likely remain in place until decommissioning. The plume from the cooling tower would cease or greatly decrease after shutdown. Noise caused by power plant operations would cease. Aesthetic impacts of plant closure would be SMALL.

Historic and Archaeological Resources

Impacts from the no-action alternative would be SMALL, since Salem and HCGS would be decommissioned. A separate environmental review would be conducted for decommissioning. That assessment would address the protection of historic and archaeological resources.

Environmental Justice

Impacts to minority and low-income populations when Salem and HCGS cease operation would depend on the number of jobs and the amount of tax revenues lost by the communities surrounding the facilities. Closure of Salem and HCGS would reduce the overall number of jobs (there are currently 1,614 permanent positions at the facilities) and the tax revenue attributed to plant operations (approximately 57 percent of Lower Alloways Creek Township's tax revenues and 2.9 percent of Salem County's tax revenues are from Salem and HCGS). Since the Salem and HCGS tax payments represent such a significant percentage of Lower Alloways Creek Township's total annual property tax revenue, it is likely that economic impacts within the township would range from MODERATE to LARGE should Salem and HCGS be shut down and closed. Therefore, minority and low-income populations in the vicinity of Salem and HCGS could experience disproportionately high and adverse environment effects from plant shutdown.

8.3.7 Waste Management

If the no-action alternative were implemented the generation of high-level waste would stop and generation of low-level and mixed waste would decrease. Impacts from implementation of no-action alternative are expected to be SMALL.

Wastes associated with plant decommissioning are unavoidable and will be significant whether the plant is decommissioned at the end of the initial license period or at the end of the relicensing period. Therefore, the selection of the no-action alternative has no impact on issues relating to decommissioning waste.

Table 8-4. Summary of the Direct and Indirect Environmental Impacts of No Action Compared to Continued Operation of Salem and HCGS

	No Action	Continued Salem and HCGS Operation
Air Quality	SMALL	SMALL
Groundwater	SMALL	SMALL
Surface Water	SMALL	SMALL
Aquatic and Terrestrial Resources	SMALL	SMALL
Human Health	SMALL	SMALL
Socioeconomics	SMALL to LARGE	SMALL to LARGE
Waste Management	SMALL	SMALL

8.4 Alternatives Summary

In this chapter, the Staff considered the following alternatives to Salem and HCGS license renewal: supercritical coal-fired generation; natural gas combined-cycle generation; and a combination of alternatives. No Action by the NRC and the effects it would have were also considered. The impacts for all alternatives are summarized in Table 8-5.

Socioeconomic and groundwater impacts would range from SMALL to MODERATE. The Staff did not determine a single significance level for these impacts, but the Commission determined them to be Category 1 issues nonetheless. The environmental impacts of the proposed action (issuing renewed Salem and HCGS operating licenses) would be SMALL for all other impact categories, except for the Category 1 issue of collective offsite radiological impacts from the fuel cycle, high level waste (HLW), and spent fuel disposal.

The environmental impacts of the proposed action (issuing renewed Salem and HCGS operating licenses) would be SMALL for all impact categories except for the Category 1 issue of collective offsite radiological impacts from the fuel cycle, high level waste (HLW), and spent fuel disposal.

In the Staff's professional opinion, the coal-fired alternative would have the greatest overall adverse environmental impact. This alternative would result in MODERATE air quality, human health, and waste management impacts. Its impacts upon socioeconomic and biological resources would range from SMALL to MODERATE. This alternative is not an environmentally preferable alternative due to air quality impacts from NO_x, SO_x, PM, PAHs, CO, CO_2, and mercury (and the corresponding human health impacts), as well as construction impacts to transportation, aquatic, and terrestrial resources.

With the exception of socioeconomic and air quality impacts, the gas-fired alternative would result in SMALL impacts. Socioeconomic and air quality impacts would range from SMALL to MODERATE. This alternative would result in substantially lower air emissions and waste management than the coal-fired alternative.

The combination alternative would have lower air emissions and waste management impacts than both the gas-fired and coal-fired alternatives; however, it would have relatively higher construction impacts in terms of aquatic and terrestrial resources and potential disruption to historic and archaeological resources, mainly as a result of the wind turbine component.

Under the no-action alternative, plant shutdown would begin to eliminate most of the approximately 1,614 jobs at Salem and HCGS and would reduce general tax revenue in the region. Depending on the jurisdiction, the economic loss would have a SMALL to LARGE impact. The no-action alternative, however, would not meet the purpose and need stated in this draft SEIS.

Therefore, in the Staff's best professional opinion, the environmentally preferred alternative in this case is the license renewal of Salem and HCGS. All other alternatives capable of meeting the needs currently served by Salem and HCGS entail potentially greater impacts than the proposed action of license renewal of Salem and HCGS.

Table 8-5. Summary of the Direct and Indirect Environmental Impacts of Proposed Action and Alternatives

Alternative	Impact Area						
	Air Quality	Groundwater	Surface Water	Aquatic and Terrestrial Resources	Human Health	Socioeconomics	Waste Management
License Renewal	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL to LARGE	SMALL[a]
Supercritical Coal-fired Alternative	MODERATE	SMALL	SMALL	SMALL to MODERATE	MODERATE	SMALL to MODERATE	MODERATE
Gas-fired Alternative	SMALL to MODERATE	SMALL	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL
Combination Alternative	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL	SMALL to LARGE	SMALL
No Action Alternative	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL to LARGE	SMALL

[a] For the Salem and HCGS license renewal alternative, waste management was evaluated in Chapter 6. Consistent with the findings in the GEIS, these impacts were determined to be SMALL with the exception of collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal.

8.5 References

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9.0 CONCLUSION

This draft supplemental environmental impact statement (SEIS) contains the preliminary environmental review of PSEG Nuclear, LLC (PSEG) application for a renewed operating licenses for Salem Nuclear Generating Station, Units 1 and 2 (Salem) and Hope Creek Generating Station (HCGS) as required by Part 51 of Title 10, of the *Code of Federal Regulations* (10 CFR Part 51), the U.S Regulatory Commission (NRC's) regulations that implement the National Environmental Policy Act of 1969 (NEPA). Chapter 9 presents the conclusions and recommendations from the site-specific environmental review of Salem and HCGS and summarizes site-specific environmental issues of license renewal that were identified during the review. The environmental impacts of license renewal are summarized in Section 9.1; a comparison of the environmental impacts of license renewal and energy alternatives is presented in Section 9.2; resource commitments are discussed in Section 9.3; and conclusions and NRC staff (the Staff) recommendations are presented in Section 9.4.

9.1 Environmental Impacts of License Renewal

The Staff's review of site-specific environmental issues in this draft SEIS leads it to conclude that issuing a renewed license would have SMALL impacts for the 21 Category 2 issues applicable to license renewal at Salem and HCGS, as well as environmental justice and chronic effects of electromagnetic fields.

Mitigation measures were considered for each Category 2 issue, as applicable. For air quality and ground water and surface water use issues, current measures to mitigate the environmental impacts of plant operation were found to be adequate. Additionally, the Staff concludes that impacts to fish and shellfish from entrainment, impingement, and heat shock at Salem and HCGS would not warrant additional mitigation beyond the Estuary Enhancement Program.

The Staff identified a variety of mitigation measures that could reduce human health impacts by minimizing public exposures to electric shock hazards. However, no cost benefit studies applicable to these mitigation measures were identified. The potential for chronic effects from these fields continues to be studied and is not known at this time. The Staff considers the GEIS finding of "Uncertain" still appropriate and will continue to follow developments on this issue.

There are no known historic and archaeological resources on the Salem and HCGS site. 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.

The Staff also considered cumulative impacts of past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes them. The Staff concluded that cumulative impacts of Salem and HCGS site license renewal is SMALL for potentially affected resources with one exception. Cumulative impacts affecting aquatic resources in the Delaware Estuary would range from MODERATE to LARGE. However, the incremental contribution from the continued operation of Salem and HCGS on aquatic resources would be SMALL for most impacts. The potential direct and indirect impacts to socioeconomics from continued operation of the Salem and HCGS would be SMALL. However, if PSEG decides to proceed with the construction of a new nuclear plant at the Salem and HCGS site, the cumulative impacts to socioeconomics could be SMALL to LARGE.

9.2 Comparison of Environmental Impacts of License Renewal and Alternatives

In the conclusion to Chapter 8, the Staff determined that impacts from license renewal are generally less than the impacts of alternatives to license renewal. In comparing likely environmental impacts from supercritical coal-fired generation, natural gas combined-cycle generation, and a combination alternative (natural gas, renewable energy, and conservation/efficiency) to environmental impacts from license renewal, the Staff found that license renewal of Salem and HCGS results in the lowest environmental impact. Therefore, in the Staff's best professional opinion, the environmentally preferred alternative in this case is the license renewal of Salem and HCGS. All other alternatives capable of meeting the needs currently served by Salem and HCGS entail potentially greater impacts than the proposed action of license renewal of Salem and HCGS.

9.3 Resource Commitments

9.3.1 Unavoidable Adverse Environmental Impacts

Unavoidable adverse environmental impacts are impacts that would occur after implementation of all feasible mitigation measures. Implementing any of the energy alternatives considered in this SEIS, including the proposed action, would result in some unavoidable adverse environmental impacts.

Minor unavoidable adverse impacts on air quality would occur due to emission and release of various chemical and radiological constituents from power plant operations. Nonradiological emissions resulting from power plant operations are expected to comply with U.S. Environmental Protection Agency (EPA) emissions standards, although the alternative of operating a fossil-fueled power plant in some areas may worsen existing attainment issues. Chemical and radiological emissions would not exceed the National Emission Standards for Hazardous Air Pollutants.

During nuclear power plant operations, workers and members of the public would face unavoidable exposure to radiation and hazardous and toxic chemicals. Workers would be exposed to radiation and chemicals associated with routine plant operations and the handling of nuclear fuel and waste material. Workers would have higher levels of exposure than members of the public, but doses would be administratively controlled and would not exceed any standards or administrative control limits. In comparison, the alternatives entailing the construction and operation of a non-nuclear power generating facility would also result in unavoidable exposure to hazardous and toxic chemicals to workers and the general public.

The generation of spent nuclear fuel and waste material, including low-level radioactive waste, hazardous waste, and nonhazardous waste would also be unavoidable. In comparison, hazardous and nonhazardous wastes would also be generated at non-nuclear power generating facilities. Wastes generated during plant operations would be collected, stored, and shipped for suitable treatment, recycling, or disposal in accordance with applicable Federal and State regulations. Due to the costs of handling these materials, power plant operators would be expected to conduct all activities and optimize all operations in a way that generates the smallest amount of waste practical.

9.3.2 Relationship Between Local Short-Term Uses of the Environment and the Maintenance and Enhancement of Long-Term Productivity

The operation of power generating facilities would result in short-term uses of the environment as described in Chapters 4, 5, 6, 7, and 8. “Short term” is the period of time during which continued power generating activities would take place.

Power plant operations would necessitate short-term use of the environment and commitments of resources, and would also commit certain resources (e.g., land and energy) indefinitely or permanently. Certain short-term resource commitments would be substantially greater under most energy alternatives, including license renewal, than under the No Action Alternative due to the continued generation of electrical power as well as continued use of generating sites and associated infrastructure. During operations, all energy alternatives would entail similar relationships between local short-term uses of the environment and the maintenance and enhancement of long term productivity.

Air emissions from power plant operations would introduce small amounts of radiological and nonradiological constituents to the region around the plant site. Over time, these emissions would result in increased concentrations and exposure, but are not expected to impact air quality or radiation exposure to the extent that public health and long-term productivity of the environment would be impaired.

Continued employment, expenditures, and tax revenues generated during power plant operations would directly benefit local, regional, and State economies over the short term. Local governments investing project-generated tax revenues into infrastructure and other required services could enhance economic productivity over the long term.

The management and disposal of spent nuclear fuel, low-level radioactive waste, hazardous waste, and nonhazardous waste would require an increase in energy and would consume space at treatment, storage, or disposal facilities. Regardless of the location, the use of land to meet waste disposal needs would reduce the long-term productivity of the land.

Power plant facilities would be committed to electricity production over the short term. After decommissioning these facilities and restoring the area, the land could be available for other future productive uses.

9.3.3 Irreversible and Irretrievable Commitments of Resources

This section describes the irreversible and irretrievable commitments of resources that have been identified in this SEIS. Irreversible resources refer to when primary or secondary impacts limit the future options for a resource. An irretrievable commitment refers to the use or consumption of resources that are neither renewable nor recoverable for future use. Irreversible and irretrievable commitment of resources for electrical power generation would include the commitment of land, water, energy, raw materials, and other natural and man-made resources required for power plant operations. In general, the commitment of capital, energy, labor, and material resources would also be irreversible.

The implementation of any of the energy alternatives considered in this SEIS would entail the irreversible and irretrievable commitment of energy, water, chemicals, and, in some cases, fossil fuels. These resources would be committed during the license renewal term and over the entire life cycle of the power plant and would essentially be unrecoverable.

Energy expended would be in the form of fuel for equipment, vehicles, and power plant operations and electricity for equipment and facility operations. Electricity and fuels would be purchased from offsite commercial sources. Water would be obtained from existing water supply systems. These resources are readily available, and the amounts required are not expected to deplete available supplies or exceed available system capacities.

The irreversible and irretrievable commitment of material resources includes materials that cannot be recovered or recycled, materials that are rendered radioactive and cannot be decontaminated, and materials consumed or reduced to unrecoverable forms of waste. However, none of the resources used by these power generating facilities are in short supply, and, for the most part, are readily available.

Various materials and chemicals, including acids and caustics, would be required to support operations activities. These materials would be derived from commercial vendors, and their consumption is not expected to affect local, regional, or national supplies.

The treatment, storage, and disposal of spent nuclear fuel, low-level radioactive waste, hazardous waste, and nonhazardous waste would require the irretrievable commitment of energy and fuel and would result in the irreversible commitment of space in disposal facilities.

9.4 Recommendations

Based on (1) the analysis and findings in the GEIS, (2) information provided in the environmental report (ER) submitted by PSEG, (3) consultation with Federal, State, and local agencies, (4) a review of pertinent documents and reports, and (5) consideration of public comments received during scoping, the preliminary recommendation of the Staff is that the Commission determine that the adverse environmental impacts of license renewal for Salem and HCGS are not so great that preserving the option of license renewal for energy planning decision makers would be unreasonable.

10.0 LIST OF PREPARERS

This supplemental EIS was prepared by members of the Office of Nuclear Reactor Regulation, with assistance from other NRC organizations and contract support from AECOM.

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[a] Pacific Northwest National Laboratory is operated by Batelle for the U.S. Department of Energy

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10. SUPPLEMENTARY NOTES

Docket Nos. 50-272, 50-311, 50-354

11. ABSTRACT *(200 words or less)*

This draft supplemental environmental impact statement (SEIS) has been prepared in response to an application submitted by PSEG Nuclear, LLC (PSEG) to renew the operating licenses for Hope Creek Generating Station (HCGS) and Salem Nuclear Generating Station, Units 1 and 2 (Salem) for an additional 20 years. The 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 for reducing or avoiding adverse impacts. It also includes the staff's preliminary recommendation regarding the proposed action.

The NRC staff's preliminary recommendation is that the Commission determine that the adverse environmental impacts of license renewal for HCGS and Salem are not so great that preserving the option of license renewal for energy-planning decision makers would be unreasonable. The recommendation is based on (1) the analysis and findings in the GEIS; (2) the Environmental Reports submitted by PSEG; (3) consultation 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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