Rikhoff, Jeffrey

From: Eccleston, Charles
Sent: Monday, August 09, 2010 11:04 AM
To: Rikhoff, Jeffrey
Subject: Chapter 2, 4, & 8
Attachments: 4.9.7 Environmental Justice (062910).docx; 4.1 Land Use (050610).docx; 4.9, 4.9.1 (050610).docx; 4.9.2 Housing (051910).docx; 4.9.3 Public Utilities (051910).docx; 4.9.4 Offsite Land Use (051910).docx; 4.9.5 Transportation (051910).docx; Chapter 2 - V.2[1] (GB, DB).docm; Chapter 8 v 2 (4) (most recent), AT, DB).docx

Follow Up Flag: Follow up
Flag Status: Completed

Jeff,

Here is chapter 2, 4, and 8. If you can simply add any changes to these files, I can send then send the files back to AECOM. They will do a "compare" between your version and their baseline version, and incorporate your changes into the baseline version.

Charles H. Eccleston

Charles H. Eccleston
Nuclear Reactor Regulation
Licensing Renewal, Project Manager
301.415.8537
charles.eccleston@nrc.gov

D-120

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* (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 defined by the National Environmental Policy Act [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 defined 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 CEQ (1997) definitions of minority individuals and populations and low-income population were used:

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.

The NRC published an environmental justice policy in 2004. This policy stated that for licensing and regulatory actions pertaining to nuclear power plants, a radius of 50 mi should be used to determine potential impacts to environmental justice populations. This policy retained the Office of Nuclear Reactor Regulations' previous radius determination (69 FR 52040). The geographic area included in this environmental justice analysis consists of those census block groups with all or part of their area within a 50-mi radius of Salem and HCGS.

Minority Population in 2000

There are a total of 23 counties in the 50-mi 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 an 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 reported in the 2000 Census as having high density minority population percentages that exceeded the 50-mi radius average (USCB, 2000a). The largest minority group was Black or African American, with 1284 block groups that exceed the 50-mi radius average. 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 radius average. A total of 202 block groups exceeded the 50-mi radius average for Hispanic or Latino ethnicity. The high density minority population nearest to Salem and HCGS is centered in the City of Salem, New Jersey.

Based on 2000 Census data, Figure 4-1 shows the block groups with high density minority populations within an 80-km (50-mi) radius of Salem and HCGS.

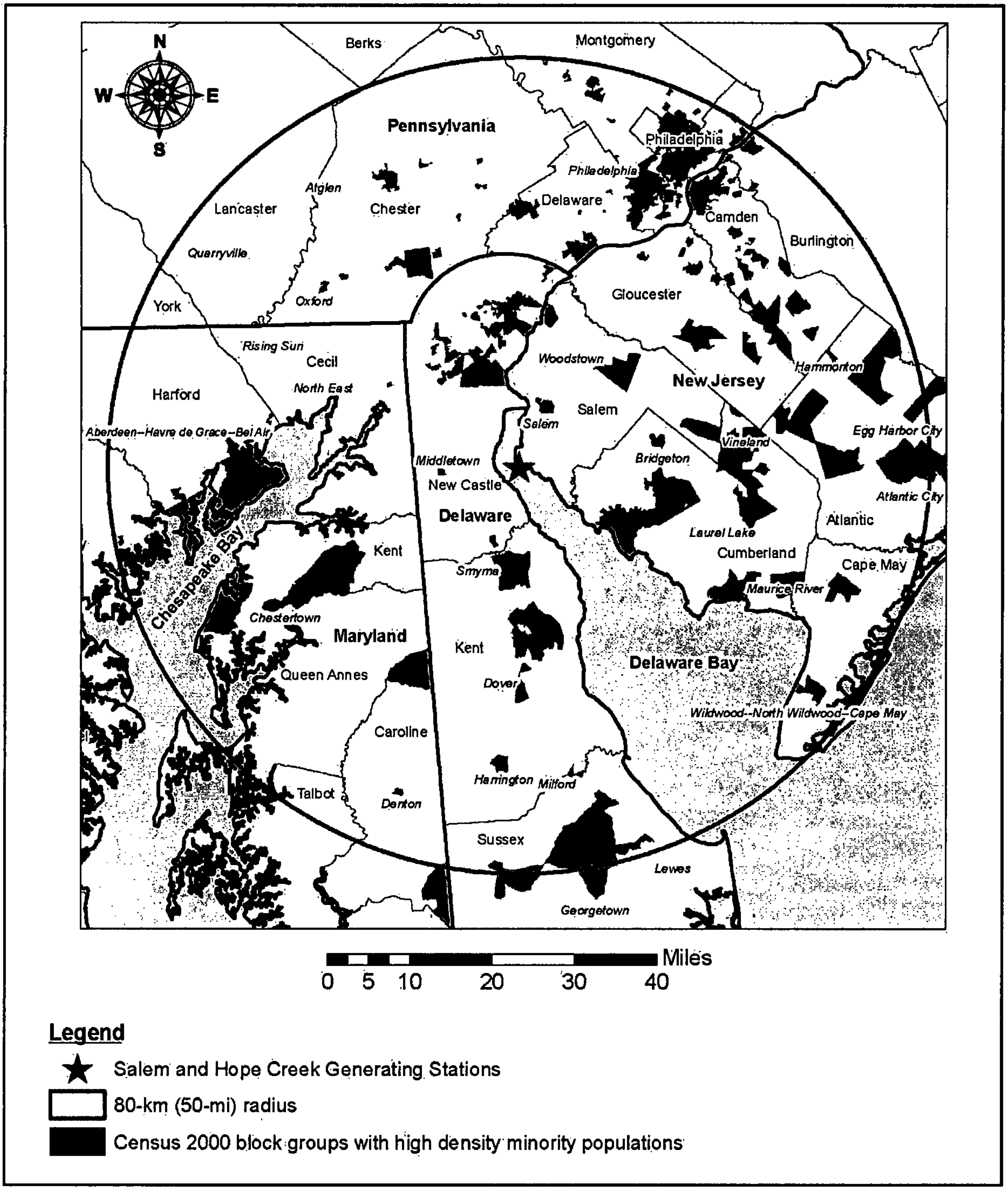
Low-Income Population in 2000

According to 2000 Census data, 119,283 families (2.2 percent) and 620,903 individuals (11.6 percent) residing within a 50-mi 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; USCB, 2000b).

Census block groups were considered high density low-income block groups if the percentage of families and individuals living below the Federal poverty threshold exceeded the 50-mi radius average. Based on 2000 Census data, there were 1,778 block groups within a 50-mi radius of Salem and HCGS that are considered high density low-income block groups. The majority of census block groups with low-income populations were located in Philadelphia County, Pennsylvania. The high density low-income population nearest to Salem and HCGS is located in Lower Alloways Creek Township in Salem County, New Jersey. Figure 4-2 shows high density low-income census block groups within a 50-mi radius of Salem and HCGS.

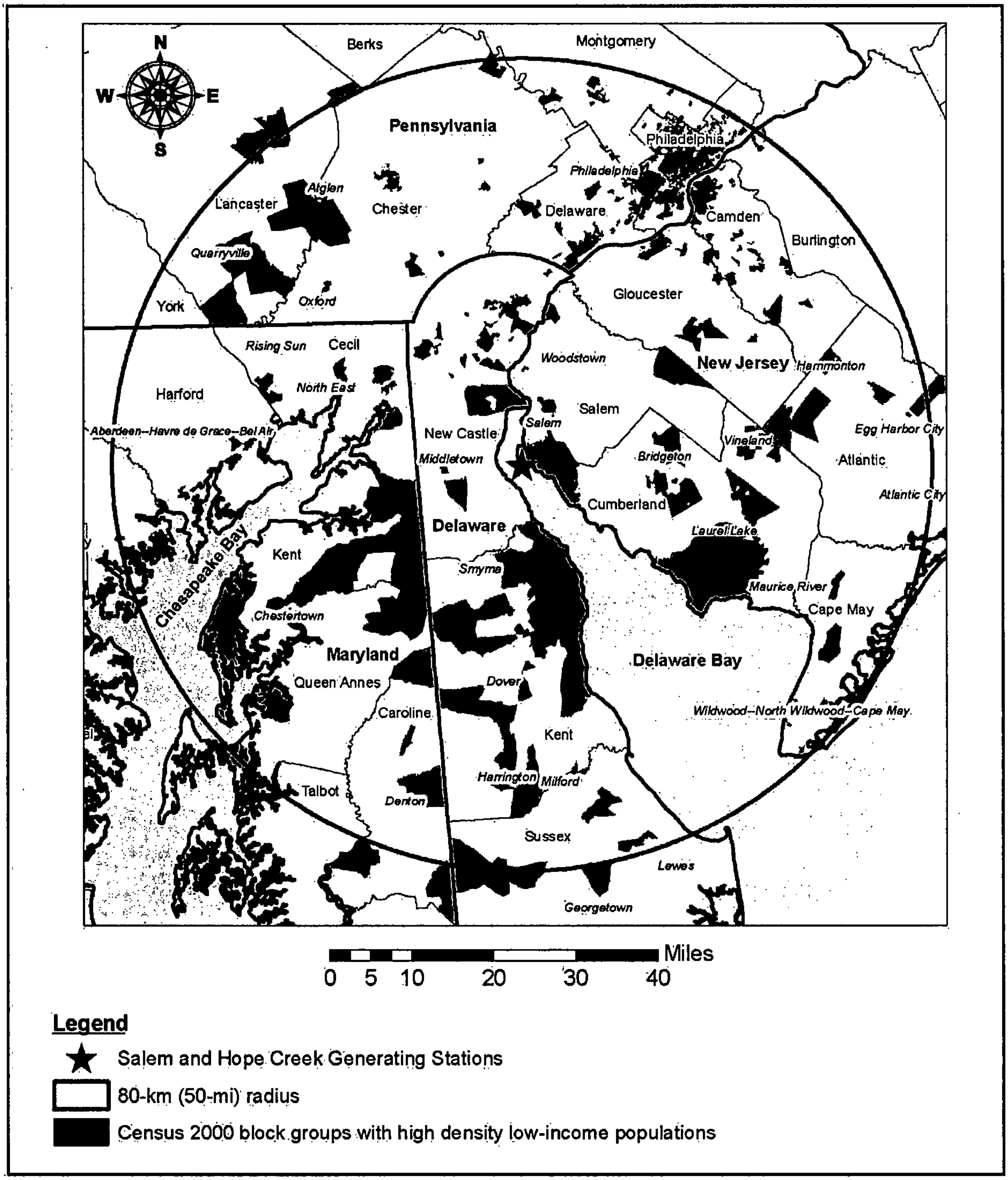
Analysis of Impacts

The discussion above indentifies the minority and low-income populations who reside within a 50-mi radius of Salem and HCGS. This area is consistent with the impact analysis for public and occupational health and safety, which similarly focuses on populations within a 50-mi radius of the facilities. Based on the analysis of impacts for all resource areas presented in this draft SEIS, it was determined that there would be no significant adverse health impacts on members of the public and, therefore, there would be no disproportionate and adverse impacts experienced by minority or low-income populations within the area of interest from the continued operation of Salem and HCGS during the license renewal period. Similarly, given the potential environmental effects of continued operation on the physical environment (water, air, aquatic and terrestrial resources) and socioeconomic conditions, there would be no disproportionately high and adverse impacts on minority and low-income populations because of adverse environmental effects.



Source: USCB 2003

Figure 4-1. Census 2000 minority block groups within a 50-mi radius of Salem and HCGS



Source: USCB 2003

Figure 4-2. Census 2000 low-income block groups within a 50-mi radius of Salem and HCGS

NRC 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 Executive Order 12898 (1994) directs Federal agencies, whenever practical and appropriate, to collect and analyze information on the consumption patterns of populations that rely principally on fish and/or wildlife for subsistence and to communicate the risks of these consumption patterns to the public. In this draft SEIS, NRC considered whether there were any means for minority or low-income populations to be disproportionately affected by examining impacts to American Indian, Hispanic, and other traditional lifestyle special pathway receptors. Special pathways that took into account the levels of contaminants in native vegetation, crops, soils and sediments, surface water, fish, and game animals on or near 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. To assess the impact of the facilities on the environment, the radiological monitoring program at Salem and HCGS uses indicator-control sampling. Samples are collected at nearby indicator locations downwind and downstream from the facilities and at distant control locations upwind and upstream from the facilities. Control locations are usually 9 to 18 miles away from the facilities. A facility effect would be indicated if the radiation level at an indicator location was significantly larger than at the control location. The difference would also have to be greater than could be accounted for by typical fluctuations in radiation levels arising from other naturally-occurring sources (PSEG, 2010).

Samples are collected from the aquatic and terrestrial pathways in the vicinity of Salem and HCGS. The aquatic pathways include fish, Delaware Bay and River (Delaware estuary) surface water, groundwater, and sediment. The terrestrial pathways include airborne particulates, milk, and food product garden (leaf) vegetation, and direct radiation. During 2009, analyses performed on collected samples of environmental media showed no significant or measurable radiological impact from Salem and HCGS site operations (PSEG, 2010).

Aquatic sampling in the vicinity of Salem and HCGS consists of semi-annual upstream and downstream collections of fish, blue crabs, and bottom sediments. Delaware estuary surface water is collected monthly from upstream and downstream locations. All samples are analyzed for gamma-emitting isotopes. Surface water is additionally analyzed for gross beta and tritium. Drinking water is collected daily from the City of Salem Water and Sewer Department water sources (surface water and groundwater) and composited in a monthly sample. Monthly composites are analyzed for gross alpha, gross beta, tritium, iodine-131, and gamma- emitting isotopes. Well water is collected monthly from one nearby farm's well, located upgradient from

Salem and HCGS, and is analyzed for gross alpha, gross beta, tritium, and gamma emitters (PSEG, 2010).

Fish were sampled twice at three locations in 2009 and blue crabs were collected twice at two locations. In the fish and blue crab samples, only naturally-occurring radionuclides were detected, at concentrations less than the pre-operational levels. There was no indication of an effect from Salem and HCGS operations (PSEG, 2010).

Sediment samples were collected twice from six indicator stations and one control station. Naturally occurring potassium-40, thorium-232, and radium-226 and radium-228 (RA-NAT) were found at all indicator and control stations, and naturally occurring beryllium-7 was detected at one indicator station; all of these detections were less than pre-operational concentrations. Cesium 137 was detected in two indicator samples, and no control samples. The positive samples showed lower levels than pre-operational samples. Manganese-54 was detected at one indicator station. There are no pre-operational data for this radionuclide; however, the average concentration of all positive sample results from 1988 to 2008 is slightly higher than the 2009 detected concentration. There was no indication of an effect from operation of the Salem and HCGS facilities (PSEG, 2010).

Surface water samples collected monthly at four indicator stations and one control station revealed trace amounts of tritium (slightly above the minimum detectable concentration range) at the indicator stations and none at the control locations. Gross beta activity was found at both indicator and control locations at levels similar to the pre-operational samples. Naturally occurring potassium-40, thorium-232 and RA-NAT were found in both indicator and control samples. Two potable water samples yielded gross alpha activity below per-operational levels, all samples had gross beta activity below pre-operational levels, no tritium or iodine-131 was detected, and naturally occurring potassium-40, thorium-232 and RA-NAT were detected at levels comparable to previous years sampled. Well water (groundwater) samples had no measureable amounts of tritium, and trace amounts of gross alpha activity. Beta activity levels were lower than the pre-operational data. Potassium-40 and RA-NAT were detected in well water at levels similar to pre-operational levels. There was no indication of an effect from operation of the Salem and HCGS facilities (PSEG, 2010).

Vegetables and fodder crops are collected annually at harvest and are analyzed for gamma-emitting isotopes. Vegetable crops contained only naturally-occurring radionuclides. Potassium 40 was detected at similar levels at both indicator and control locations, at concentrations below pre-operational levels. RA-NAT was not detected in any of the indicator samples, but was detected at two of the control locations. Beryllium 7 was detected in four of the indicator samples, at concentrations comparable to previous years sampled. Fodder crops contained beryllium-7 and potassium-40 at similar concentrations at both indicator and control locations. Milk samples were collected semi-monthly from three indicator farms and one control farm when cows were at pasture, and monthly when cows were not at pasture, and analyzed for iodine-131 and gamma-emitting isotopes. Iodine-131 was not detected in any of the samples, while potassium-40 and RA-NAT were detected at naturally levels less than those found in pre-operational samples. There was no indication of an effect from operation of the Salem and HCGS facilities (PSEG, 2010).

Air quality samples were collected weekly from six locations. These samples were analyzed for gross beta and iodine-131 as a weekly composite and for gamma-emitting isotopes on a quarterly composite basis. Air particulate samples had similar results for both indicator and control locations, and were also comparable to pre-operational levels. Air iodine was not detected. There was no indication of an effect from operation of the Salem and HCGS facilities (PSEG, 2010).

Previously, PSEG had also tested muskrat populations in the area. Muskrats are trapped and consumed by the local population (PSEG, 2006). 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, 2007). The last muskrat data collected in 2005 resulted in only one sample with detectable levels of potassium-40; no other radionuclides were found (PSEG, 2006).

The results of the 2009 REMP (and consideration of the 2005 REMP muskrat data) demonstrate that the routine operation at Salem and HCGS had no significant or measurable radiological impact on the environment. No elevated radiation levels were detected in the offsite environment as a result of plant operations and the storage of radioactive waste. The results of the REMP continue to demonstrate that the operation of Salem and HCGS did not result in a significant measurable dose to a member of the general population or adversely impact the environment as a result of radiological effluents. The REMP continues to demonstrate that the dose to a member of the public from the operation of Salem and HCGS remains significantly below the federally required dose limits specified in 10 CFR 20, 10 CFR 72, and 40 CFR 190.

The New Jersey Department of Environmental Protection (NJDEP) Bureau of Nuclear Engineering (BNE) also samples the area around Salem and HCGS for radionuclides that could be elevated due to the presence of the two facilities. Ten stations within the vicinity are monitored with thermoluminescent dosimetry. During 2008, all station results were comparable to previous years. Air samples were taken at three locations, with results not significantly different from ambient background levels. Surface water was collected from the Delaware River at the onsite surface water inlet building discharge and at a location on the west bank of the river upstream from Salem's effluent discharge; potable well water samples were taken on site. No gamma emitting isotopes or tritium were found in these samples. 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 detected only potassium-40, a naturally-occurring radionuclide. Trace amounts of strontium-90 were found in all milk samples, at levels consistent with what is expected as a result of nuclear weapons testing in the 1950s and 1960s (NJDEP, 2009).

Based on recent monitoring results, concentrations of contaminants in native leafy vegetation, sediments, surface water, and fish and game animals in areas surrounding Salem and HCGS have been quite 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.

References:

59 FR 7629. "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations." Federal Register. February 16, 1994.

69 FR 52040. "Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions." Federal Register. August 24, 2004.

CEQ (Council on Environmental Quality) 1997. *Environmental Justice: Guidance Under the National Environmental Policy Act.* Executive Order of the President, Washington. DC.

NJDEP (New Jersey Department of Environmental Protection). 2009. Environmental Surveillance and Monitoring Report For the Environs of New Jersey's Nuclear Power Generating Stations. January 1, 2008 – December 31, 2008. Bureau of Nuclear Engineering. Accessed May 17, 2010 at www.state.nj.us/dep/rpp.

PSEG (PSEG Nuclear, LLC) 2006. 2005 Annual Radiological Environmental Operating Report. January 1 to December 31, 2005. Radiological Environmental Monitoring Program for Salem Generating Station, Unit 1: Docket No. 50-272; Salem Generating Station, Unit 2: Docket No. 50-311; Hope Creek Generating Station: Docket No. 50-354.

PSEG 2007. 2006 Annual Radiological Environmental Operating Report. January 1 to December 31, 2006. Radiological Environmental Monitoring Program for Salem Generating Station, Unit 1: Docket No. 50-272; Salem Generating Station, Unit 2: Docket No. 50-311; Hope Creek Generating Station: Docket No. 50-354.

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.

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.

PSEG 2010. 2009 Annual Radiological Environmental Operating Report. January 1 to December 31, 2009. Radiological Environmental Monitoring Program for Salem Generating Station, Unit 1: Docket No. 50-272; Salem Generating Station, Unit 2: Docket No. 50-311; Hope Creek Generating Station: Docket No. 50-354.

Tetra Tech NUS, Inc. 2010. Subsistence Living in the Vicinity of Salem and Hope Creek Nuclear Generating Stations. Prepared for PSEG Nuclear, LLC. Nicole Hill, Tetra Tech NUS, Inc., Aiken, SC. February 18, 2010.

USCB (U.S. Census Bureau) 2000a. "P87. Poverty Status in 1999 by Age [17] – Universe: Population for whom poverty status is determined. Data Set: Census 2000 Summary File 3 (SF 3) Sample Data." Accessed June 28, 2010 at http://factfinder.census.gov/.

USCB 2000b. "P90. Poverty Status in 1999 of Families by Family Type by Presence of Related Children under 18 Years of Age by Age of Related Children [41] – Universe: Families. Data Set: Census 2000 Summary File 3 (SF 3) Sample Data." Accessed June 28, 2010 at http://factfinder.census.gov/.

USCB 2003. LandView 6 – Census 2000 Tables "P-4. Hispanic or Latino, and Not Hispanic or Latino by Race [73] – Total population. Data Set: Census 2000 Summary File 1 (SF 1) 100-Percent Data"; "P87. Poverty Status in 1999 by Age [17] – Universe: Population for whom poverty status is determined. Data Set: Census 2000 Summary File 3 (SF 3) Sample Data"; and "P90. Poverty Status in 1999 of Families by Family Type by Presence of Related Children under 18 Years of Age by Age of Related Children [41] – Universe: Families. Data Set: Census 2000 Summary File 3 (SF 3) Sample Data" for Census Block Groups within an 80-km (50-mi) radius of Salem and HCGS. December.

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, b), 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, and additional site-specific mitigation measures are not likely to be warranted.

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

REFERENCES

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.

PSEG Nuclear, LLC (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.

4.9 Socioeconomics

The socioeconomic issues applicable to Salem and HCGS during the license renewal term are listed in Table 4-x, including applicable GEIS section and category (Category 1, Category 2, or uncategorized).

Table 4-x. 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 staff reviewed and evaluated the Salem and HCGS ERs (PSEG 2009a, b), scoping comments, and other available information, and visited the Salem and HCGS sites. The NRC staff did not identify any new and significant information that would change the conclusions presented in the GEIS. Therefore, it is expected that 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 staff incorporates the GEIS conclusions by reference. Impacts for Category 2 and uncategorized issues are discussed in Sections 4.9.2 through 4.9.7, below.

4.9.2 Housing Impacts

Appendix C of the GEIS presents a population characterization method based on two factors, sparseness and proximity (GEIS, Section C.1.4). Sparseness measures population density within 20 mi of the site, and proximity measures population density and city size within 50 mi. Each factor has categories of density and size (GEIS, Table C.1). A matrix is used to rank the population category as low, medium, or high (GEIS, Figure C.1).

According to the 2000 Census, approximately 501,820 people lived within 20 mi of Salem and HCGS, which equates to a population density of 450 persons per square mile (PSEG 2009a, b). This density translates to GEIS Category 4 – least sparse (greater than or equal to 120 persons per square mile within 20 mi). Approximately 5,201,842 people live within 50 mi of Salem and HCGS (PSEG 2009a, b). This equates to a population density of 771 persons per square mile. Applying the GEIS proximity measures, Salem and HCGS are classified as proximity Category 4 – in close proximity (greater than or equal to 190 persons per square mile within 50 mi). Therefore, according to the sparseness and proximity matrix presented in the GEIS, the Salem and HCGS rankings of sparseness Category 4 and proximity Category 4 result in the conclusion 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 the Salem and HCGS site is 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 Salem and HCGS employment-related impact on housing availability in these counties would likely be small. Since PSEG has indicated that that there would be no major plant refurbishment and no non-outage employees would be added during the license renewal term, 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 impact on permanent housing during the license renewal term.

4.9.3 Public Services: Public Utilities

Impacts on public utility services are considered SMALL if there is little or no change in the ability of the system to respond to demand and thus there is no need to add capital facilities. Impacts are considered MODERATE if service capabilities are overtaxed during periods of peak demand. Impacts are considered LARGE if services (e.g., water, sewer) are substantially degraded and additional capacity is needed to meet ongoing demand. The GEIS indicated that, in the absence of new and significant information to the contrary, the only impacts on public utilities that could be significant are impacts on public water supplies.

Analysis of impacts on the public water 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 2004]) 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.

Salem and HCGS operations during the license renewal term would not increase facility-related population demand for public water services. Given that PSEG has indicated that there would be no major plant refurbishment, overall employment levels at Salem and HCGS would remain relatively constant during this period with no additional demand for public services. In addition, public water systems in the region would be adequate to provide the capacity required to meet the demand of residential and industrial customers in the area. Based on a review of available public water supply use and capacity information in the region, there would be no impact to public water services during the license renewal term.

<u>REFERENCES</u> (from Section 2.1.7)

Delaware River Basin Commission (DRBC). 2000. Groundwater Withdrawal. Docket No. D-90-71 Renewal. West Trenton, New Jersey, Delaware River Basin Commission. Publication date: November 1, 2000.

New Jersey Department of Environmental Protection (NJDEP). 2004. Water Allocation Permit WAP040001. Trenton, New Jersey. New Jersey Department of Environmental Protection. Issue Date: December 30, 2004.

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."

Section 4.7.4 of the GEIS defines the magnitude of land-use changes as a result of plant operation during the period of extended operation 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 to Salem and HCGS during the license renewal period, there would be no noticeable change in land use conditions in the vicinity of the Salem and HCGS site. Therefore, there would be no population-related land use impacts during the license renewal term.

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. However, discontinuing the current level of tax revenues would have a significant negative economic impact on Lower Alloways Creek Township.

PSEG has indicated that there would be no major plant refurbishment or license renewal-related construction activities necessary to support the continued operation of Salem and HCGS during the license renewal period. Accordingly, there would be no increase in the assessed value of Salem and HCGS, and annual property tax payments to Lower Alloways Creek Township would 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.

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 by 10 CFR 51.53(c)(3)(ii)(J) to assess the impacts of highway traffic generated by the proposed project on the level of service of local highways during the term of the renewed license.

Given that Salem and HCGS have no plans to add non-outage employees during the license renewal period, there would be no noticeable change in traffic volume and levels of service on roadways in the vicinity of the Salem and HCGS site. Therefore, there would be no transportation impacts during the license renewal term.

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 and River Mile 51, respectively, approximately 17 miles south of the Delaware Memorial Bridge. Philadelphia is about 40 miles northeast and the city of Salem, New Jersey, is 8 miles northeast of the site (U.S. Atomic Energy Commission [AEC] 1973). Figure 2-1 shows the location of Salem and HCGS within a six-mile 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 1500 acre island that was created by the U.S. Army Corps of Engineers (USACE) beginning in the early twentieth 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 low and flat tidal marsh and grassland has an average elevation of about 9 feet (ft) above mean sea level (MSL) and a maximum elevation of about 18 ft above MSL. (AEC 1973)

PSEG Nuclear, LLC (PSEG) owns approximately 740 acres on the southern end of Artificial Island. The Salem and HCGS facilities occupy 373 acres (220 acres for Salem and 153 acres for HCGS) in the southwestern corner of the island. The remainder of Artificial Island is undeveloped.

Adjacent land owners include 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-mile 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 nearby inland property. Distance to the PSEG property boundary from the two Salem reactor buildings is approximately 4200 ft. Distance to the PSEG property boundary from the HCGS reactor building is 2960 ft.

There are no major highways or railroads within about 7 miles 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.

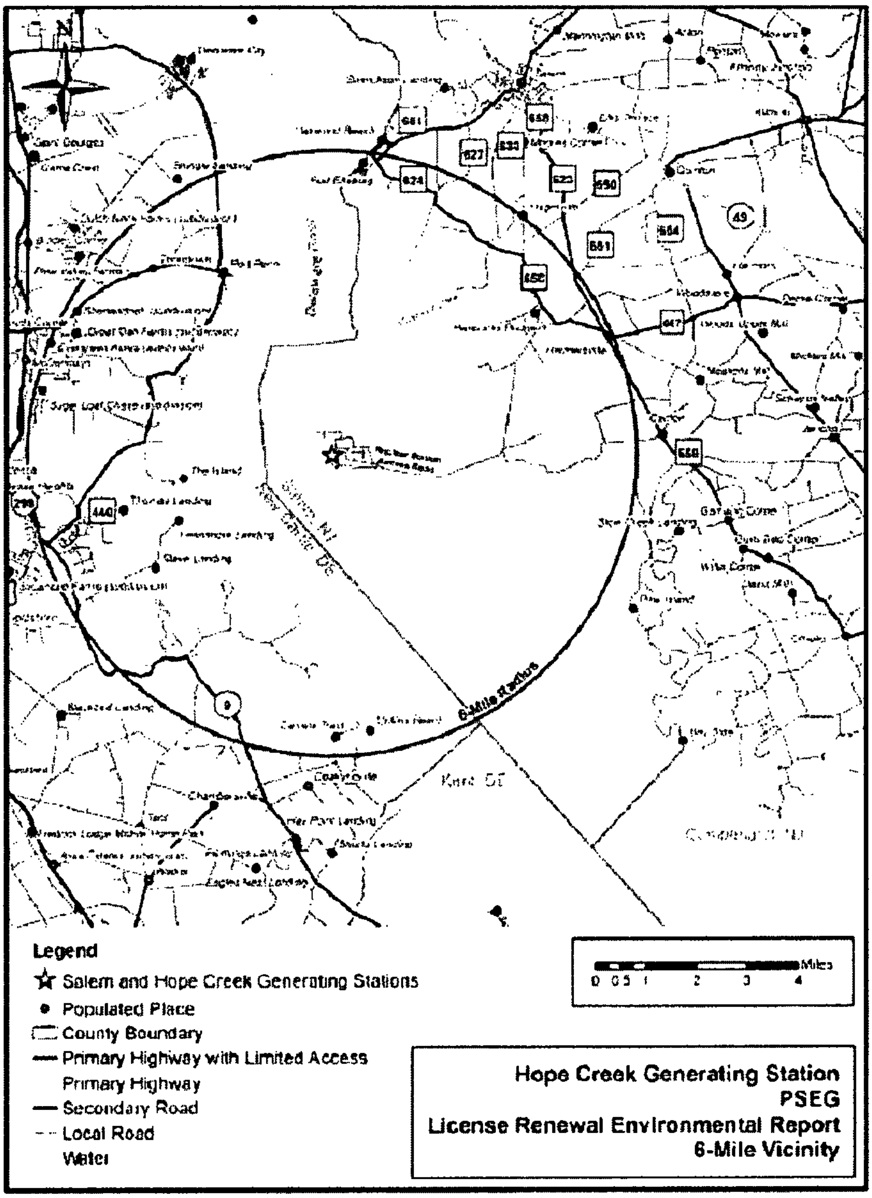


Figure 2-1. Location of Salem and HCGS Site, within a 6-Mile Radius
(Source: PSEG 2009a; PSEG 2009b)

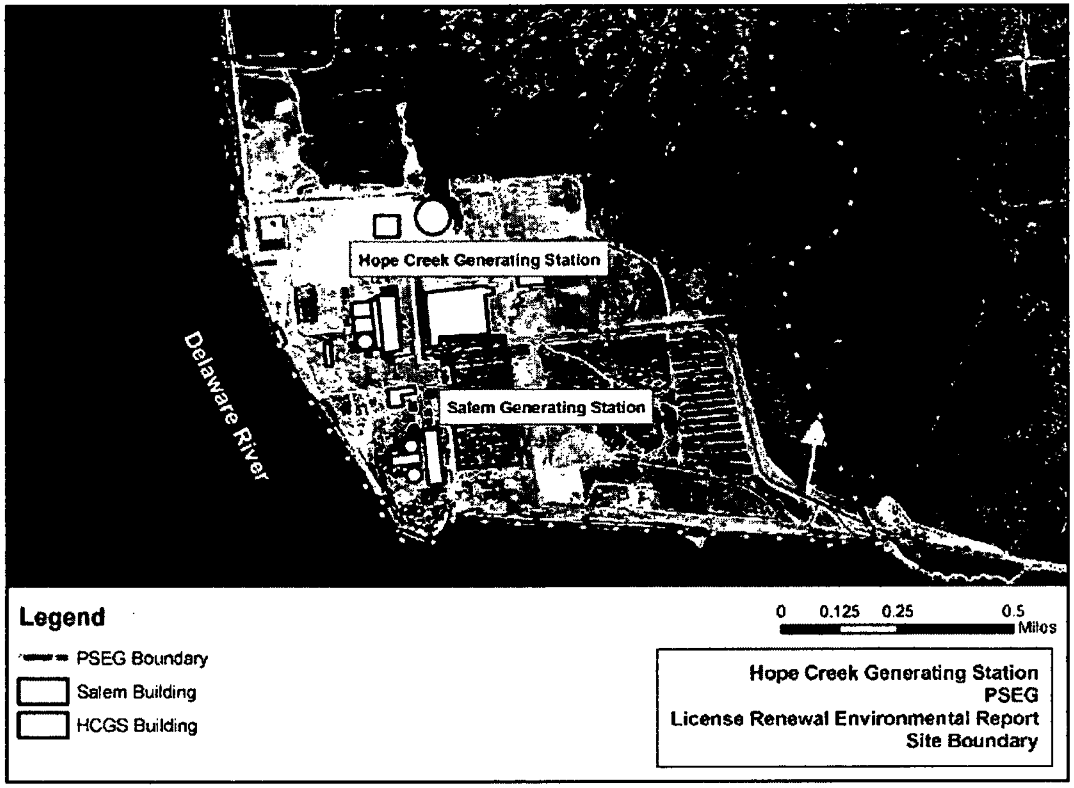

Hope Creek Generating Station
Salem Generating Station
Delaware River
Legend
PSEG Boundary
Salem Building
HCGS Building
0 0.125 0.25 0.5
Miles
Hope Creek Generating Station
PSEG
License Renewal Environmental Report
Site Boundary

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

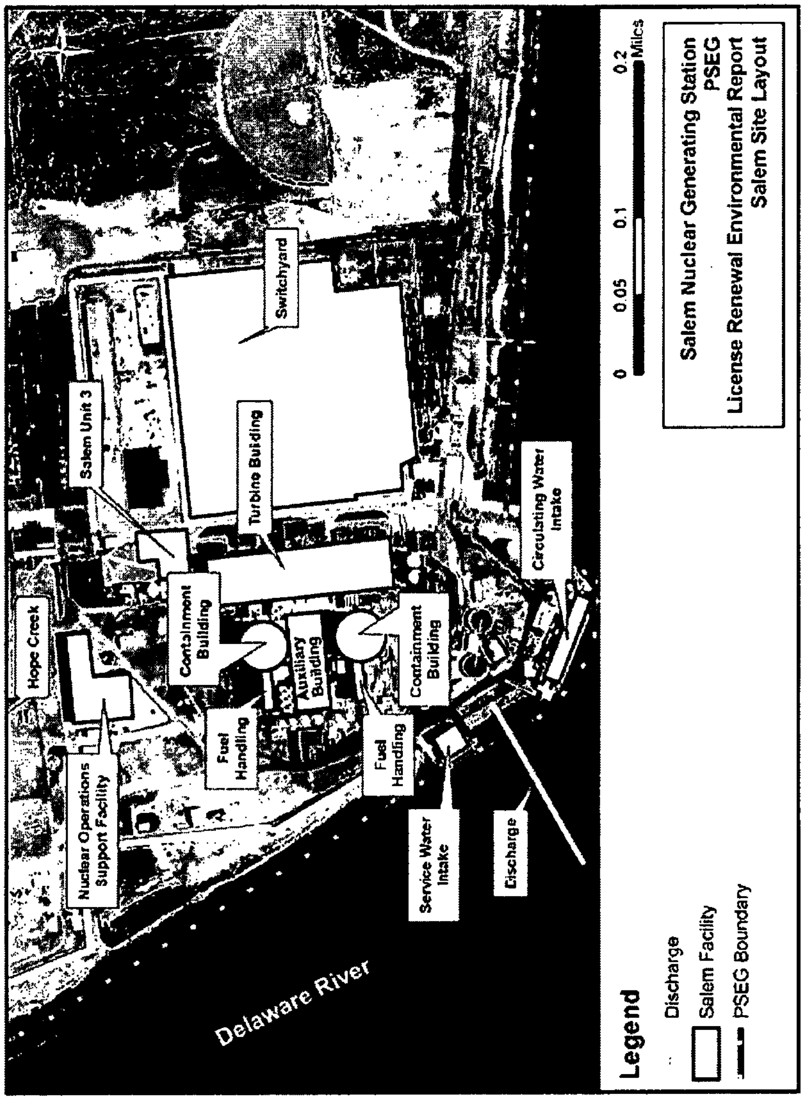


Figure 2-3. Salem Facility Layout (Source: PSEG 2009a)

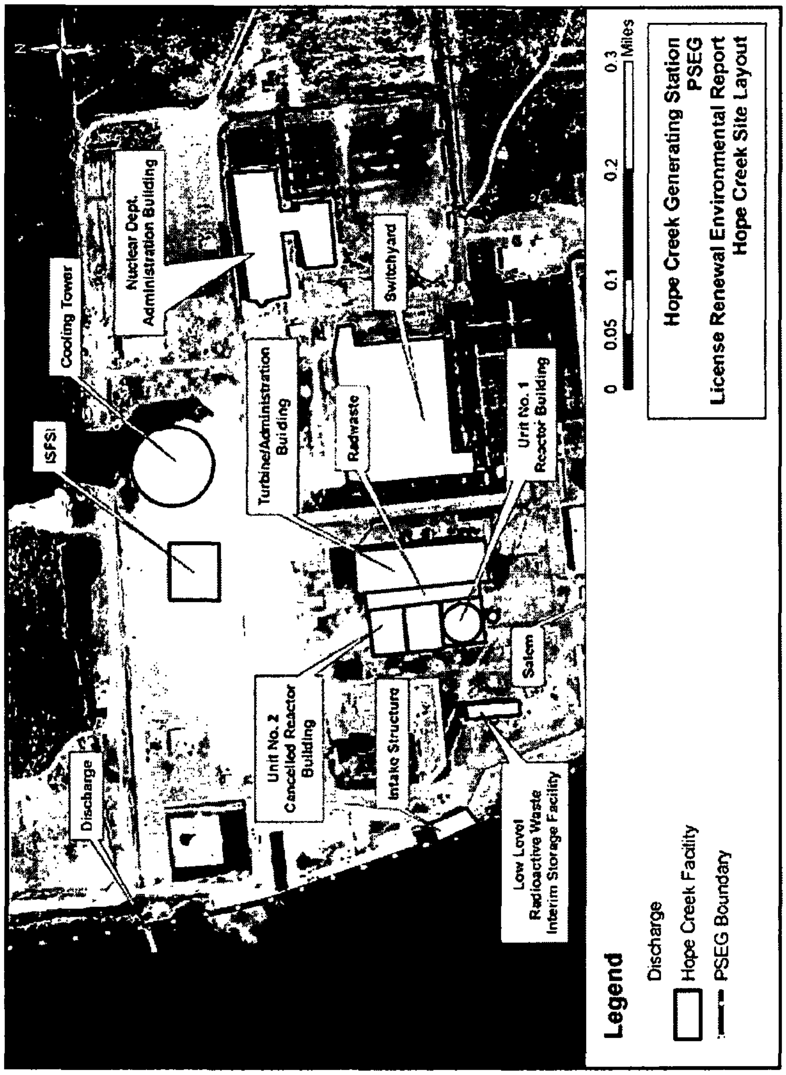


Figure 2-4. HCGS Facility Layout (Source: PSEG 2009b)

Three metropolitan areas lie within 50 miles of the PSEG site: Wilmington, Delaware, the closest city, approximately 15 miles to the northwest; Philadelphia, Pennsylvania, approximately 35 miles to the northeast; and Baltimore, Maryland, approximately 45 miles to the ~~east-~~ southwest~~east~~ (Figure 2-5 shows a map of the site within a 50-mile radius).

Industrial activities within 10 miles of the site are confined principally to the west bank of the Delaware River north of Artificial Island (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 (U.S. Census Bureau [USCB] 2006). Smaller communities in the vicinity of the site (Haddock's Bridge, New Jersey; Salem, New Jersey; Quinton, New Jersey; and Shenandoah, Delaware) consist of primarily of small retail businesses.

Located about two miles west of the site on the western shore of the Delaware River is the Augustine State Wildlife Management Area, a 2667-acre 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 northeast of the site is the upper section of the Mad Horse Creek Fish and Wildlife Management Area. This is a non-contiguous 9500-acre wildlife area managed by the New Jersey Division of Fish and Wildlife with sections northeast, east, and southeast of the site (NJDFW 2009a). Recreational activities at these wildlife areas within 10 miles of the site consist of boating, fishing, hunting, camping, hiking, picnicking, and swimming.

Salem currently employs a workforce of approximately 665 regular, full-time employees and HCGS currently employs a workforce of approximately 513 regular, full-time employees. The facilities share up to an additional 270 PSEG corporate and 86 matrixed employees for a total of about 1500 site employees (PSEG 2009a, PSEG 2009b).

2.1.1 Reactor and Containment Systems

2.1.1.1 Salem

Salem is a two-unit plant utilizing pressurized water reactors (PWR) designed by Westinghouse Electric. Each unit has a current licensed thermal power at 100 percent power of 3459 megawatt-thermal (MWt; PSEG 2009a). Salem Units 1 and 2 entered commercial service June 1977 and October 1981, respectively~~(Nuclear News 2009)~~(NRC Information Digest, NUREG-1350). At 100 percent reactor power, the currently anticipated net electrical output is approximately 1169 megawatt-electric (MWe) for Unit 1 and 1181 for Unit 2 (Nuclear News 2009). 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 MWe (referred to as "Salem Unit 3") is also present. (PSEG 2009a, PSEG 2009b)

Comment [C1]: We should use an NRC source for this information.

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 straight tube-and-shell heat exchanger that

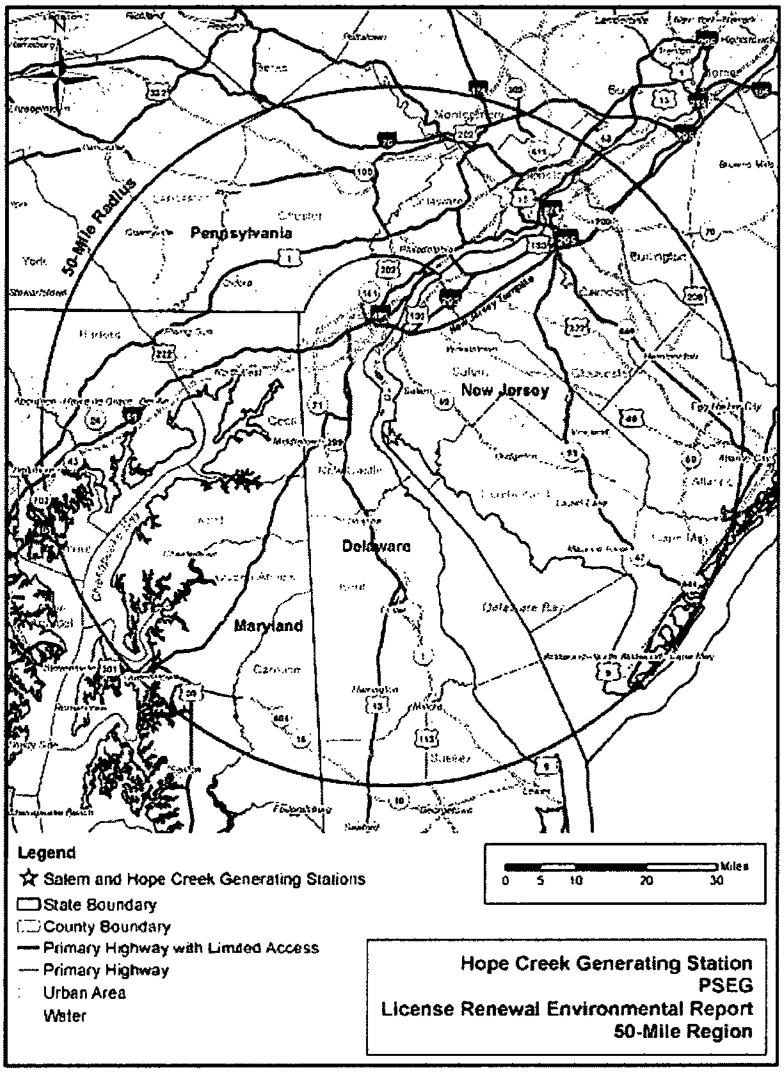


Figure 2-5. Location of of Salem and HCGS Site, within a 50-Mile Radius (Source: PSEG 2009a, PSEG 2009b)

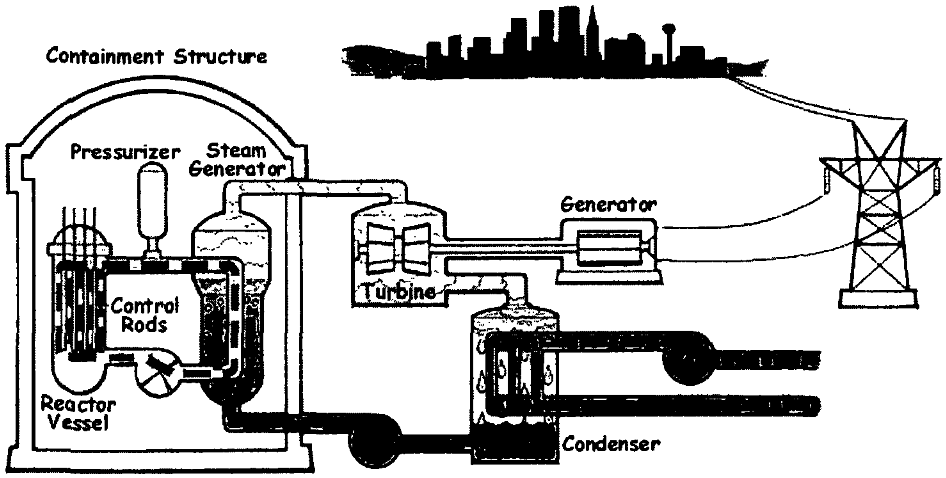


Figure 2-6. Simplified Design of a Pressurized Water Reactor (U.S. Nuclear Regulatory Commission [NRC] 2010a)

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 it cools and converts back to liquid water. This cool water is then cycled back to the steam generator, completing the loop. (NRC 2010a)

The ~~secondary~~ containment for radioactive material that might be released from the core following a loss-of-coolant accident are the units' independent Containment and Fuel Handling Buildings and their associated isolation systems. The structures serve as both a biological shield and a pressure container for the entire reactor cooling system. The reactor containment structures are vertical cylinders with 16 ft (4.88 meters [m]) thick flat foundation mats and 2 to 5 ft (0.61 to 1.52 m) thick reinforced concrete slab floors topped with hemispherical dome roofs. The side walls of each building are 142 ft (43.28 m) high and the inside diameter is 140 ft (42.67 m). The concrete walls are 4.5 ft (1.37 m) thick and the containment building dome roofs are 3.5 ft (1.07 m) thick. The inside surface of the reactor building is lined with a carbon steel liner with a varying thickness of 0.25 inch (0.635 centimeter [cm]) to 0.5 inch (1.27 cm) (PSEG 2007).

Comment [C2]: Using "secondary" containment is confusing. There was no discussion of the "primary" containment (i.e., fuel pellet and rod). Primary and secondary containment can be confused with BWR physical structures. I recommend that "secondary" be deleted.

The cores of the Salem reactors are moderated and cooled by light water (^1H_2O as compared to heavy water, ^2H_2O) at a pressure of 2250 pounds per square inch absolute (psia). Boron is present in the light water coolant as a neutron absorber. A moderator, or neutron absorber, is a substance that slows the speed of neutrons increasing the likelihood of fission of a 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 2007a).

Both Salem units utilize slightly enriched uranium dioxide (UO_2) ceramic fuel pellets in zircaloy cladding (PSEG 2007a). Fuel pellets form 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 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

HCGS is a one-unit station utilizing a boiling water reactor (BWR) designed by General Electric. The power plant has a current licensed thermal power at 100 percent power of 3840 MWt with an electrical output estimated to be approximately 1083 MWe (73 FR 13032)~~, Nuclear News 2009)~~. 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).

Comment [C3]: See above comment (S1) to use an NRC reference, NUREG-1350

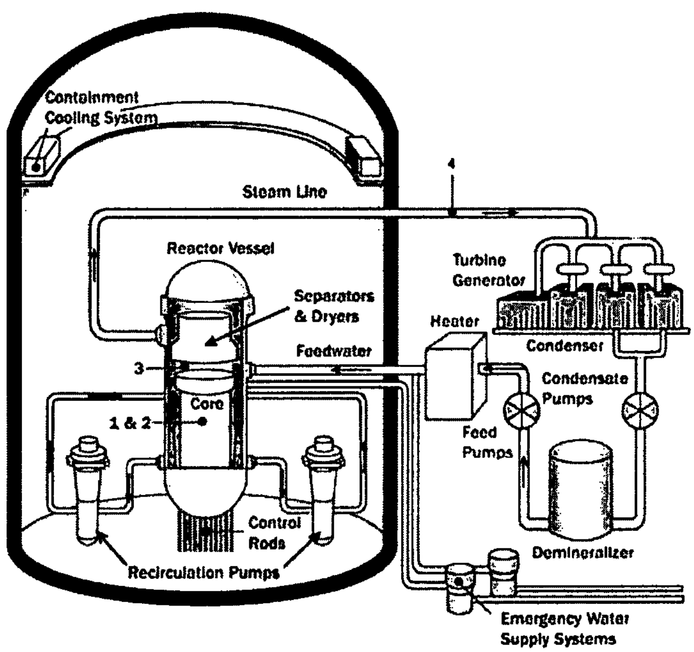


Figure 2-7. Simplified Design of a Boiling Water Reactor (NRC 2010b)

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 it cools and converts back to liquid water. This cool water is then cycled back to the reactor core, completing the loop (NRC 2010b).

The ~~secondary~~ containment for radioactive material that might be released from the core following a loss-of-coolant accident is the Reactor Building. The structure serves as both a biological shield and a pressure container for the entire reactor cooling system. The reactor building structure is a vertical cylinder with 14-ft (4.28-m) thick flat foundation mats and 2 to 5 ft (0.61 to 1.52 m) thick reinforced concrete slab floor. The side walls of the cylinder are approximately 250 ft (72.2 m) high, topped with torispherical dome roof, and surrounded by a rectangular structure that is up to 132 ft (40.2 m) tall. (PSEG 2006).

Comment [C4]: Similat to comment S2. Delete "secondary"

The HCGS reactor utilizes slightly enriched UO_2 ceramic fuel pellets in zircaloy cladding (PSEG 2007). Fuel pellets form 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 megawatt-days per metric ton uranium (73 FR 13032).

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 reactor coolant system or were contaminated by contact with liquids from the reactor coolant system (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 reactor coolant system, solids that came into contact with reactor coolant system liquids or gases, or solids used in the reactor coolant system or steam and power conversion system operation or maintenance.

The Salem and HCGS facilities include radioactive waste systems, which collect, treat, and provide for disposal of radioactive and potentially radioactive wastes that are byproducts of plant operations. Radioactive wastes include are 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 reactor coolant system. 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 been exhausted, a certain percentage of its fissile uranium content is referred to as spent fuel. Spent fuel assemblies are removed from the reactor core and replaced with fresh fuel assemblies during routine refueling outages, typically every 18 months. Spent fuel assemblies are stored in the spent fuel pool. Salem's spent fuel pool storage capacity for each unit is 1632 fuel assemblies that will allow sufficient storage up to the year 2011 for Unit 1 and 2015 for Unit 2 (PSEG 2009a). The HCGS spent fuel pool facility is designed to store up to 3976 fuel assemblies (PSEG 2009b).

In 2005, the NRC issued a general license to PSEG authorizing that spend 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 50, to store spent fuel from both HCGS and Salem at the ISFSI, provided that such storage occurs in pre-approved casks in accordance with the requirements of 10 CFR 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 spent fuel pool 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 (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 Control 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 Federal and State regulation. 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 prior to releasing it to the Delaware Estuary via the circulating water system and a permitted outfall. Discharge streams are appropriately monitored, and safety features are incorporated to preclude releases in excess of the limits of 10 CFR 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 Spent Fuel Pool. 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 ground-water recovery system (GRS) had been installed (PSEG 2009a). The groundwater recovery system pulls groundwater toward the recovery system and away from the site boundary.

Since 2005, tritium-contaminated groundwater from the groundwater recovery system 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 off-site 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 groundwater recovery system 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 prior to 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 20, *Standards for Protection Against Radiation* (PSEG 2009b).

Both Salem and HCGS release liquid effluents into the environment. Rereleases are controlled and monitored. Doses from these releases represent a fraction of the regulatory allowable 100 millirem per year (mrem/yr) doses specified in the facility operating license and NRC regulations. Radiological monitoring began in 1968. Monitoring results are presented in the Radiological Environmental Monitoring Program reports. The NRC staff reviewed the Salem/ HCGS radioactive effluent release reports for 2004 through 2009 for liquid effluents were reviewed by the NRC Staff (PSEG 2005a, PSEG 2006a, PSEG 2007a, PSEG 2008a, PSEG 2009c, PSEG 2010a). No unusual trends were identified in the total activity of the liquid waste effluent (measured in curies). However, while the effluent activity remained rather constant in the trend graphs presented in the 2009 report (PSEG 2010a), the calculated dose to the hypothetical maximum exposed individual showed a dramatic decrease from 2007 to 2008 and the dose stayed near the 2008 level in 2009. The decrease in dose demonstrated on the trend graph is about three orders on magnitude, or 1000 times. No explanation is provided in the 2008 or 2009 reports for the dramatic decrease in calculated dose.

~~Both Salem and HCGS release liquid effluents into the environment. Rereleases are controlled and monitored. Doses from these releases represent a fraction of the regulatory allowable 100 millirem per year (mrem/yr) doses specified in the facility operating license and NRC regulations. Radiological monitoring began in 1968. Monitoring results are presented in the Radiological Environmental Monitoring Program reports. The NRC staff reviewed the Salem/ HCGS radioactive effluent release reports for 2004 through 2009 for liquid effluents were reviewed by the NRC Staff (Staff) (PSEG 2005a, PSEG 2006a, PSEG 2007a, PSEG 2008a, PSEG 2009c, PSEG 2010a).~~

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 gasses 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 gasses are collected in tanks in the Auxiliary Building and released intermittently in a controlled manner. At HCGS, gasses 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 prior to being released to the atmosphere from the north plant vent.

Radioactive effluent release reports for 2004 through 2009 for gaseous effluents were reviewed by the Staff (PSEG 2005a, PSEG 2006a, PSEG 2007a, PSEG 2008a, PSEG 2009c, PSEG

2010a). While variations in total effluents and effluent concentrations can vary from year to year due to outages and plant performance, based on the gaseous waste processing system's performance from 2004 through 2008, the gaseous discharges for 2009 are consistent with prior year effluents. The NRC identified no unusual trends.

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 radioactive 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 Low-Level Waste Compact. New Jersey is a member of the Atlantic Low-Level Interstate Compact and has access to the Barnwell Low Level Radioactive Waste facility (Barnwell). Shipments to Barnwell include spent resins from the demineralizers and filter cartridges (wet processing waste). 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 for volume reduction by a licensed off-site vendor. The volume-reduced DAW is repackaged at the vendor and shipped for disposal at a licensed low-level waste disposal facility (PSEG 2009a, PSEG 2009b). DAW and other non-compactable contaminated wastes are typically shipped to the Energy Solutions' Class A disposal facility in Clive, Utah.

The LLRSF also maintains a 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.

Solid waste and irradiated fuel shipment reports from 2005 through 2009 were reviewed by the NRC staff (Annual Radiological Release Reports for 2005-2009).) The solid waste volumes and radioactivity amounts generated in 2009 are typical of previous years. Typically all waste consisted for Class A LLW.; however, in 2009, Class B and Class C wastes (resins, filters, and/or evaporator bottoms) were shipped from Salem. Class B waste had not been shipped from Salem since 2006 and no Class C waste was shipped in any of the previous 5 years. Variations in the types and amount of solid waste generated and shipped from year to year are expected based on the overall performance of the plants and the number and scope of outages and maintenance activities. The most recent outages were April 2010 for Salem Unit 1, October 2009 for Salem unit 2, and April 2009 for Hope Creek. Schedule outages occur at each plant every 18 months. The volumes and activity of solid waste LLW reported are reasonable and no unusual trends were noted.

~~LLRSF LLW reports for ____ through 2009 were reviewed by the Staff (__*Document available May 30________). The solid waste volumes and radioactivity amounts generated in 2009 are typical of previous annual waste shipments. Variations in the amount of solid radioactive waste generated and shipped from year to year are expected based on the overall performance of the plant and the number and scope of outages and maintenance activities. The volume and activity of solid radioactive wastes reported are reasonable and no unusual trends were noted.~~

No plant refurbishment activities were identified by the applicant as necessary for the continued operation of either Salem or HPGS through the license renewal terms. Routine plant operational and maintenance activities currently performed will continue during the license renewal term. Based on past performance of the radioactive waste system, and the lack of any planned refurbishment activities, similar amounts of radioactive solid waste are expected to be generated during the license renewal term.

2.1.2.4 Mixed Waste

The term "mixed waste" refers to waste that contain 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 Resources 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 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, daily refuse (PSEG 2009a, PSEG 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 waste 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 currently is a small-quantity hazardous waste generator (PSEG 2010b), generating less than 220 pounds/month (lb/month; 100 kilograms/month[kg/month]). Hazardous waste storage (180-day) areas include the Hazardous Waste Storage Facility (Locations Numbers [Nos.] SH3 and SH30), the Combo Shop (Location No. SH5), and two laydown areas (Location Nos. SH6 and SH7) 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 2010).

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]). On October 17, 2008, the EPA finalized several changes to the Emergency Planning (Section 302), Emergency Release Notification (Section 304), and Hazardous Chemical Reporting (Sections 311 and 312) regulations that were proposed on June 8, 1998 (63 Federal Register [FR] 31268). 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 NRC 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 NRC viewed the PSEG sewage sludge waste volumes from 2005 through 2009. The average annual volume for these years was about 50,000 lbs. 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 [approximately 5000 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

Salem facility maintains a New Jersey Pollutant Discharge Elimination System (NJPDES) permit, NJ 0005622, which authorizes the discharge of wastewater to the Delaware Estuary and stipulates the conditions of the permit. HCGS maintains a separate NJPDES permit, NJ 0025411 for discharges to the Delaware Estuary. All monitoring shall be 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 2) the method approved by the NJ DEP 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 Hope Creek cooling tower blowdown outfall to the Delaware Estuary. Residual cooling tower blowdown dechlorination chemical, ammonium bisulfite, de-chlorinates the sewage treatment effluent (PSEG 2009a, PSEG 2009b).

Salem and HCGS share the Non-Radioactive Liquid Waste Disposal System (NRLWDS) chemical waste treatment system. The NRLWDS is located at Salem facility and operated by Salem staff. The NRLWDS collects and processes non-radioactive secondary plant wastewater prior to discharge into the Delaware Estuary. The waste water originates in plant process such as demineralizer regenerations; steam generator blowdown, chemical handling operations, and reverse osmosis reject waste. The outfall is monitored in accordance with the current Hope Creek NJPDES Permit (No. NJ0025411) (PSEG 2009a, PSEG 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 Hope Creek 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

2.1.3.6 Release of Plant-Related Radionuclides

To provide a history of spills for Salem and Hope Creek site, an expanded 10 CFR 50.75(g) report was provided to the NRC at the site audit. For completeness, it included some legacy items that are not required to be retained under 10 CFR 50.75(g). The only 50.75(g) events named in the report (i.e., instances where significant contamination remains after cleanup) are the April 1995 Hope Creek incident and the Salem condensate polisher event from May 2007 described below.

- Hope Creek: April 5, 1995: Approximately 88 millicuries (mCi): Steam from the decontamination Solution Evaporator release from Hope Creek's south plant vent due to inadequate rigor during the design review process.

- Salem: May 24, 2007: 2.8 mCi of Cs-137 released in front of the Salem Unit 2 condensate polisher as a result of burst site glass during operation and resin was blown through the wall into the switchyard.

In 2002, low-level tritium contamination was detected on the shoes of several Salem technicians. In September of the same year, a remedial investigation identified that the source of the contamination was water leaking from the Salem spent fuel pool (SFP) (Arcadis 2006). Remediaiton activities that were conducted between 2002 and 2006 help to further define the pathway of the contamaintion to the shallow groundwater where tritium concentrations exceeded the NJDEP Groundwater Quality Criteria (GWQC). The source of the contamination was identified as SFP water leaking into the seismic gap between the SFP Building and the Salem Unit 1 Containment Building (Arcadis 2006).

In 2006, PSEG performed a Preliminary Assessment and Site Investigation (PA/SI) describing the environmental status of a release of tritium, strontium, and plant-related gamma emitting radionclides (GER). Groundwater samples indicated that tritium had not migrated beyond the shallow groundwater in area south of the Salem Auxiliary Building and that GERs had not migrated beyond the seismic gap. Monitoring of the GERs in the seismic gap also indicates that releases from the SFP have stopped (Arcadis 2006). However, given that there is no transport mechanism to remove the GERs from the area of the seismic gap, the GERs with long half-lives are expected to remain until plant decommissioning.

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 in-service 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 in-service inspection, and scheduled maintenance. Salem and HCGS are on an 18-month refueling cycle (PSEG 2009a, PSEG 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, PSEG 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 HCGS-Red Lion and Red Lion-Keeney lines, which narrow to 200 ft. Unless otherwise noted, the discussion of the power transmission system is adapted from the Applicant's Environmental Reports (ER) (PSEG 2009a, PSEG 2009b) or information gathered at 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). 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 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 ROW

- *Salem-New Freedom North* – This 500-kV line, which is operated by PSE&G, runs northeast from HCGS for 39 miles (mi; 63 kilometers [km]) within a 350-ft (107-m) wide corridor to the New Freedom switching station north of Williamstown, New Jersey. 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 a 350-ft (107-m) wide corridor to the New Freedom switching station north of Williamstown, New Jersey. This line shares the corridor with the 500-kV Salem-New Freedom North line. During 2008, a new substation (Orchard) was installed along this line, dividing it into two segments.

2.1.5.2 New Freedom South ROW

- *Salem-New Freedom South* - This 500-kV line 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, New Jersey.

2.1.5.3 Keeney ROW

- *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 (70 m) wide, and the remainder is 350-ft (107-m) wide.

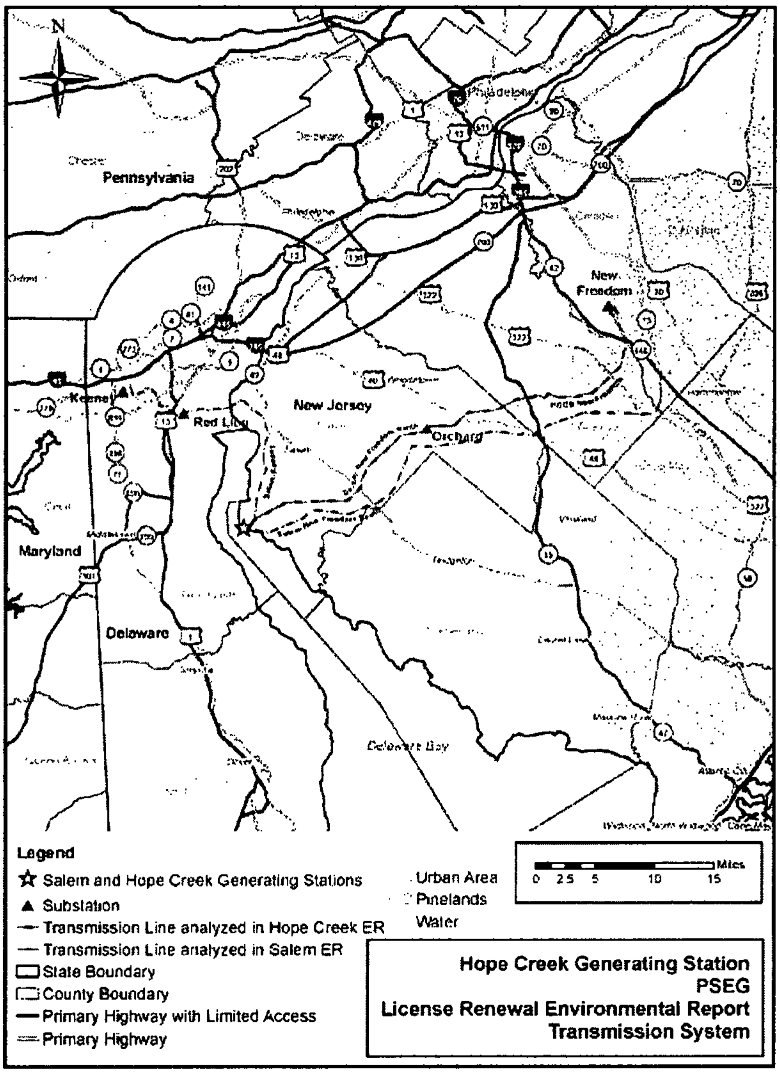


Figure 2-8. Salem and HCGS Transmission Line System (Source: PSEG 2009b)

The ROW corridors comprise approximately 149 mi (240 km) and 4,376 acres (ac; 1771 hectares [ha]); the lines cross within Camden, Gloucester, and Salem counties 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 PSE&G and PHI regardless of Salem and HCGS continued operation (PSEG 2009a, PSEG 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 2000 ft (610 m); this line does not pass beyond the site boundary and is not discussed as an offsite ROW.

Table 2-1. Salem and HCGS Transmission System Components

	Approximate Length			*ROW width*	*Approximate ROW area*
Line	***Owner***	***kV***	***mi (km)***	***ft (m)***	***ac (ha)***
New Freedom North ROW					
Salem–New Freedom North	PSE&G	500	39 (63)	350 (107) —	1824
HCGS–New Freedom	PSE&G	500	43 (69)		
New Freedom South ROW					
Salem–New Freedom South	PSE&G	500	42 (68)	350 (107)	1782
Red Lion ROW					
Salem-Red Lion	PSE&G	500	17 (27)	*200/350 (107)	521
Red-Lion Keeney	PHI	500	8 (13)	*200/350 (107)	249
Total acreage within ROW					4,376

* two–thirds of the corridor is 200 ft (70 m) wide.
Source: PSEG 2009a, PSEG 2009b.

2.1.6 Cooling and Auxiliary Water Systems

Salem and HCGS use different types of cooling water systems (CWS) for condenser cooling but both withdraw from and discharge water to the Delaware Estuary. Salem Units 1 and 2 use once-through circulating water systems. 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, PSEG 2009b), or information gathered at the site audit.

Both sites use groundwater as the source for fresh potable water, fire protection water, industrial process make-up water, and for other sanitary water supplies. Under authorization from the NJDEP (NJDEP 2004a) and Delaware River Basin Commission (DRBC) (DRBC 2000), PSEG can services both facilities with up to 43.2 million gallons (163 million liters) 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

The Salem facility includes two intake structures, each equipped with equipment used to remove debris and biota from the intake water stream (i.e., removable ice barriers, trash racks, traveling screens, and a fish return system). 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 and discharges water north on the CWS intake structure via a discharge pipe that extends 500 ft (152 m) from the shore line. Heavy duty trash racks protect the circulating water pumps and traveling screens from damage by large debris. The trash racks are constructed of 0.5-inch (1.27-cm) wide steel bars with slot opening that are 3 inch (7.6 cm) wide. No biocides are required in the CWS.

The CWS provides approximately 1,050,000 gallons per minute (gpm) (3,974,670 liters per minute [lpm]) to each of Salem's two reactor units. The total design flow is 1,110,000 gpm (4,201,794 lpm) through each unit. The intake velocity is approximately 1 per second (fps) (0.3 meters per second [mps]) (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 (flow path shown in the lower right of Figure 2-3).

Approximately 400 ft (122 m) north of the CWS intake structure, a separate intake structure withdraws water for the SWS which supplies cooling water to the reactor safeguard and auxiliary systems. The structure contains four bays, each containing three pumps. The 12 service-water pumps have a total design rating of 130,500 gpm (493,922 lpm). The average velocity throughout the SWS intake is less than 1 fps (0.3 mps) at the design flow rate. Like the CWS intake structure, the SWS intake structure is equipped with trash racks, traveling screens, and filters to remove debris and biota from the intake water stream. Debris collected from the system is removed and transported to a landfill for disposal. Backwash water is returned to the estuary.

To prevent organic buildup and 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. Residual chlorine levels are maintained in accordance with the site's NJPDES Permit.

2.1.6.2 Hope Creek

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 at a rate of 0.3 fps (0.09 mps) passing through trash racks and traveling screens. 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 (62,459 lpm). 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 million liters) of water and provides approximately 612,000 gpm (2.317 million lpm) 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 (flow path shown in the lower right of Figure 2-4).

The HCGS cooling tower is a 512-foot (156-meter) high single counterflow, hyperbolic, natural draft cooling tower (PSEG 2008). While the CWS is a closed-cycle system, water is lost due to evaporation. Monthly losses average from 9600 gpm (36,340 lpm) in January to 13,000 gpm (49,210 lpm) 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 make-up, fire protection, and sanitary purposes (PSEG 2009a, PSEG 2009b). Facility groundwater withdrawal is authorized by the NJDEP and the DRBC. The total authorized withdrawal volume is 43.2 million gallons (163 million liters) per month for both the Salem and HCGS sites combined (NJDEP 2004a, 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, PSEG 2009b). The NJDEP permit is a single permit which establishes a combined permitted limit for both facilities combined of 43.2 million gallons (163 million liters) per month (NJDEP 2004a).

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. Well PW-5 has a capacity of 800 gpm (3016 lpm), and PW-6 has a capacity of 600 gpm (2262 lpm) (DRBC 2000). The average water withdrawal from these two wells between 2002 and 2008 was 114 million gallons (430 million liters) per year (TetraTech 2009). These wells are used to maintain water volume within two 350,000 gallon (1.3 million liter) storage tanks, of which 600,000 gallons (2.26 million liters) 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 stand-by wells by NJDEP (NJDEP 2004a), 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 (2,827 liters per minute), and the average water withdrawal from the two wells between 2002 and 2008 was 96 million gallons (362 million liters) per year (TetraTech 2009). The wells are used to maintain water supply within two 350,000 gallon (1.3 million liter) storage tanks. The bulk of the water in the storage tanks (656,000 gallons [2.47 million liters]) 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 (792 million liters) per year, or 17.5 million gallons (66 million liters) per month (TetraTech 2009). This usage is approximately 41 percent of the withdrawal permitted under the DRBC authorization and NJDEP permit (DRBC 2000, NJDEP 2004a).

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, PSEG 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 (4,201,794 liters per minute) for each unit, or a total of 2,220,000 gpm (8,403,588 liters per minute) 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, to provide 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 (246,996 liters per minute) for each unit, or a total of 130,500 gpm (493,992 liters per minute) for both units combined. The

Salem SWS water is treated with sodium hypochlorite biocides to prevent biofouling (PSEG 2009a).

The withdrawal of Delaware River water for the Salem CWS and SWS systems is regulated under the terms of the Salem NJPDES permit, Number NJ005622, and is also authorized by the DRBC. The NJPDES permit limits the total withdrawal of Delaware River water to 3,024 million gallons per day (11,447 million liters per day), for a monthly maximum of 90,720 million gallons (342,014 million liters) (NJDEP 2001). The DRBC authorization allows withdrawals not to exceed 97,000 million gallons (365,690 million liters) in a single 30-day period (DRBC 1977, DRBC 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 mps) (PSEG 2006c). The discharge from Salem is regulated under the terms of the NJPDES permit number NJ005622 (NJDEP 2001). The locations of the intake and discharge for the Salem facility are shown on 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 (62,459 lpm) for each pump, or a total of 66,000 gpm (249,836 lpm) 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 million liters) of water, and circulates water through the CWS at a rate of 612,000 gpm (2.317 million liters per minute). 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 (36,340 liters per minute) in January to 13,000 gpm (49,210 liters per minute) 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 the HCGS NJPDES permit, Number 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 for HCGS operations (NJDEP 2003). Actual withdrawals average 66.8 million gallons per day (253 million liters per day), of which 6.7 million gallons per day (25 million liters per day) are returned as screen backwash, and 13 million gallons per day (49 million liters per day) is evaporated. The remainder (approximately 46 million gallons per day [179 million liters per day]) is discharged back to the river (PSEG 2009b).

The HCGS DRBC contract allows withdrawals up to 16.998 billion gallons (64 billion liters) per year, including up to 4.086 billion gallons (15.4 billion liters) 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, New Jersey (DRBC 2001). To accomplish this, PSEG is one of several utilities which own and operate the Merrill Creek reservoir in Washington, New Jersey. 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 1500 ft (458 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 the NJPDES permit number NJ0025411 (NJDEP 2001). The locations of the intake and discharge for the HCGS facility are shown on 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 wide at this location. Artificial Island is a 1500-acre island of tidal marsh and grassland that was created, beginning early in the twentieth century, by the U.S. Army Corps of Engineers. The island was created by disposal of hydraulic dredge spoils within a progressively enlarged diked area, which was established around a natural bar that projected into the river. The average elevation of the island is about 9 ft above MSL with a maximum elevation of approximately 18 ft MSL (AEC 1973). The site is located approximately 17 mi south of the Delaware Memorial Bridge, 30 mi southwest of Philadelphia, Pennsylvania, and 7.5 mi southwest of the City of Salem, NJ (PSEG 2009d).

PSEG owns approximately 740 acres at the southern end of the island, with Salem located on approximately 220 acres and HCGS occupying about 153 acres. The remainder of Artificial Island remains undeveloped. 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, LACT 1988b, PSEG 2009a, PSEG 2009b). The U.S. government also owns a one-mile wide inland strip of land abutting the island (AEC 1973). 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 related to the Delaware River tide line at that time (PSEG 2009a, PSEG 2009b).

The area within 15 mi 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 south-southwest and west-northwest of Salem and HCGS in Delaware. The nearest permanent residence in New Jersey is located 3.6 mi east-northeast of the facilities (PSEG 2009c). The closest densely populated center (with 25,000 residents or more) is located 15.5 mi from Salem and HCGS (PSEG 2009a, b). There is no heavy industry in the area surrounding Salem and HCGS; the nearest such industrial area is located more than 15 mi north of the site (PSEG 2009c).

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, PSEG 2009b). Correspondence related to the certification is in Appendix D of this SEIS. By letters dates 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 Southwest Zone, which is characterized by low elevation near sea level and close proximity to 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 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 (116.2 cm), with most rain falling in July and August and 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; and
- 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 (21.9 ha) and in 2009 a series of brush fires destroyed approximately 15 ac (6.1 he) 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 (14.4 km) northwest of the facilities (NOAA 2010d).

2.2.2.2 Air Quality

Salem County 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). 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, nitrogen dioxide, ozone, sulfur dioxide, particulate matter, and meteorological characteristics. The closest air quality monitoring station to the Salem and HCGS facilities is in Millville, located approximately 23 mi (36.8 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 (particulate matter[pm]), ground-level ozone, carbon monoxide (CO), sulfur oxides (SO^2), nitrogen oxides (NO_x), 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 $PM_{2.5}$, 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 (Pennsylvania -New Jersey -Delaware -Maryland) non attainment 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 2010a). 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).

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 miles (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 (161 km) of the facilities (40 CFR 81.400).

PSEG has a single Air Pollution Control Operating Permit (Title V Operating Permit), Number BOP080001, from the NJDEP to regulate air emissions from all sources at Salem and HCGS (PSEG 2009a, PSEG 2009b). This permit was last issued on February 2, 2005, and expired on February 1, 2010. 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 located at Salem which are regulated under the permit include:

Comment [C5]: Indicate re-application, under which permit it is operating since expiration in February 1, 2010, and when to expect renewal of permit by NJDEP.

- A boiler for heating purposes
- Salem Unit 3, a 40 MW fuel-oil fired peaking unit which is 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

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 start-up steam for the boiling water reactor
- 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

[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 > 100 tons/year, or any single hazardous air pollutant (HAP) at a rate of greater than 10 tons/year or a combination of HAPs at a rate greater than 25 tons/year.

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-foot (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 2006).

2.2.3 Ground Water 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) bgs (PSEG 2007b). 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 towards the southwest, towards 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 Vincentown aquifer is confined and semi-confined beneath Miocene clays of the Kirkwood Formation. Groundwater within the Vincentown aquifer flows towards the south. Water within the Vincentown aquifer is potable, and is 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 2007b).

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 aquifer, which is found at a depth of 450 ft (145 m), with fresh water encountered to a depth of 900 ft (290 m) bgs at the facility location (PSEG 2007b). The Potomac-Raritan-Magothy 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 1000 gpm (1885 to 3770 lpm) (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 mile (1.6 km) of the Salem and HCGS facilities (PSEG 2009a, PSEG 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 Potomac-Raritan-Magothy Aquifer to more than 14,000 customers in Pennsgrove, located approximately 18 miles (29 km) north of the Salem and HCGS facilities (EPA 2010b, NJAW 2010). The other two major suppliers are Pennsville Township and the City of Salem (EPA 2010b). 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 2010b). The Pennsville Township water system is located approximately 15 miles (24 km) north of the Salem and HCGS facilities, and supplies water to approximately 13,500 residents from the Potomac-Raritan-Magothy Aquifer (EPA 2010b; NJDEP 2007a).

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 2010c). The nearest offsite use of groundwater for potable water supply is located approximately 3.5 miles (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 (Delaware Department of Natural Resources and Environmental Control [DNREC] 2003).

2.2.3.3 Available Volume

Groundwater within the Potomac-Raritan-Magothy 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 the available water quantity within the aquifer (U.S. Geological Survey [USGS] 1983). Large scale withdrawals of water from the aquifer are known to influence water availability at significant lateral distances from pumping centers (USGS 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 Potomac-Raritan-Magothy aquifers in the Salem County area (USGS 2009).

2.2.3.4 Existing Quality

Annual Radiological Environmental Monitoring Program (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 (PSEG 2007a, PSEG 2008a, PSEG 2009c) were reviewed. 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 Spent Fuel Pool was identified. The initial indication of the release was the detection of low-level radiation on a worker's shoes in the Unit 1 Auxiliary Building in 2002. This led to the discovery of a chalk-like radioactive substance on the walls of the Mechanical Penetration Room, which had resulted from the seepage of water from the Spent Fuel Pool. The seepage was caused by 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 of the cofferdam, and this 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 towards 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 Groundwater Recovery System (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 migration of the plume towards the property boundaries. The tritium-impacted water removed from the groundwater is processed in the facility's Non-Radioactive Liquid Waste Disposal System (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, the groundwater 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, NRC staff interviewed NJDEP staff~~, including Ms. Karen Tucillo, the director of the NJDEP Radiation Protection Program, and Jerry Humphreys, Tom Kolesnik, and Paul Schwartz of the NJDEP Bureau of Nuclear Engineering,~~ 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 confirm 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 groundwater Radiological Groundwater Protection Program (RGPP) at the Salem and HCGS facilities in 2006. The program, which is separate from the monitoring associated with the groundwater recovery system, 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 semi-annual 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 detections 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 1200 picocuries per liter (pCi/L) in four wells, and at approximately 3500 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 NRC 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, PSEG 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 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 located between Delaware Bay and Trenton, New Jersey (DRBC 2008a). The Lower Region and 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: allocating and regulating water withdrawals and discharges; resolving interstate, water-related disputes; establishing water quality standards; managing flow; and 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 New Jersey Pollutant Discharge Elimination System (NJPDES) permits 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 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 (4,025,953 million liters) 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 (73,745 million liters).

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 River Mile 48.2 to River Mile 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 permits NJ0025411 (for HCGS) and NJ005622 (for Salem).

2.2.4.4 Salem NJPDES Requirements

The current NJPDES permit NJ005622 for the Salem facility was issued with an effective date of August 1, 2001, and an expiration date of July 31, 2006 (NJDEP 2001). 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, so the 2001 permit is still considered to be in force. No substantial changes in permit conditions are anticipated.

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 Disposal System, Radiological Liquid Waste Disposal System, 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 outfalls DSN 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 Outfalls DSN 048C, 481A, 482A, 483A, 484A, 485A, 486A, 487B, and 489A. DSN Outfall 048C is the discharge system for the NRLWDS, and also receives stormwater from the DSN 487B outfall. 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 2001).

1 **Table 2-2. NJPDES Permit Requirements for Salem**

Discharge	Description	Required Reporting	Permit Limits
Discharge Serial Number (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
DSN 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
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
DSN Outfall FACC	Combined for discharges 481A, 482A, 483A, 484A, 485A, and 486A.	Influent flow	3024 MGD monthly average
		Effluent Thermal Discharge	30,600 MBTU/hr daily maximum

2 Source: NJDEP 2001.

Outfalls DSN 481A, 482A, 483A, 484A, 485A, and 486A are the discharge systems for cooling water, Service Water, and the Radiological Liquid Waste Disposal System. Outfalls 481A, 482A, and 483A are associated with Salem Unit 1, while outfalls 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 millions of gallons per day), 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 2001).

Outfall DSN 487B is the discharge system for the #3 skim tank. The permit establishes reporting requirements for discharge volume (in millions of gallons per day), and compliance limits for pH, Total Suspended Solids, temperature of effluent, petroleum hydrocarbons, and Total Organic Carbon (NJDEP 2001).

Outfall DSN 489A is the discharge system for the oil/water separator. The permit establishes reporting requirements for discharge volume (in millions of gallons per day), and compliance limits for pH, Total Suspended Solids, petroleum hydrocarbons, and Total Organic Carbon (NJDEP 2001).

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, a gross temperature of 43.3°C from October to May, and a gross temperature of 46.1°C from June to September (NJDEP 2001).

Similarly, outfall FACB is the combined discharge from Outfalls 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 2001).

Outfall FACC is the combined results from outfalls 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 3024 million gallons per 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 2001).

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

- 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; and
- 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 2001).

2.2.4.5 HCGS NJPDES Requirements

The current NJPDES permit NJ0025411 for the HCGS facility was issued on in early 2003, with an effective date of March 1, 2003 and 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. However, the current status of that renewal is not provided within the ER and attached NJPDES permit (PSEG 2009b).

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 (458 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 collect and discharged through outfalls DSN 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 DSN 461A, DSN 461C, (missing Part D), 516A (Oil Water Separator), and SL1A (sewage treatment plant ~~STP~~ System). 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 millions of gallons per day), 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).

1 **Table 2-3. NJPDES Permit Requirements for HCGS**

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	36.2°C 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 lbs/100 ml monthly geometric, 400 lbs/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
SL1A	STP System residuals from 462B.	17 separate metal and inorganic contaminants	None
		Volumes and types of sludge produced and disposed	None

Comment [C6]:

2 Source: NJDEP 2005a.

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).

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 2005a).

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 sewage treatment plant (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 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).

~~2.2.4.6 REMP~~

~~Annual Radiological Environmental Monitoring Program (REMP) reports document regular sampling of surface water, sediment, and a potable water source. In support of this SEIS, the annual REMP reports for 2006, 2007, and 2008 (PSEG 2007a, PSEG 2008a, PSEG 2009c) were reviewed. In addition, the NJDEP Bureau of Nuclear Engineering (BNE) conducts its own independent Environmental Surveillance and Monitoring Program (ESMP) which includes similar radiological monitoring and sampling of surface water, sediment, and other media. In support of this SEIS, the annual ESMP reports for 2006, 2007, and 2008 were reviewed (NJDEP 2007b, NJDEP 2008a, NJDEP 2009c).~~

~~The REMP program includes the collection and analysis of surface water and sediment samples as follows:~~

- ~~Five surface water locations (four indicator and one control location) sampled monthly, and analyzed for gross beta, gamma emitters, and tritium;~~
- ~~Seven sediment locations (six indicator and one control) sampled semi-annually, and analyzed for gamma emitters; and~~
- ~~One potable water sample, collected from the City of Salem Water and Sewer Department, composited monthly based on daily samples, and analyzed for gross alpha, gross beta, gamma emitters, tritium, and iodine-131. The source of this potable water is surface water from Laurel Lake, combined with water from nearby groundwater wells.~~

~~Surface water results indicate that gross beta have been detected at activities that exceeded pre-operational levels at both the indicator and control locations. In 2008, the maximum pre-operational level for gross beta was 110 pCi/L, with an average of 32 pCi/L. Gross beta activities reported in the 2008 indicator samples had a maximum of 300 pCi/L, and an average of 97 pCi/L. Activities reported in the control sample had a maximum of 158 pCi/L, with an average of 73 pCi/L. Gross beta results from 2006 and 2007 were similar, indicating gross beta activities that exceeded pre-operational levels (PSEG 2007a, PSEG 2008a). For all three years, tritium and gamma emitter were detected at levels below pre-operational activities (PSEG 2007a, PSEG 2008a, PSEG 2009c).~~

~~Sediment results for all three years indicated that no gamma emitters were detected at levels that exceeded their pre-operational activities (PSEG 2007a, PSEG 2008a, PSEG 2009c).~~

~~Potable water sample results for all three years indicate that gross alpha and gross beta were detected, but at activities that were lower than their pre-operational levels. Tritium and iodine-131 were not detected. Naturally occurring gamma emitters potassium-40 and radium were detected in all three years, although there was no pre-operational data for comparison. No other gamma emitters were detected (PSEG 2007a, PSEG 2008a, PSEG 2009c).~~

~~The BNE's ESMP reports each conclude that the data do not indicate any discharges to the environment above the NRC regulatory limits. Also, the reports state that there is no upward trend in radioactivity for those radionuclides associated with commercial nuclear operations (NJDEP 2007a, NJDEP 2008a, NJDEP 2009c).~~

Comment [C7]: The REMP discussion need s to be moved to Chapter 4!

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 river mi (84 river km) north of the mouth of 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 and biological communities. 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 zone that includes 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 (5000 m) (Figure 2-1). The U.S. Army Corps of Engineers maintains a dredged navigation channel near the center of the estuary and about 6600 ft (2011 m) west of the shoreline at Salem and HCGS. The navigation channel is about 40 ft (12 m) deep and 1300 ft (397 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 hr and a mean tidal range of 5.5 ft (1.68 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 Corp. (2005b) characterized salinity at the plant as ranging between 0 and 20 ppt and, in summer during periods of low flow, 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. Visual examination of their Figure B6 indicates that salinity appears to have a median of about 5 ppt, exceeded 12 ppt in only two years and 13 ppt in only one year, and never exceeded about 15 ppt during the entire 11-year period. Based on these observations, NRC staff assumes that salinity in the vicinity of Salem and HCGS is typically from 0 to 5 ppt in periods of low flow (usually, but not always, summer) and 5 to 12 ppt in 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 Delaware Estuary in the Vicinity of Salem and HCGS

Condition	Salinity Range (ppt)
High Flow	0-5
Low 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 (30.4-°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 2.0 ppt per meter of water depth (NRC 1984).

Estuarine waters are classified into three categories based on salinity: oligohaline (0 to 5 ppt), mesohaline (5 to 18 ppt), and polyhaline (greater than 18 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, which it described as 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, which it described as meaning that a diver would not be able to see his hand at arm's length. Most estuarine waters in the Mid-Atlantic have good water clarity, and lower water clarity typically is due to phytoplankton blooms and suspended sediments and detritus (EPA 1998).

2.2.5.2 Plankton

Planktonic organisms live in the water column and are characterized by a relative inability to control their movements. They drift with the water currents and are usually very small (Sutton et al. 1996). Plankton can be primary producers (phytoplankton), secondary producers, consumers (zooplankton), and decomposers (bacteria and fungi). Some organisms spend their entire lives in the plankton (holoplankton) and others spend only specific stages as plankton (meroplankton). Meroplankton include larval fish and invertebrates that use the planktonic life stage to disperse and feed before transitioning to another stage.

Phytoplankton

Phytoplankton are microscopic, single-celled algae that are responsible for the majority of primary production in the water column. Species composition, abundance, and distribution are regulated by water quality parameters such as salinity, temperature, and nutrient availability. As such, seasonal fluctuations are observed, with high abundances in spring, when high runoff from land (nutrients), warmer temperatures, and increasing light levels are experienced. Primary production is limited to the upper 2 m (6.6 ft) of the water column due to light limitation from high turbidity (NRC 1984). These blooms tend to proceed up the estuary over time, presumably due to anthropogenic nutrient increases (Versar 1991). Species found in the upper estuary are generally freshwater species and those in the lower areas are marine species. In the highly variable, tidally influenced zone, species with a high tolerance for widely fluctuating environments are found. Species composition also fluctuates seasonally, with flagellates dominating in the summer and diatoms becoming more abundant in the fall, winter, and spring (DRBC 2008b).

Studies of phytoplankton in the Delaware Estuary which were conducted prior to the operation of Salem Units 1 and 2, are rare and difficult to obtain. These organisms were quantitatively and qualitatively sampled as part of the pre-operation ecological investigations for Salem performed by Ichthyological Associates in the late 1960s and early 1970s (PSEG 1983). These studies revealed that the phytoplankton was dominated by a few highly abundant and productive species, mainly the chain-forming diatoms *Skeletonema costatum, Melosira* sp., and *Chaetoceros* sp. Additionally, species normally found in freshwater (including *Ankistrodesmus falcatus* and *Cyclotella* sp.) were found in the samples, having been transported downriver to the vicinity of the plant. These studies also postulated that phytoplankton were not sufficiently numerous to produce enough primary productivity to sustain the estuarine system, making detritus an important contributor to the trophic structure in Delaware Bay (PSEG 1983). Data published later (PSEG 1984) noted dominance by *S. costatum*, *Melosira* sp., and *Nitzschia* sp. Phytoplankton studies related to operation of Salem Units 1 and 2 were discontinued in 1978, as NJDEP and NRC agreed that operation had no effect on phytoplankton populations (PSEG 1984).

A major literature survey for the Delaware Estuary Program assessed the various biological resources of the estuary and possible trends in their abundance or health (Versar 1991). This study found that phytoplankton formed the basis of the primary production in the estuary, contrary to the studies related to the Salem facility, which postulated a large detrital contribution to trophic dynamics. This study divided the estuary into three regions: bay, mid-estuary or transitional, and tidal fresh. Phytoplankton assemblages in the bay region were dominated by *S. costatum*, *Leptocylindrus* sp., and *Thalasiosira* sp. This area of the estuary also experiences a seasonal dominance shift, switching to an assemblage dominated by flagellates in the summer months. The tidal fresh region was dominated by *Cyclotella meneghiniana*, *Closterium* sp., *Melosira* sp. *Nitzschia* sp., *Scenedesmus* sp., and *Pediastrum* sp. Species dominant in the mid-estuary region were *S. costatum*, *Asterionella* sp., *Cyclotella* spp., *Melosira* sp., *Chlorella* sp., *Closterium* sp., and *Scenedesmus* sp. (Versar 1991).

More recent studies have summarized the data of many older and qualitative surveys and investigations. Phytoplankton in the lower bay (in less turbid water) account for most of the primary production in the system, which is subsequently transferred to other areas by the currents. Detritus is no longer considered a major source of energy in the trophic structure. Several hundred phytoplankton species have been recorded in the Delaware Estuary, but the assemblage is most often dominated by a few highly abundant species. These species include

S. costatum, Asterionella glacialis, Thalassiosira nordenskioeldii, Rhizosolenia sp., and *Chaetoceros* sp. (Sutton et al. 1996). In the fresher reaches of the Delaware River, assemblages are dominated by the diatom *Skeletonema potamos* and various cyanobacteria and green algae.

Phytoplankton are currently surveyed by the New Jersey Department of Environmental Protection (NJDEP). These surveys are conducted in order to monitor harmful algal blooms, and samples are mostly collected for chlorophyll measurements only. Blooms are highly variable between years but 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 2005c).

<u>Zooplankton</u>

Zooplankton live in the water column but are not primary producers. They serve as a vital link between the micro algae and the larger organisms in the Delaware Estuary, some of which are called secondary producers. These animals consume the algae, but are still 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. Two types of zooplankton occur in the water column: holoplankton, which spend their entire life cycle in the water column, and meroplankton, which spend only part of the time in the water column.

Holoplankton include various invertebrates such as shrimps, mysids, amphipods, copepods, ctenophores (comb jellies), jellies, nemerteans, rotifers, and oligocheates. They are dependent on either phytoplankton 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. These organisms also show seasonal and spatial variability in abundance and species composition. During times when runoff is low, more marine species occur farther upstream. Numerical abundance is related to water temperatures and food availability, which are seasonal factors (PSEG 1983). Smaller-scale distribution of holoplankton can be affected by currents, salinity, temperature, and light intensity (NRC 1984). The main factor dictating the distribution of individual species is salinity. There also are seasonal peaks in abundance. In the lower estuary, high densities typically occur in spring and additional peaks can occur in summer and fall. The species composition also varies seasonally, with *Acartia tonsa* more dominant in the winter and summer months. In the upper estuary, cladocerans and *Cyclops viridis* are highly abundant in spring, and gammarid amphipods and *Halicyclops fosteri* are dominant in summer (Versar 1991).

Holoplankton in the Delaware estuary have been more studied than phytoplankton dating back to 1929. Early research observed a large diversity of organisms in the zooplankton assemblage. These studies also revealed the dominance of three copepod species throughout estuary: *A. tonsa*, *Eurytemora hirundoides*, and *Eurytemora affinis,* amounting to 84 percent of all zooplankton. Five species dominated by volume: an amphipod crustacean, or scud *(Gammarus fasciatus)*, *A. tonsa*, *E. hirundoides*, *E. affinis* and an oppossum shrimp (*Neomysis americanus*). Generally, the lower bay was dominated by marine species and species tolerant of high salinity, such as calanoid copepods, and the fresher areas contained less tolerant species, such as cyclopoid copepods, cladocerans, and gammarid amphipods (Versar 1991).

These organisms also were sampled as part of the pre-operational ecological studies for Salem Units 1 and 2. The assemblage was dominated mostly by mysids, primarily opossum shrimp, but also *Mysidopsis bigelowi*, *Metamysidopsis munda*, and *Gastrosaccus dissimilis*. Other species observed during these collections were the medusae of *Blackfordia manhattensis*, the estuarine copepods *E. hirundoides* and *A. tonsa*, and the amphipods *Corophium cylindricum*, *C. lacustre*, *C. acherusicum*, *G. fasciatus*, *G. daiberi*, and *Melita nitida* (AEC 1973). Later collections included additional species, such as *E. affinis*, *Brachionus angularis*, *H. fosteri*, *Notholca* sp., ctenophores, and several rotifer species (PSEG 1983). During the late winter and spring, when large amounts of runoff occur, freshwater zooplankton, such as *B. angularis*, *H. fosteri* and *Nothalca* sp, were found to be more common. When freshwater input was low, more marine forms were found, including *A. tonsa*, and *Pseudodiaptomus coronatus* (PSEG 1984). Studies related to plant operations registered 110 microzooplankton taxa in the early to mid 1970s. Larger zooplankton collections resulted in a total of 46 taxa that were extremely numerically dominated by opossum shrimp and *Gammarus* spp. This dominance resulted in the selection of these species for future ecological studies related to Salem operations because they were deemed important due to their abundance and their status as known prey items for many of the fishes in the estuary. General studies of the zooplankton in the estuary were discontinued in favor of an approach more focused on individual species (PSEG 1984).

Recent studies have not shown a major change in the zooplankton assemblage since the early 1960s. In 1982, over 50 taxa were collected in one study, and copepods were the most dominant species, including *A. tonsa* and *Oithone* sp. throughout and *Temora longicornis*, *Pseudocalanus minutus*, and *Centropages hamatus* in the more saline regions. Copepods are a major prey resource for fish and larval fish in the Delaware Estuary (Sutton et al. 1996).

Macroplankton are large enough to have some control over their movement in the water column, usually accomplished by making use of the tidal currents. Macroplankton species encountered in early studies related to HCGS included opossum shrimp, *Gammarus* spp., sand shrimp (*Crangon septemspinosa*), *Corophium lacustre*, and *Edotia triloba* (PSEG 1983). Due to their dominance and importance to the fish species in the estuary, opossum shrimp and a group of *Gammarus* species were selected as target species in the PSEG ecological monitoring program (PSEG 1984). Although data were collected for these macroplankton, no specific trend analyses were done with respect to changes in their populations (PSEG 1999). Later studies conducted independent of the Salem facility often did not differentiate between macroplankton and zooplankton but noted that there had not been any significant changes in the zooplankton in general since the early 1900s (Versar 1991).

Meroplankton consists of larval fish and invertebrates that have a planktonic stage before their development into a pelagic, demersal, or benthic adult form is complete. This stage provides 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 larval organisms in large numbers, including estuarine mud crab (*Rhithropanopeus harrisii*), fiddler crab (*Uca minax*), grass shrimp (*Palaemonetes pugio*), and copepod nauplii (PSEG 1983).

Due to the fact that many of the fish species found in the Delaware Estuary are managed, either Federally or by the 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. Ichthyoplankton studies initially were general surveys but then were 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 reviewed an extensive amount of data with respect to ichthyoplankton, including both the power plant studies and more general surveys focused on managed fish species. The ichthyoplankton of the tidal freshwater region upstream was found to be dominated by the alosids: American shad (*Alosa sapidissima*), hickory shad (*A. mediocris*), alewife (*A. pseudoharengus*), blueback herring (*A. aestivalis*), and other anadromous species. Due to alosid lifecycles, both eggs and larvae have seasonal peaks in abundance and distribution, depending on the species. The ichthyoplankton of the transitional region, in which Artificial Island is located, is dominated by the bay anchovy (*Anchoa mitchilli*); other species include naked goby (*Gobiosoma bosc*), blueback herring, alewife, Atlantic menhaden (*Brevoortia tyrannus*), weakfish (*Cynoscion regalis*), and silverside (*Menidia menidia*). Species diversity was highest in the spring and summer months, but bay anchovy generally 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. 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. The various benthos discussed here are macroinvertebrates – invertebrates large enough to be seen with the naked eye. The species composition, distribution, and abundance of benthic invertebrates is affected by physical conditions such as salinity, temperature, water velocity, and substrate type. Substrates within the Delaware Estuary include mud, sand, clay, cobble, shell, rock, and various combinations of these.

The estuarine community of benthic invertebrates performs many ecological functions. Some benthic species or groups of species form habitat 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 are limited by salinity and substrate type. Additionally, localized poor water quality can have a major effect on species composition. Species found in the lower bay, such as *Spisula solidissima,* 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. Overall, densities of benthic macroinvertebrates in the Delaware Estuary are lower than in other east coast estuaries and generally are below 1000 individuals per square meters (m^2). Secondary production, however, appears to be similar to other estuaries, with the bivalves *E. directus*, *Mytillus edulis*, and *Tellina agilis* and the polychaete *Asabellides oculata* responsible for most of the energy produced (Versar 1991).

The tidal fresh portion of the estuary is dominated by species that are typical of other North American estuaries, such as 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 the proximity of pollutant sources. Highly tolerant species are found here, often with only one extremely dominant species (for example, along one 10-mi [16-km] segment, 90 percent were *Limnodrillus* spp., and 90 percent of these were *L. heffmeisterii*). The transition zone generally is dominated by oligochaetes and amphipods. The bay region has abundant bivalves (*T. agilis* and *E. directus*) and polychaetes (*Glycera dibranchiata* and *H. filiformis*) (Versar 1991).

Near the Salem and HCGS facilities, estuarine substrates include mud, sand, clay, and gravel (PSEG 1983). Pre-operational studies for Salem Units 1 and 2 found mostly euryhaline species in the vicinity of the plant. Such species are tolerant of a wide variety of salinity conditions, which can change rapidly both daily and seasonally (NRC 1984). The assemblage near the facilities was highly dominated by a few species that could inhabit the available substrate types. These species were the polychaetes *Scolecolepides viridis* and *Polydora* sp., the oligochaete *Paranais litoralis*, the barnacle *Balanus improvisus*, and the isopod *Cyathura polita*. The lowest species richness and density were found in sand due to its tendency to be scoured by rapid currents and its lack of attachment surfaces. Organisms dominating these sandy areas included *S. viridis*, the isopod *Chiridotea almyra*, *Parahaustorius* sp., *Gammarus* spp., opossum shrimp, flat worms (*Turbellaria* sp.) and *P. litoralis*. Clay is also a difficult substrate for most species to colonize, and benthos density and biomass in these areas were reported to be moderate. Dominant species in clay included *Gammarus* spp., *Corophium lacustre, S. viridis, C. polita*, and the polychaetes *Polydora* sp. and *Nereis succinea* (now *Neanthes succinea*). Mud habitats also had moderate species richness and abundance, dominated by *P. litoralis, S. viridis, C. polita*, the nemertean *Rhynchocoela* sp., and unidentified oligochaetes. Gravel substrates had the highest species diversity and richness, although they were still dominated by a few species. Species found living within gravel substrates included *B. improvisus, P. litoralis, S. viridis, N. succinea*, and *C. lacustre*. Other species were found attached to hard surfaces, including the ribbed mussel (*Modiolus demissus*, now *Geukensia demissa*), *Crassostrea virginica*, the ghost anemone *Diadumene leucolena*, and bryozoans (PSEG 1983).

Species composition also was found to vary seasonally, reflecting higher diversity and abundance during periods of higher salinity. This was reported to be a result of both recruitment dynamics and immigration from the lower bay. Seasonal immigrants include *G. dibranchiata, G. solitaria*, the polychaete *Sabellaria vulgaris, Mulinia lateralis*, the pelecypod *Mya arenaria*, and the tunicate *Molgula manhattensis* (PSEG 1983).

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. The EPA collected benthic samples in the Delaware Estuary between 1990 and 1993 in an effort to assess the health of the system. These samples resulted in the determination that 93 percent of the tidal river between the Chesapeake and Delaware Canal and Trenton, New Jersey was either degraded or severely degraded. South of this area, only 2 percent of the benthic invertebrate community was classified as impaired, and none was considered severely impaired (Delaware Estuary Program 1996~~5~~). More recently, the Delaware-Maryland-Virginia coastal bays are considered impacted over one-fourth of their total area. In the Delaware Bay itself, the upper portions are considered severely impacted, the transition area is classified impacted, and the lower bay is mostly considered in good condition, with a large central area impacted, possibly due to scouring from high currents or eutrophication resulting in high organic carbon levels in the sediments (EPA 1998).

Studies conducted during the 1984 NPDES 316(b) permitting process included data from over 1000 grab samples in the Delaware Estuary. A total of 57 taxa in eight phyla were identified. These were dominated by the same species as found in previous studies (*S. viridis*, *Polydora* sp., *P. litoralis*, *B. improvisus*, and *C. polita*). No other changes in the dominant species per substrate type were reported, but additional species (*E. triloba* and the cumacean *Leucon americanus*) were enumerated among the seasonal immigrants. General densities of benthic organisms ranged between 17,000 per m^2 and 25,000 per m^2. Benthic studies were discontinued as part of the monitoring program for PSEG in 1984 due to the determination that benthic invertebrates would not be substantially affected by plant operations (PSEG 1984).

The most prominent types of parabenthos in the Delaware Estuary are mysids (mostly opossum shrimp), sand shrimp, and amphipods. Mysids are a key biological resource in the bay because they are highly abundant and are a prey item 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, 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 dominate 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).

Epifauna and parabenthos in the Delaware estuary also include mollusks, crabs, and other large crustaceans, such as the blue crab (*Callinectes sapidus*) and horseshoe crab (*Limulus polyphemus*). These species can be difficult to sample with the equipment usually used for benthos, sediment grab samplers (PSEG 1984). Blue crabs were often caught 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 the early ecological studies with respect to operation of Salem Units 1 and 2, but they were later determined to be unaffected by the facility and were no longer specifically monitored. The life histories and habitats of the blue crab, horseshoe crab, and American oyster (*Crassostrea virginica*) in Delaware Bay are described below.

<u>Blue Crab</u>

The blue crab is an important ecological, cultural, commercial, and recreational resource in Delaware Bay. It is found in estuaries on the east coast of the United States from Massachusetts to the Gulf of Mexico (Hill et al. 1989). The blue crab is highly abundant in estuaries and, therefore, in addition to its economic importance, it plays an important role in the coastal ecosystem. It is an omnivore, feeding on many other commercially important species, such as oysters and clams. Young blue crabs are also prey items for other harvested species, especially those that use the estuary as a nursery area (Hill et al. 1989). 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 (Atlantic States Marine Fisheries Commission [ASMFC] 2004).

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, storing the sperm in seminal receptacles for subsequent spawning events (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. The first larval stage is the zoea. Zoea larvae are planktonic filter feeders approximately 0.009 inch (0.25 millimeter [mm]) long and develop in 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). Megalops larvae are approximately 0.04 inches (1 mm) in length and can swim but are found more often near the bottom in the lower estuary (ASMFC 2004). After 6 to 20 days, this stage molts into the first crab stage, resembling an adult crab. These juveniles migrate up the estuary into lower salinity regions (Hill et al. 1989). This migration takes approximately 1 year, after which the crabs are adults. Initially, sea grass beds are an important habitat, but crabs then make extensive use of marsh areas as nurseries (ASMFC 2004).

Adult male crabs usually stay in the upper estuary once they are mature, but females will migrate annually to higher-salinity areas to release their young. Crabs bury themselves in the mud during the winter months, and females will do this near the mouth of the estuary so they can release hatchlings in the spring. Adult crabs are unlikely to travel between estuaries, but they are good swimmers and can travel over land. Movements within an estuary are related to life stage, environmental conditions (temperature and salinity), and food availability. Growth and molting rates are controlled by environmental variables (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 also are omnivorous and consume fish larvae, small shellfish, aquatic plants, and each other. Post-larval stages also are omnivorous scavengers, consuming detritus, carcasses, fish, crabs, mollusks, and organic debris. Blue crabs are prey for a variety of predators, depending on life stage. 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, including the spotted sea trout (*Cynoscion nebulosus*), red drum (*Sciaenops ocellatus*), black drum (*Pogonius cromis),* and sheepshead (*Archosargus robatocephalus*). 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 (ASMFC 2004). Declines in blue crab populations could be a result of attempts to increase populations of other fisheries species that prey upon crabs (ASMFC 2004).

<u>Horseshoe Crab</u>

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 (U.S. Fish and Wildlife Service [FWS] 2006). Horseshoe crabs play a major ecological role in the migration patterns of shore birds from the Arctic to the southern Atlantic. They also are used for bait in the American eel and conch (*Busycon carica* and *B. canaliculatum*) fisheries. The biomedical industry uses their blood to detect contaminated medicines. The crabs are bled and released, although up to 15 percent of them do not survive the procedure.

Around 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. By 1960, catches had declined to 42,000 crabs. In 2007, the estimated harvest was 811,000 crabs, a decrease from the 2.75 million caught in 1998. This reduction is 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 prohibits harvesting of all horseshoe crabs in New Jersey and Delaware between January 1 and June 7 and females between June 8 and December 31. It also limits New Jersey and Delaware to 100,000 crabs per year (ASMFC 2008b). Annual revenues from the horseshoe crab fishery amount to approximately $150 million for the biomedical industry and $21 million for the American eel and conch bait industry (FWS 2003). Threats to their 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).

Horseshoe crabs are found along the Atlantic coast from the Gulf of Maine to Florida and into the Gulf of Mexico to the Yucatan Peninsula (ASMFC 2008a). They are most abundant between New Jersey and Virginia (ASMFC 2010a). The largest spawning population in the world inhabits 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). Females climb up the beach with a male attached to their backs. Other males in the area will also try to fertilize the eggs, resulting in up to five males converging on one female. The female will partially burrow into the sand and deposit several thousand eggs. Eggs hatch in 3 to 4 weeks, and the larvae will enter the water about 1 month later. Temperature, moisture, and oxygen content of the nest environment affect egg development and timing (FWS 2006). The larvae resemble adult crabs without the tails. They spend their first 6 days swimming in shallow water then settle to the bottom (FWS 2006, ASMFC 1998a). Juveniles will spend their first 2 years on intertidal sand flats. Older juveniles and adults are found in subtidal habitats, except when actively spawning (ASMFC 2010a). Once the juvenile stage is reached, molting continues, with each on increasing the crab's size by up to 25 percent. Sexual maturity is reached after about 17 molts, or 9 to 12 years (ASMFC 2008a). Molting ceases when maturity is reached, and crabs can live up to 10 additional years (ASMFC 2010a). Horseshoe crabs exhibit limited beach fidelity, usually returning to their native beaches to spawn (FWS 2003). However, crabs tagged in Delaware Bay have been recaptured in New Jersey, Delaware, Maryland, and Virginia (ASMFC 2008b).

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). Horseshoe crab eggs that have been exposed on the beach are an important food source for migrating shorebirds using the Atlantic flyway (ASMFC 2008a, FWS 2006). In addition to providing a rich food source for birds, eggs and larvae are consumed by fish such as striped bass, white perch, American eel, killifish (*Fundulus* spp.), silver perch, weakfish, kingfish (*Menticirrhus saxatilis*), silversides, summer flounder, and winter flounder, crabs, gastropods, and loggerhead sea turtles (*Caretta caretta*) (ASMFC 1998a). Overturned adults are often attacked and eaten by gulls (FWS 2003).

American Oyster

The American oyster is also known as the eastern oyster and the Atlantic oyster. The oyster is a commercially and environmentally important species and has been harvested in Delaware Bay since the early 1800s (Delaware Estuary Program 2010). Oysters not only support an important fishery in both New Jersey and Delaware, but they are ecologically important as filterers (enhancing water quality) and provide a complex three-dimensional habitat used by a variety of fishes and invertebrates (DNREC 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 is limited, mainly due to diseases such as MSX ("multinucleated sphere unknown," later classified as *Haplosporidium nelson)* and Dermo (caused by the southern oyster parasite, *Perkinsus marinus*). MSX is thought to have been imported into Delaware Bay in the 1950s from infected Chesapeake Bay populations. As a result, harvests dropped to 49,000 bushels in 1960. When imports were banned, the disease disappeared, but it resurfaces periodically when water temperatures are high. The populations recovered slowly, but in the 1985 an additional outbreak of MSX crashed the industry again. In 1990, Dermo decimated the oyster population in Delaware Bay. Oysters are now directly harvested from the seed beds. A portion of the revenue has been directed at placing shell for increasing the size of existing beds and creating new seed beds down bay (Delaware Estuary Program 2010).

There is currently a joint effort involving Delaware, New Jersey, and the USACE 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, all of which will allow the oyster to play its ecological role as a filterer, enhancing general water quality. Approximately 290,000 and 478,650 bushels of shell were planted in Delaware Bay in 2005 and 2006, respectively. The program also has a monitoring and assessment portion to evaluate its efficacy (USACE 2007).

Oysters are found along the Atlantic coast in sounds, bays, estuaries, drowned river mouths, and behind barrier beaches from Canada to the Gulf of Mexico (Burrell 1986, Sellers and Stanley 1984). They are found in 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 Delaware Bay are part of the population that spawns at 20 °C. Spawning is begun by the males who release their sperm and a pheromone into the water column, the females respond by releasing their eggs. Spawning occurs in the summer months, with several events per season. Larvae remain in the water column for 2 to 3 weeks, dispersing with the water currents. While in this stage, larvae pass through several morphological changes from the blastula (3.2 hr) to the gastrula (4.5 hr), trochophore (10 hr), and prodissoconch I stage, at which point they develop a shell and cilia for locomotion. The prodissoconch II stage is a very active swimmer, with eyes, a foot, and a byssal gland. These larvae show evidence of directed motions in relation to the salinity of the water. Most larvae will die before reaching the settlement stage. The next larval stage settles on a hard surface, preferably other oyster shells. The larva attaches to the substrate and looses the foot and vellum, becoming stationary. Adult oysters are sessile found in beds or reefs in dense masses. They are often the only large organism in the bed and can change water currents enough to affect the deposition rate of the local environment. They are dioecious, but 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).

Oyster larvae feed on plankton such as naked flagellates and algae. They are eaten by a wide variety of other filter feeders. Adults are stationary filter feeders, feeding on plankton as well. 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 habitat, which can be home to over 300 other species. 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).

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 68 and 86 °F (20 and 30 °C). 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 (156 to 260 centimeters per second [cm/sec]) provide for optimal growth (Sellers and Stanley 1984).

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.

<u>Representative Species</u>

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 Clean Water Act included a provision to select Representative Species (RS) to focus such investigations (the terms target species or Representative Important Species also have been used) (PSEG 1984, PSEG 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

Blueback herring and alewife can be difficult to differentiate and are collectively known and managed as "river herring." Both species are currently listed as species of concern by the National Marine Fisheries Service (NMFS) (NMFS 2009). River herring are used for direct human consumption, fish meal, fish oil, pet and farm animal food, and bait. The eggs (roe) are also canned for human consumption. River herring are managed by the ASMFC. They are ecologically important due to their trophic position in both estuarine and marine habitats. As planktivores, they link the zooplankton to the piscivores, providing a vital energy transfer (Bozeman and VanDen Avyle 1989).

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 1 month before the blueback herring (NMFS 2009). The entire length of the Delaware River and portions of Delaware Bay are confirmed spawning runs for river herring (NJDEP 2005d). The adults of both species return to the ocean after spawning. While at sea, river herring are consumed by many predators, including marine mammals, sharks, tuna, and mackerel. While in the estuaries, they are consumed by American eel, striped bass, largemouth bass, mammals and birds. Interspecific competition between alewife and blueback herring is minimized by several mechanisms, including the timing of spawning, juvenile feeding strategies and diets, and ocean emigration timing. Both blueback herring and alewife can be found in land-locked lakes. These populations are genetically distinct from the anadromous ones (ASMFC 2009a).

Blueback herring are found in estuaries and offshore along the east coast of the United States from Nova Scotia to Florida. They 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. This species migrates inshore to spawn in late spring, and spends winters offshore in deeper waters. It uses 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. Eggs hatch within 5 days and the yolk sac is absorbed within 3 days after hatching. The eggs are initially demersal but soon become pelagic. 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 copepods, cladocerans, ostracods, benthic and terrestrial insects, molluscs, fish eggs, hydrozoans, and stratoblasts. They are consumed in all life stages and in all habitats by other fish, birds, amphibians, mammals, and reptiles. Adults in the ocean are consumed by spiny dogfish, American eel, cod, Atlantic salmon, silver hake, white hake, Atlantic halibut, bluefish, weakfish, striped bass, seals, gulls, and terns (ASMFC 2009a).

Alewife have a smaller range than the blueback herring, from Newfoundland to North Carolina. They reach maturity at approximately 4 years and can live 10 years, reaching up to 15 inches 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 are found in 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. Eggs and juveniles are eaten by white perch, yellow perch, shiners, American eel, grass pickerel, walleye and alewife; larvae are consumed by a variety of fish, birds, and mammals. Young alewife are also a high quality food source for turtles, snakes, birds and mink. Juveniles are opportunistic feeders, consuming midges, cladocerans, chironomids, odonates, epiphytic fauna, ostracods, and oligocheates (ASMFC 2009a). Alewife are schooling pelagic omnivores while offshore, feeding mainly on zooplankton, but also small fishes and their eggs and larvae (NMFS 2009). Food items include euphausids, calanoid copepods, hyperiid amphipods, chaetognaths, pteropods, decapod larvae, salps, Atlantic herring, other alewife, eel, sand lance, and cunner (ASMFC 2009a). 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 bluefish, weakfish, striped bass, dusky shark, spiny dogfish, Atlantic salmon, goosefish, cod, pollock, and silver hake. Alewife also are important as hosts to parasitic larvae of freshwater mussels, some species of which are threatened or endangered (ASMFC 2009a).

The river herring fishery has been active in the United States for 350 years. Until the 1960s, it was mainly an inland fishery, but thereafter expanded offshore. 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 which harvested over 350,000 fish in 2004. Commercial landings declined from over 50 million lbs (22.6 million kgs; before 1970 to under 1 million lbs [453 thousand kg] in 2007. Blueback herring are exhibiting signs of overfishing in several of the estuary systems on the east coast, including the Connecticut, Hudson and Delaware Rivers (ASMFC 2009a). River herring population declines have been attributed to overfishing and the loss of historic spawning habitat all along the eastern coast of the United States (NMFS 2009). Reasons for habitat loss include dam construction, streambank erosion, pollution, and siltation (ASMFC 2009a). River herring are also often taken as bycatch in other fisheries (NMFS 2009). New Jersey currently has a small commercial river herring small-mesh gillnet fishery; the catch is mostly used as bait. Delaware also has a small river herring fishery, which is 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. Although data are lacking, it is estimated that large numbers of river herring are harvested recreationally for use as bait (ASMFC 2009a).

<u>American Shad</u>

American shad have been a commercially and culturally important species on the east coast of the United States since colonial times. The range of the American shad extends from Newfoundland to Florida (ASMFC 2007a). They are most abundant between Connecticut and

North Carolina (MacKenzie et al. 1985). Huge numbers of these fish were historically harvested during their annual spring spawning runs. Up to 1850, 91 million pounds (41,000 metric tons) were harvested annually in the Chesapeake Bay (Chesapeake Bay Program 2009). The Atlantic catch in 1896 was 50 million lbs (22,680 metric tons) (MacKenzie et al. 1985). By the end of the 19th century, only 17.6 million lbs (8000 metric tons) were caught, representing a severe decline in the American shad stock, and the fishery began fishing in the waters of the lower bays. Stock has continued to decline, with only 1000 metric tons landed in the Chesapeake in the 1970s (Chesapeake Bay Program 2009). By 1983, the Atlantic catch was only 3.5 million lbs (1585 metric tons). Several states, including Maryland, had closed the American shad fishery by 1985 (MacKenzie et al. 1985).

American shad are schooling anadromous fish, migrating 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 years. Spawning is accomplished by one female and several males swimming to the surface to release their gametes. Preferred 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. They hatch in approximately 8 to 12 days, and the yolk sac is absorbed when the larvae are between 0.35 and 0.47 inches (9 and 12 mm) long. At 4 weeks the larvae become juveniles, which 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, and will remain in the estuary until they are 1 year old (ASMFC 1999~~8b~~). In the Delaware River, this happens when the water reaches 68°F (20 °C), usually in October and November. Juveniles remain in the ocean until they are mature, approximately 3 to 5 years for males and 4 to 6 years for females. American shad are likely to return to their natal rivers to spawn (MacKenzie et al. 1985).

Ecologically, American shad play an important role in the coastal estuary systems, providing food for some species and preying on others. They also transfer nutrients and energy from the marine system to the freshwater areas as many shad die after they spawn (ASMFC 1999~~8~~). 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 1999~~8b~~). During the spawning run, shad consume mayflies and small fish. Shad are preyed upon by many species while they are small, including striped bass, American eels, and birds. Adults are eaten by seals, porpoises, sharks, bluefin tuna (*Thunnus thynnus*), and kingfish (*Scomberomorus regahni*) (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 68°F (20 °C). Deformities develop if eggs encounter temperatures above 72°F (22 °C) and they do not hatch above 84°F (29 °C). Juveniles have been shown to actively avoid rises in temperature of 39 °F (4 °C) (MacKenzie et al. 1985).

American shad are managed by the ASMFC. A stock assessment completed in 2007 showed that American shad stocks are still severely depleted and are not recovering, with Atlantic harvests of approximately 550 tons (500 metric tons). 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 over fishing (ASMFC 2007a). Increased predation by the striped bass has also been named as a factor in their decline (ASMFC 1999~~8b~~). 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). Adults are highly abundant in Delaware Bay, potentially confirming the American shad's use of the estuary as part of the spawning run (ASMFC 1999~~8b~~).

Bay Anchovy

The bay anchovy is an abundant forage fish found along the Atlantic coast from Maine to the Gulf of Mexico, including the Yucatan Peninsula. It is a small, schooling, euryhaline fish that grows to approximately 4 inches (10 cm) and can live for several years (Morton 1989, Smithsonian Marine Station 2008). It can be found in freshwater and in hypersaline water over almost any bottom type including sand, mud, and submerged aquatic vegetation. It is highly important 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).

Bay anchovy spawn 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 54°F (12 °C) and over 10 ppt salinity. The eggs are pelagic and hatch after about 24 hours, the yolk sac is absorbed after another 25 hours. Newly hatched fish move upstream into lower salinity areas to feed, eventually migrating to the lower estuary in the fall. Young bay anchovies feed mainly on copepods, and adults consume mysids, small crustaceans, mollusks, and larval fish. Copepods have been reported as 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). They have been reported to be the most important link in the food web, and are a primary forage item for many other fish, birds, and mammals (Morton 1989; Smithsonian Marine Station 2008; Newberger and Houde 1995). Bay anchovy eggs are consumed by various predators, including juvenile fish and gelatinous predators such as sea nettles and ctenophores. Bay anchovy often account for over half the fish, eggs, or larvae caught in research trawls (Smithsonian Marine Station 2008). Studies in the Chesapeake Bay found that 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 (Chesapeake Bay Ecological Foundation, Inc. 2010).

Atlantic Menhaden

Atlantic menhaden have been an important commercial fish along the Atlantic Coast since colonial times. Ecologically, they are a vital forage fish for larger piscivorous species including fish, birds, and mammals, and they play an important role in the aquatic system as filter feeders (ASMFC 2005a). They are used in the reduction industry (producing fish meal and oil) and are used as bait by both commercial and recreational fisheries. This species has been fished since the early 1800s and landings increased over time as new technologies developed. Their populations suffered in the 1960s when they were severely overfished, but they recovered in the 1970s. The reduction fishery landed 203,320 tons (184,450 metric tons) in 2004 and the bait fishery has become increasingly important, with the most bait fish landed in New Jersey and Virginia. A stock assessment completed in 2003 declared the Atlantic menhaden not overfished, and a review in 2004 resulted in a decision not to require an assessment in 2006

(ASMFC 2005a). The 2008 Atlantic menhaden fishing season resulted in a catch of 141,133 tons (128,030 metric tons) for the reduction industry (NOAA 2009a).

Atlantic menhaden are small schooling fish found along the Atlantic Coast from Nova Scotia to northern Florida in estuarine and nearshore coastal waters. They migrate 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 almost year round along the Atlantic Coast (ASMFC 2001). They spawn offshore in fall and early winter between New Jersey and North Carolina (ASMFC 2005a). Spawning is concentrated over the continental shelf off the North Carolina Capes between December and February, in water 328 to 656 ft (100 to 200 m) deep at mid-depths. 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. Areas that do not have sufficient plankton densities may not produce many surviving larvae, leading to a poor year class. 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. Young fish leaving the estuaries tend to migrate south along the North Carolina coast during the winter months. 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 their high abundance and positioning in the nearshore and estuarine ecosystems, Atlantic menhaden are ecologically vital along the Atlantic coast (Rogers and Van Den Ayvle 1989). They are filter feeders, straining plankton from the water column. They provide a trophic link between the primary producers and the larger predatory species in nearshore waters. (ASMFC 2005a). It has been hypothesized that due to their abundance and migratory movements, Atlantic menhaden may change the assemblage structure of plankton in the water column. Larvae in the estuaries feed preferentially upon copepods and copepodites, and they may eat detritus as well. As young fish and adults, they filter feed on anything larger than 7 to 9 micrometers including zooplankton, large phytoplankton, and chain diatoms (Rogers and Van Den Avyle 1989). Atlantic menhaden provide a food source for bluefish, striped bass, bluefin tuna, king mackerel, Spanish mackerel, pollock, cod, weakfish, silver hake, tunas, swordfish (*Xiphias gladuis*), and sharks (ASMFC 2001, Rogers and Van Den Avyle 1989). They establish a direct link between the phytoplankton primary producers and the higher level predators, including transferring energy in and out of estuary systems and on and off the coastal shelf (Rogers and Van Den Avyle 1989). They are especially important in this regard, as most marine fish species cannot use phytoplankton as a food source (ASMFC 2001). Their filter-feeding habits have also lead to a variety of physiological characteristics, such as high lipid content, enabling survival during periods of low prey availability (Rogers and Van Den Avyle 1989).

Weakfish

Weakfish are part of a mixed stock fishery that has been economically vital since the early 1800s (ASMFC 2009b). They were highly abundant in Delaware Bay. They topped commercial landings in the state of Delaware until the 1990s and were 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 at 36 million lbs (over 16 million kg), then declined throughout the 1980s, ending in a low of 6 million lbs (approximately 2.7 million kg) in 1994. 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).

Weakfish range along the Atlantic coast from Nova Scotia to southern Florida, but are more common between New York and North Carolina (ASMFC 2009b). Their growth varies, with northern populations becoming much larger (up to 32 inches [810 mm]) and living longer (11 years) than the more southern populations (28 inches [710 mm] and 6 years). Within Delaware Bay, a survey in 1979 found the oldest females (age 9 years) to be an average of 710 mm long, and the oldest males (six years) to be an average of 27 inches [681 mm] long (Mercer 1989). Spring warming induces inshore migration from offshore wintering areas and spawning (ASMFC 2009b). Weakfish are batch spawners, continuously producing 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, after which they are considered mature (ASMFC 2009b, Mercer 1989). Spawning occurs in estuaries and nearshore areas between May and July in the New York Bight (Delaware Bay to New York). Eggs are pelagic and hatch between 36 and 40 hours after fertilization. Larvae become demersal soon after this, when they have reached 8 mm in length. Juvenile weakfish use the deeper waters of estuaries, tidal rivers, and bays extensively but are not often found in the shallower areas closer to shore. Within Delaware Bay, juvenile weakfish have been shown to 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. Spawning is initiated with warming water temperatures. As temperatures cool for the winter, weakfish migrate to ocean wintering areas, the most important of which is the continental shelf between Chesapeake Bay and North Carolina (Mercer 1989).

Weakfish play an important ecological role as both predators and prey in the estuarine and nearshore food webs (Mercer 1989). Adults feed on peneid and mysid shrimps, anchovies, clupeid fishes, other weakfish, and a variety of other fishes, including butterfish, herrings, silversides, Atlantic croaker, spot, scup, and killifishes. Younger weakfish consume mostly mysids and other zooplankton and invertebrates, including squids, crabs, annelid worms, and clams (Mercer 1989, ASMFC 2002). More fish species are taken as the fish grow to larger sizes. In Chesapeake Bay eelgrass beds, weakfish have been shown to be important top carnivores, feeding mostly on blue crabs and spot. 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 and 82.4 °F (17 and 28 °C) and salinities of 0 to 32 ppt (Mercer 1989).

Spot

Spot are not only an important commercial and recreational fish species on the Atlantic coast, they also support many other important fisheries as a forage species (ASMFC 2008b). They are used for human consumption and as part of the scrap fishery. Spot make up a major portion of the fish biomass and numbers in estuarine waters of the mid-Atlantic region (Phillips et al. 1989). They are also a large component of the bycatch in other fisheries, including the South Atlantic shrimp trawl fishery. Commercial landings fluctuate widely due to the fact that spot are a short-lived species (4 to 6 years) and most landings constitute a single age class (ASMFC 2008c). Commercial landings fluctuated between 3.8 and 14.5 million lbs (1.7 and 6.6 million kg) between 1950 and 2005 (ASMFC 2006a). They are also a very popular recreational species, with recreational landings sometimes surpassing commercial ones (ASMFC 2006a).

The range of spot along the Atlantic coast stretches from Maine to Florida. They are most abundant from 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 preflexion larvae. During the flexion stage, larvae become more demersal, migrating from the mid depths during the day to the surface at night. These 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, moving into higher salinity areas as they mature (ASMFC 2008c). Seagrass beds and tidal creeks are important nursery habitat 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).

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 pteropods, larval pelecypods, and cyclopoid copepods. Juveniles are benthic opportunistic feeders, preferring sand and mud bottoms, but capable of feeding anywhere. Larger spot will consume copepods, mysids, nematodes, clam siphons, dipterans, and amphipods. Adult spot are also benthic feeders, scooping up sediments and consuming large numbers of polychaetes, copepods, decapods, nematodes, and diatoms. Over the continental shelf, cheatognaths are both predators and competitors with early larval spot stages. Large predatory fish are more likely to eat adult spot than juveniles, as these are found in the estuarine shallows. Larger spot are an important source of food for cormorants, spotted seatrout, and striped bass. Spot are tolerant of a wide variety of environmental variables. They have been found in temperatures between 46.4 and 87.8 °F (8 and 31 °C) and salinities between 0 and 61 ppt (Phillips et al. 1989).

Atlantic Silverside

Atlantic silverside are a highly abundant forage fish on the Atlantic coast, providing a food resource for many commercially and recreationally important fish species such as striped bass (*Morone saxatilis*), Atlantic mackerel (*Scomber scombrus*), and bluefish (*Pomatomus saltatrix*). Atlantic silverside are found in 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. There is no direct commercial or recreational fishery for this species, although many recreational fishers net and use these minnows as bait (Fay et al. 1983a).

Spawning by the Atlantic silverside is initiated by a combination of water temperature, photoperiod, tidal cycle, and lunar cycle. Spawning occurs in the intertidal zones of estuaries between March and July in the Mid-Atlantic Region. The initial spawning event is during the daytime, usually accompanied by a high tide and a full or new moon. Subsequent events are spaced by 14 or 15 days, tracking the lunar cycle (Fay et al. 1983b). Most fish die after their first spawning season (fish may spawn between 5 and 20 times in one season), but some individuals do return for a second season (New York Natural Heritage program [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. They hatch after 3 to 27 days, depending on temperature. The yolk sac is absorbed between 2 and 5 days later. Atlantic silverside become either males or females, but the sex of an individual fish is determined by water temperature during the larval stage. Thus, 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. Transformation to the juvenile stage is usually at 0.86 inches (20 mm) in length, and juveniles continue to grow until late fall, when they reach adult size. Juveniles and adults are found in intertidal creeks, marshes and shore areas in bays and estuaries during spring, summer, and fall. During winter in the Mid-Atlantic Region, they often migrate to deeper water within the bays or offshore (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. Little is known about the larval diet. 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. Juvenile and adult fish are opportunistic omnivores and eat copepods, mysids, amphipods, cladocerans, fish eggs, squid, worms, molluscan larvae, insects, algae, diatoms, 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. Eggs, larve, juveniles, and adults are eaten by striped bass, Atlantic mackerel, bluefish, egrets, terns, gulls, cormorants, blue crabs, mummichogs (*Fundulus heteroclitus*), and shorebirds (Fay et al. 1983a).

Eggs and larvae tolerate wide degree of environmental conditions, but rapid increases in temperature can prevent eggs from hatching and kill larvae. Juveniles and adults appear to prefer temperatures of between 64.4 and 77 °F (18 and 25 °C). The optimum salinity for hatching and early development is 30 ppt, but a wide range of salinities (0 ppt to 38 ppt) is tolerated by juveniles and adults (Fay et al. 1983a).

<u>Atlantic Croaker</u>

Atlantic croaker are an important commercial and recreational fish on the Atlantic Coast and are the most abundant bottom-dwelling fish in this region. They have been taken as part of a mixed stock fishery since the 1880s. Commercial landings appear to be cyclical, with catches ranging between 2 million and 30 million lbs (0.9 and 13.6 million kg). This is may be due to variable annual recruitment, which appears to be dependent on natural environmental variables. Recreational landings have been increasing, with 10.6 million lbs (4.8 million kg) caught in 2005. The 2003 stock assessment (reported in 2004) determined that Atlantic croaker were not overfished in the Mid-Atlantic Region (ASMFC 2007b). An amendment to the management plan was developed in 2005 using the 2004 stock assessment data, establishing fishing mortality and spawning stock biomass targets and thresholds. 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).

Atlantic croaker are a migratory species, although movements have not been well defined. They appear to move inshore in the warmer months and southward in winter (ASMFC 2007b). They range from Cape Cod to Argentina and are uncommon north of New Jersey. Gulf of Mexico and Atlantic populations appear to be genetically separate (ASMFC 2005b). They 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 polyhaline and euryhaline waters. 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. Recruitment of young fish to the shallow marsh habitats of estuaries is variable but appears to show seasonal peaks depending on latitude. This peak is in August through October in the Delaware River. The long spawning period and the variable recruitment peaks make the aging of recruits to estuary areas difficult, ages could vary from 2 to 10 months of age at recruitment. Larvae complete their development into juveniles in brackish shallow bottom 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, which provide a stable food source, but they are considered generalists (ASMFC 2005b).

Atlantic croaker are bottom feeders eating benthic invertebrate fauna such as polychaetes, mollusks, ostracods, copepods, amphipods, mysids, and fish. Larvae tend to consume large amounts of zooplankton, and juveniles feed on detritus. Their predators include striped bass, southern flounder, bluefish, weakfish, and spotted seatrout. They are able to live with other competitive fishes (such as spot) by utilizing temporal and spatial habitat niches within the overall bottom environment. Juvenile Atlantic croaker are sensitive to pollution and anoxic areas as these conditions deplete or change the composition of their prey. Shoreline alterations such as bulkheads and rock jetties can also negatively affect juvenile populations. Adult croaker are usually found in estuaries in spring and summer and move 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 sensitive to low oxygen levels (ASMFC 2005).

White Perch

White perch are members of the bass family. They are a commercially and recreationally important species found in coastal waters from Nova Scotia to South Carolina, with their highest abundance in New Jersey, Delaware, Maryland, and Virginia (Stanley and Danie 1983). The largest landings were made at the turn of the century, then catch levels decreased, rising sporadically to reflect large year classes. White perch are a popular recreational fish in freshwater and in estuaries. They are often the dominant species caught recreationally in the northern Atlantic states. White perch fill a vital trophic niche as both predator and prey to many species (Stanley and Danie 1983). They are managed by the Maryland Department of Natural Resources, but not by the ASMFC. Populations in Maryland are considered stable with approximately 1.5 million lbs (680 metric tons) harvested commercially and 0.5 million lbs (226 metric tons)harvested recreationally in 2004 (Maryland Department of Natural Resources [MDNR] 2008).

White perch are schooling fish that can grow up to 10-inches (25.4-cm) long in freshwater and 15-inches (38.1-cm) long in brackish water and may live up to 10 years (Pennsylvania Fish and Boat Commission 2010, MDNR 2008). They spawn 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. Spawning is induced by rising water temperature and occurs in April through May in freshwater and May through July in estuaries (Stanley and Danie 1983). Marine and estuarine populations migrate to freshwater areas to spawn and thus are anadromous (Pennsylvania Fish and Boat Commission 2010). Spawning is accomplished by a single female and several males. The eggs attach to the bottom immediately. Females may spawn two or three times per season and older fish produce many more eggs than younger ones. Eggs hatch in 30 to 108 hours, depending on water temperature. Hatchlings remain in the spawning area for up to 13 days, then they drift downstream or with estuarine currents, becoming more demersal as they grow. Larvae can tolerate up to 5 ppt salinity, adults can tolerate full seawater. Juveniles are often found in upper estuarine nurseries, where they may stay for a year, preferring habitats with silt, mud, or plant substrates. Older juveniles have been reported to move to offshore beach and shoal areas during the day, but return to the more protected nursery areas at night. Maturity is usually reached by year 2, but may take up to 4 years. Growth to maturity and beyond is affected by temperature, food supply and population density, with growth becoming stunted in high density areas (Stanley and Danie 1983).

Ecologically, white perch play several important roles throughout their lifecycle. The white perch is omnivorous, depending on age, season, and food availability. It will feed on both plankton and benthic species, but 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; amphipods; crayfish; shrimp; squid; crabs; and fish eggs (Stanley and Danie 1983, Pennsylvania Fish and Boat Commission 2010). White perch are preyed upon by Atlantic salmon, brook trout, chain pickerel, smallmouth bass, largemouth bass, and other piscivorous fish and terrestrial vertebrates. Juveniles are often eaten by copepods (Stanley and Danie 1983).

<u>Striped Bass</u>

Striped bass are 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, ASMFC 2008d). Their population has recovered since a sharp decline from its peak in the 1970s of 15 million lbs (6800 metric tons) to 3.5 million lbs (1590 metric tons) by 1983 (ASMFC 2008d). In 1981 ASMFC approved a management plan focusing on size limits and spawning season closures to recover population levels. This plan proved ineffective, and several states closed the fishery entirely, reopening in the early 1990s once the population had grown. Several amendments were made to the management plan, and the fishery was declared recovered in 1995 (ASMFC 2003, ASMFC 2008d). The most recent amendment in 2003, focused on increasing the proportion of the population over 15 years of age and creating a biomass target and threshold (ASMFC 2003). The 2007 stock assessment declared the fishery recovered, fully exploited and not overfished. This recovery is considered one of the greatest successes in the fisheries management field, with commercial and recreational landings totaling 3.8 million fish (29.3 million lbs [13,290 metric tons] recreationally) in 2006 (ASMFC 2008). The recovery of the striped bass fishery has been hypothesized to be the cause of the decline in weakfish, which it preys upon (DNREC 2006b). Striped bass are found on the Atlantic coast from the St. Lawrence River in Canada to northern Florida. They are highly abundant in both 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 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 upper Chesapeake Bay and the Chesapeake-Delaware Canal (Fay et al. 1983b). In the Delaware River, the main spawning grounds are located between Wilmington, Delaware and Marcus Hook, Pennsylvania (Delaware Division of Fish and Wildlife 2010). Males arrive in the spawning area first. Up to 50 males will spawn with a single female at the water surface. The eggs are pelagic and hatch from 29 to 80 hours after fertilization, depending on the temperature. The yolk sac is absorbed in 3 to 9 days, during which time water turbulence is required to keep the larvae from sinking to the bottom. The larvae then develop into the finfold stage, lasting approximately 11 days, then transform to the postfinfold stage, lasting up to 65 days. Both eggs and larvae tend to remain in the spawning area throughout these developmental stages. Fish are considered juveniles in between the lengths of 1 and 12 inches (2.5 and 30.5 cm) for males and 1 and 20 inches (2.54 and 50.8 cm) for females. 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 also will 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 habitats for successful reproduction. Adults spawn in a large variety of habitats, but only some of these produce an adequate amount of surviving young. Higher water flows and colder winters are hypothesized to produce successful year classes. Eggs are tolerant of temperatures between 57.2 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 be found over sandy bottoms in shallow water, but can also inhabit areas over gravel, mud, and rock. Adults are found in a wide variety of bottom types, such as rock, gravel, sand and submerged aquatic vegetation (ASMFC 2010a). Larvae and juveniles consume nauplii, copepods, chironomid larvae, and fish eggs and larvae. Young striped bass eat mysids, insect larvae, gobies, shrimp, amphipods, and small fish. Adults are mainly piscivorous, consuming schooling bait fish such as bay anchovy, Atlantic menhaden, spot, and croaker, but they will also consume invertebrates in the spring, including blue crabs, amphipods, and mysids (Fay et al. 1983b, DNREC 2006). Young striped bass are fed upon by weakfish, bluefish, white perch, and other large fishes; larvae and eggs are eaten by a variety of predators. 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).

Bluefish

Bluefish are a highly important recreational fish species, popular since the 1800s. They are commercially harvested for human consumption, but there is no commercial bluefish industry. In the early 1980s, an average of 16.3 million lbs (7.4 million kg) of bluefish per year were caught, making up only 0.5 percent of the Atlantic finfish landings. As of 1989, bluefish made up 15 percent of recreational landings on the Atlantic coast, and 90 percent of these were caught in the mid-Atlantic Region. Slightly less than half the recreational catch is in inland bays and estuaries. A management plan was developed in 1984, but was rejected as bluefish represent such a small portion of the commercial fisheries; therefore, federal regulation was deemed unnecessary (Pottern et al. 1989). Recreation landings averaged 60 million lbs per year between 1981 and 1993. A bluefish management plan was developed in 1990 due to the continuous decline in landings since the early 1980s (ASMFC 2006b, ASMFC 1998b~~c~~). By 2002, bluefish landings had declined to 11 million lbs (4.9 million kg) per year, but recent numbers have been rising in response the management amendment that was developed in 1998 (ASMFC 2006b). Although it is unknown if bluefish are estuary dependent, NOAA has designated essential fish habitat (EFH) for the species as including all major estuaries from Penobscot Bay, Maine to St. Johns River, Florida for juvenile and adult bluefish (NOAA 2006, NOAA 2010e~~b~~).

Bluefish are a migratory schooling fish, found in estuaries and over the continental shelf in tropical and temperate waters globally. They occur in the Atlantic from Nova Scotia to northern Mexico. Adults migrate north during the summers, between Cape Hatteras and New England, winters are spent to the south, near Florida in the Gulf Stream. They reach sexual maturity at age 2 and 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 1998b). Eggs are pelagic and hatch in approximately 48 hours, and larvae drift with the offshore currents until coastal water become warmer (Pottern et al. 1989, ASMFC 1998b~~c~~). These larve transform to a pelagic-juvenile stage at 18 to 25 days, improving swimming ability (NOAA 2006). Spring spawned juveniles then migrate into bays and estuaries at 1 to 2 months old, where they complete their development, 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 1998b~~c~~). 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 2006b).

Due to their large size and numbers, bluefish probably play a large role in the community structure of forage species along the Atlantic coast. As they are pelagic, larval bluefish consume available zooplankton, mostly copepods, in large quantities in the open ocean (Pottern et al. 1989, NOAA 2006). Juveniles in the estuaries eat small shrimp, anchovies, killifish, silversides, and other available small prey, depending upon availability. Adult bluefish are mostly piscivorous, but a wide array of prey items have been found in the stomachs of adult bluefish, including invertebrates. Adults are preyed upon by large coastal and estuarine species, such as sharks, tuna, and swordfish. Bluefish would compete with other large piscivorous species in the Atlantic region, such as striped bass, spotted sea trout, and weakfish (Pottern et al. 1989). Recent studies have hypothesized that juvenile and adult bluefish eat whatever is locally abundant (ASMFC 1998b~~c~~).

Bluefish are highly sensitive to temperature regimes, with an optimum range of 64.4 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 relatively euryhaline, found in estuaries at 10 ppt and waters of up to 38 ppt in the ocean. As they are pelagic, they are not well adapted to the periodic low oxygen levels that are occasionally found in estuaries (Pottern et al. 1989). They have been found to be excluded from estuarine areas where Atlantic silversides are spawning due to the low oxygen levels induced by the high activity of such a large number of fish (ASMFC 1998b~~e~~).

Species with Essential Fish Habitat

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 essential fish habitat (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 (New England Fisheries Management Council [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.). Designating 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 (NMFS 1999). 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. In accordance with the consultation requirements of the MSA, an EFH Assessment for the proposed action is provided in Appendix D.

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 ASMFC, the New England Fisheries Management Council (NWMFC), 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. NRC staff considered all the designated EFH that could occur in the vicinity of Salem and HCGS based on geographic coordinates and eliminated EFH for some species and life stages with EFH requirements that are outside of the conditions that normally occur in the local area.

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 description of the general location and New Jersey shoreline within this square confirm 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. The salinity requirements of these 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 NRC 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 in the vicinity for one or more life stages (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 EFH by species and life stage in NMFS' 10' x 10' square of latitude and longitude in the Delaware Estuary that includes Salem and HCGS

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 EFH 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] ~~Packer et al. (2003a)~~ NOAA Technical Memorandum NMFS-NE-174~~.~~ (NOAA, 2003a).
[c] ~~Packer et al. (2003b)~~ NOAA Technical Memorandum NMFS-NE-175~~.~~ (NOAA, 2003a).
[d] ~~NOAA (2003)~~ NOAA Technical Memorandum NMFS-NE-179 NOAA (2003) .
[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 EFH in the Vicinity of Salem and HCGS

Species	Eggs	Larvae	Juveniles	Adults
Winter Flounder	X	X	X	X
Windowpane	X	X	X	X
Summer Flounder			X	X
Atlantic Butterfish			X	

Source: NRC 2007.

Winter Flounder (*Pleuronectes americanus*)

Winter flounder are highly abundant in estuarine and coastal waters and therefore are one of the most important commercial and recreational fisheries species on the Atlantic coast (Buckley 1989). They are managed by the NEFMC and ASMFC as part of the multi-species groundfish fishery. This plan manages a total of 15 demersal species (NEFMC 2010). The winter trawl fishery was established in the 1920s when northern trawlers began to make use of the waters off Cape Hatteras. This fishery targets multiple species and landings between 1974 and 1978 totaled approximately 18.5 million lbs (8.4 million kg) annually (Grimes et al. 1989). Winter flounder are also 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 declines from 30,000 million tons in 1981 to 8500 million tons in 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. 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).

There are two major populations of winter flounder in the Atlantic, one is found in estuarine and coastal waters from Newfoundland to Georgia, the other is found offshore on Georges Bank and Nantucket Shoal (Buckley 1989). In the Mid-Atlantic it is most common between the Gulf of Saint Lawrence and Chesapeake Bay (Grimes et al. 1989). They spawn in coastal waters beginning in December in the south Atlantic through June in Canada (February and March in the Delaware Bay region). Spawning occurs in depths of 6.5 to 262 ft (2 to 80 m) over sandy substrates in inshore coves and inlets between 31 to 32.5 ppt (Buckley 1989, NOAA 1999). Sexual maturity is dependent on size, rather than age, with southern individuals (age two or three) reaching spawning size more rapidly than northern fish (age six or seven). The eggs are demersal, stick to the substrate, and are most often found at salinities between 10 and 30 ppt (Buckley 1989). They hatch in two to three weeks, depending on water temperature (NOAA 1999a). The yolk sac is absorbed at 12 to 14 days, and metamorphosis to the juvenile stage is complete in 49 to 80 days, also dependant on temperature (Buckley 1989). Larvae are planktonic initially, but become increasingly benthic with developmental stage (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. 1989a). Adult movements appear to be dictated by water temperature as well, with three distinct population ranges, Georges Bank, and north and south of Cape Cod. South of Cape Cod, winter flounder will spend the colder months in inshore ad estuarine waters, moving further off shore in the warmer summer months (Buckley 1989). Winter flounder can live for 15 years and may reach 22.8 inches (58 cm) in length (NOAA 1999a).

As larvae, winter flounder feed on copepods, nauplii, harpacticoids, calanoids, polychaetes, invertebrate eggs, and phytoplankton, moving on to larger prey such as small polycheates, nemerteans and ostracods and they grow larger (Buckley 1989, NOAA 1999a). Adults feed on benthic invertebrates including polycheates, cnidarians, mollusks and hydrozoans. They find their prey by sight, therefore are more active in the daylight and in shallow water. They have few competitors due to their use of the highly productive estuarine and coastal habitats, and their omnivorous diet. Due to their high abundance, they prey upon by many other large coastal species. Larvae are eaten in large numbers by hydromedusae (Buckley 1989). Juveniles are eaten by bluefish, (*Pomatomus saltatrix),* gulls, cormorants, sevenspine bay shrimp, (*Crangon septemspinosa),* summer flounder, (*Paralicthys dentatus),* sea robins (*Prionotus evolans*), and windowpane (*Scophthalmus aquosus*) (NOAA 1999a). Adults and juveniles are an important food source for striped bass (*Morone saxatilis*), bluefish (*Pomatomus saltatrix*), goosefish (*Lophius americanus*), spiny dogfish (*Squalus acanthias*), oyster toadfish (*Opsanus tau*), sea raven (*Hemitripterus americanus),* great cormorant (*Phalacrocorax carbo*), great blue heron (*Ardea herodias*) and the osprey (*Pandion haliaetus*) (Buckley 1989).

Winter flounder are found at temperatures of between 32 and 77 °F (0 and 25 °C), but will burrow into the sediments above 71.6 °F (22 °C), and higher temperatures for extended periods can cause wide-scale mortality. They are relatively euryhaline, tolerating salinities of 5 to 35 ppt (Buckley 1989). Larvae are susceptible to thermal shock, four minutes at temperatures elevated by 28 to 30°C will produce 100 percent mortality (Buckley 1989). Increases of less than 80.6 °F (27 °C), however, appear to be well tolerated if the shock lasts for less than 32 minutes (NOAA 1999a). Additionally, winter flounder catch has been negatively correlated with high temperatures in the preceding 30 months, and a minor increase in temperature of mess than 32.9 °F (0.5 °C) may cause a decrease in recruitment (Grimes et al. 1989).

<u>Windowpane Flounder</u> (Scopthalmus aquosus)

Windowpane flounder is one of the 15 groundfish species managed by the NEFMC under the multispecies plan (NEFMC 2010). Although it is not directly targeted by the fishery, it is caught as bycatch in the groundfish trawls, although they are exploited for human consumption (NOAA 1999b, Morse and Able 1995). The ground fish fishery has been highly important for the economy of the New England region, with 100 million dollars in landings reported in 2000 (NEFMC 2010). Due to their demersal habitat, windowpane flounder are found in close association with other groundfish species such as yellowtail flounder (*Limanda ferruginea*), ocean pout (*Macrozoarces americanus*), little skate (*Raja erinacea*), northern searobin (*Prionotus carolinus*), and spiny dogfish (*Squalus acanthias*) (NOAA 1999b). Between 1975 and 1982, landings of windowpane flounder fluctuated between 532 and 838 million tons. Between 1984 and 1990, landings increased to between 890 and 2065 million tons, after which they gradually declined to between 39 and 85 million tons during the time range of 2002 to 2007 (Northeast Fisheries Science Center [NEFSC] 2008).

Windowpane flounder are found in estuaries, coastal waters and 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 and silt or mud substrates (NOAA 1999b). They spawn from April to December, but in the Mid-Atlantic region spawning occurs with two peaks in spring and fall, in may and September (NOAA 1999b, Morse and Able 1995). They tend to spawn on the bottom of the water column in waters of 16 to 19 °C (Morse and Able 1995). The eggs are pelagic and buoyant and hatch at approximately eight 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 shelf for spring spawned fish, and these individuals are found in the polyhaline portions of the estuary throughout the summer. Fall spawned fish settle mostly on the shelf. Juveniles will migrate to coastal waters from the estuaries as they grow larger during the autumn, they overwinter in deeper waters. Adults remain offshore throughout the year, and are highly abundant off of southern New Jersey. Sexual maturity is reached between 3 and 4 years of age, and growth generally does not exceed 18.1 inches (46 cm) (NOAA 1999b).

Juvenile and adult windowpane flounder have similar food sources including small crustaceans such as mysids and decapod shrimp, and fish larvae including hake, tomcod and windowpane flounder. Juvenile and small windowpane flounder are eaten by spiny dogfish, thorny skate, goosefish, Atlantic cod, black sea bass, weakfish and summer flounder (NOAA 1999b).

Adult windowpane are tolerant of a wide range of temperatures and salinities, from 23 to 80.2 °F (0 to 26.8 °C), and 5.5 to 36 ppt. They are, however, sensitive to low oxygen concentrations, they have not been found in areas where dissolved oxygen was below 3 mg/L. Adults and juveniles are abundant in the mixing and saline zones of the Delaware Bay, and are common in the inland bays (NOAA 1999b). Both the Delaware Bay mixing and saline zones and the inland bays have been established for all life stages of the windowpane flounder, including eggs, larvae, juveniles, adults and spawning adults (NEFMC 1998b).

Summer Flounder

The summer flounder, also known as fluke, is a highly important commercial and recreational species along the Atlantic Coast. The commercial and recreational fishery is managed by both the ASMFC and the MAFMC, 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. Stock biomass declined in the 1980s after a peak landing total of 26,100 million tons in 1983. Between 1986 and 1995, total landings averaged 13,100 million tons per year, and have fluctuated between 8600 and 12,500 since then. In 1999, the summer flounder stock was considered overexploited, but as of 2005, the stock has been considered not overfished (NOAA 1999c, NEFSC 2006a). In 2009, the ASMFC increased total allowable landings due to the results of the 2008 stock assessment. Although the stock is currently considered not overfished, it has not reached rebuilt status (ASMFC 2008e).

NOAA has designated EFH for summer flounder larvae, juveniles, and adults in Delaware Bay (NOAA 2010g). Summer flounder adults and juveniles are present in Delaware Bay and Delaware inland bays in salinity zones of 0.5 to above 25 ppt, and larvae are only present in the inland bays in salinities of 0.5 to above 25 ppt (NOAA 2005). Delaware Bay is important as a habitat for adults and as a nursery for juveniles. Summer flounder are found most often in the middle and lower portions of the estuary, but juveniles especially also are found in the inland bays (NOAA 1999c).

The summer flounder is a demersal fish found in coastal waters over sandy substrates from Nova Scotia to Florida, but it is most abundant between Cape Cod and Cape Fear (ASMFC 2008e). It occurs 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 for the winter over the continental shelf (NEFSC 2006a, NOAA 1999c). Eggs are pelagic and buoyant, as are the early stages of larvae. Larvae hatch between 56 and 216 hours after fertilization, depending on temperature, and begin to feed after 3 to 4 days (NOAA 1999c). Larvae are transported 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. They then 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 are found in the deeper parts of Delaware Bay throughout the winter (NOAA 1999c). Sexual maturity is reached by age 2, females may live up to 20 years and reach 26.5 lbs (12 kg) in weight, but males generally live for only 10 years (NEFSC 2006a).

Tidal movements of juveniles have been hypothesized to be due to the desire to stay within a desired set of environmental variables, including temperature, salinity and dissolved oxygen. Larvae and juveniles are found in temperatures between 32 and 73.4 °F (0 °C and 23 °C) and usually are found in the higher-salinity portions of estuaries. Newly recruited juveniles are found over a variety of substrates, including mud, sand, shell hash, eelgrass beds, and oyster bars, but as they grow, they are more often found over sand. They are visual predators, so they feed mostly during the daylight hours. While they are pelagic, larvae feed on copepodites, copepods, nauplii, tintinnids, bivalve larvae, appendicularians, and copepod eggs. Larger larvae and juveniles eat crustaceans, polychaetes, and small fish, including the copepod *Temora longicornis,* Atlantic silversides, mummichogs, juvenile spot, northern pipefish (*Syngnathus fuscus*), grass shrimp, sand shrimp, blue crabs, and the mysid *Neomysis americana,* with benthic prey items becoming increasingly important with age. Larvae and small juveniles of the summer flounder are consumed by spiny dogfish, goosefish, cod, silver hake, red hake, spotted hake, sea raven, longhorn sculpin (*Myoxocephalus octodecemspinosus*), fourspot flounder (*Paralichthys oblongus*), striped killifish (*Fundulus majalis*), blue crabs, and sea robin (*Prionotus* spp.). Adult summer flounder are most often found over substrates of sand, coarse sand or shell fragments, but are also found over mud and in marsh creeks and seagrass beds. Their diet consists of crustaceans, other invertebrates, and fish, including Atlantic silversides, herrings, juvenile spot, windowpane, winter flounder, northern pipefish, Atlantic menhaden, bay anchovy, red hake, silver hake, scup, American sand lance, bluefish, weakfish, mummichog, rock crabs, squids (*Loligo* sp.), small bivalve and gastropod mollusks, small crustaceans (sand shrimp, mysids, grass shrimp, hermit crabs [*Pagurus longicarpus],* mantis shrimp [*Squilla empusa*], and isopods, marine worms, and sand dollars. Summer flounder are eaten by large predators, such as sharks, rays, and goosefish (NOAA 1999c).

Atlantic Butterfish

Atlantic butterfish is an important commercial fish species that also is caught as bycatch in other fisheries such as the fluke, squid, mixed groundfish, and silver hake fisheries (NEFSC 2006b, 2004). Butterfish are an ecologically important species as forage fish for many larger fishes, marine mammals, and birds. The fishery has been in operation since the late 1800s. Between 1920 and 1962, U. S. landings averaged 3000 million tons annually (NOAA 1999ce). U. S. commercial landings averaged 3200 million tons annually between 1965 and 2002. They peaked in 1984 at 11,972 million tons, with an estimated annual bycatch of 1000 to 9200 million tons. A record low catch occurred in 2005 at 432 million tons (NEFSC 2006b). The Atlantic butterfish fishery is managed by the MAFMC 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). NOAA has designated EFH for Atlantic butterfish in Delaware Bay (NOAA 2010b). According to the NOAA EFH source document, larvae, juveniles, and adults are common in Delaware Bay, with larvae and adults found in the saline zones and juveniles found in both the mixing and the saline zones. Juveniles and adults are also common in the saline zones of the Delaware inland bays; thus, these areas are considered EFH for this species (NOAA 1999ce).

The Atlantic butterfish is a pelagic schooling fish. Its range includes the Atlantic coast from Newfoundland to Florida, but it is most abundant between the Gulf of Maine and Cape Hatteras (NEFSC 2006b, NOAA 1999e). Butterfish are found in bays, estuaries, and coastal waters up to 200 mi offshore during the summer over sand, mud, and mixed substrates. Butterfish spawn offshore and in large bays and estuaries from June through August after a northward migration. They are broadcast spawners; spawning occurs at night in the upper part of the water column in water of 15 °C or more. Eggs are pelagic and buoyant, hatching between 48 and 72 hours after fertilization, depending on the temperature. The yolk sac is absorbed by the time the larval fish is 0.1 inches (2.6 mm) long (NOAA 1999ce). Larvae of more than 0.4 inches (10 mm) in length become nektonic, with these larvae and juveniles often associating with jellyfish during their first summer as a strategy to avoid predators (NEFSC 2006b, NOAA 1999ce). Adults migrate seasonally, moving south and offshore in the Middle Atlantic Bight for the winter, and inshore in the spring (NOAA 1999ce). Sexual maturity is reached by age 1, fish rarely live more than 3 years, and they reach a weight of up to 1.1 lbs (0.5 kg) (NEFSC 2006b).

Butterfish feed on small fish, mollusks (primarily squids), crustaceans, and other pelagic animals such as thaliaceans, copepods, amphipods, decapods, coelenterates (primarily hydrozoans), polychaetes, euphausids, and ctenophores. They are eaten by haddock, silver hake, goosefish, weakfish, bluefish, swordfish, sharks, spiny dogfish, long-finned squid, pilot whales, common dolphins, greater shearwaters (*Puffinus gravis*), and northern gannets (*Morus bassanus*) (NEFSC 2006b, NOAA 1999ce, NEFSC 2004). Butterfish are eurythermal, found between 39.9 and 79.5 °F (4.4 and 26.4 °C), and euryhaline, found in waters of 5 to 32 ppt (NOAA 1999ce).

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 non-wet uplands, as well as non-tidal wetlands and bodies of freshwater located on Artificial Island or the ROWs.

2.2.6.1 Artificial Island

As discussed above in the site description, Artificial Island, on which the Salem and HCGS facilities were constructed, 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. All terrestrial resources on the island have become established since creation of the island began approximately 100 years ago. Consequently, Artificial Island contains poor quality soils and very few trees. Approximately 75 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 of the mainland (Figure 2.9). The terrestrial, non-wetland habitats of the island consist principally of areas covered by grasses and other herbs, with some shrubs and planted trees present in developed areas. Small, isolated, freshwater impoundments and associated wetland areas also are present.

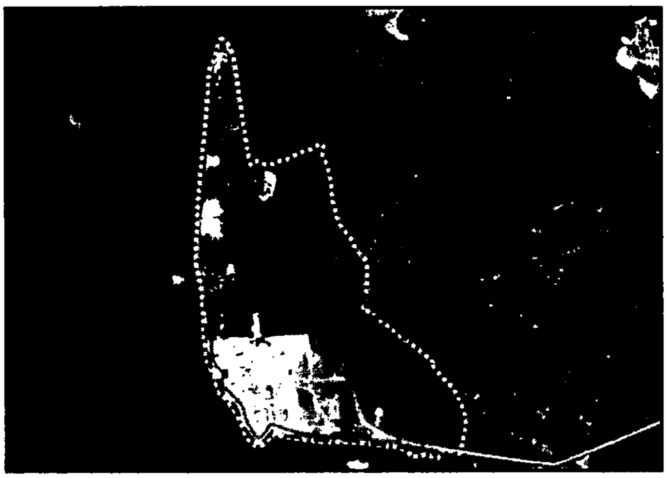


Figure 2-9. Aerial showing the Boundaries of Artificial Island (dotted yellow), PSEG property (red dashed), and Developed Areas (solid blue)

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 site (approximately 266 ac [108 ha]). Maintained areas of grass, including two baseball fields, cover about 12 ac (5 ha) of the site interior. The remaining 25 percent of the PSEG property (approximately 100 ac [40 ha]) consists primarily of 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 Artificial Island are Udorthents consisting of dredged fine material (NRCS 2010). The National Wetlands Inventory (NWI) identifies an inland marsh/swamp area on the periphery of the project site adjacent to Hope Creek Road and two small 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 occupied by freshwater emergent wetlands and freshwater ponds (FWS 2010a).

The site is within the Middle Atlantic coastal plain of the eastern temperate forest ecoregion (EPA 2007). 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.

The animal species present on Artificial Island likely are typical of those inhabiting estuarine tidal marshes and adjacent habitats within the Delaware Estuary. 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). In 1972, Salem pre-construction surveys conducted within a 6 km (4 mi) radius of the project site recorded 44 avian species, including many shorebirds, wading birds, and waterfowl associated with open water and emergent marsh areas of the estuary. During construction of the Salem facility, several avian species were observed on the project site, 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 16 km (10 mi) of the project site. Approximately half of these species were recorded primarily from tidal marsh and the open water of the Delaware River (habitat similar to the project site) and roughly 45 of the 178 total observed species were classified as permanent resident species (PSEG 1983). The osprey (*Pandion haliaeetus*) has been observed nesting on transmission line towers on Artificial Island (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*), have been observed using the nearby Alloway Creek Estuary Enhancement Program restoration site for breeding purposes (PSEG 2004b). These and other marsh species likely occur in the marsh habitats on Artificial Island.

Mammals reported to occur on Artificial Island in the area of the Salem and HCGS facilities before their construction include the eastern cottontail (*Sylvilagus floridanus*), Norway rat (*Rattus norvegicus*), and house mouse (*Mus musculus*) (AEC 1973). Signs of raccoon (*Procyon lotor*) have been observed near Salem, and other mammals likely to occur in the vicinity of the two facilities include the white-tailed deer (*Odocoileus virginianus*), muskrat (*Ondatra zibethica*), opossum (*Didelphis marsupialis*), and striped skunk (*Mephitis mephitis*). Surveys conducted in association with the construction of HCGS identified 45 mammals that could be expected to occur within 16 km (10 mi) of the project site (PSEG 1983). Of the 45 species identified, eight were species associated with marsh habitats, such as the meadow vole (*Microtus pennsylvanicus*) and marsh rice rat (*Oryzomys pulustris*).

Eight of 26 reptile species observed during surveys related to the early operation of HCGS were recorded from tidal marsh (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 could occur in tidal marsh adjacent to the project site.

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 1000 acres (405 ha) and is located about 4 mi (6.4 km) northeast of HCGS.
- Mad Horse Creek State WMA encompasses roughly 9500 acres (3844 ha), of which the northernmost portion is situated approximately 0.5 mi (0.8 km) from the site. 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, which also is State-listed as endangered, as well as many other birds dependent on salt marsh/wetland habitats (National Audubon Society 2010).

2.2.6.2 Transmission Line ROWs

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 – Salem and HCGS Transmission Line System)

In total, the three ROWs for the Salem and HCGS power transmission system occupy approximately 4376 ac (1771 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). When the ROWs exit Salem and HCGS, they initially pass through approximately 3 mi (5 km) of estuarine emergent marsh east of the property boundary. The primary land cover type then crossed by the north and south New Freedom ROWs (approximately 30 mi [48 km]) within their middle segments is a mixture of agricultural and forested land. The Keeney ROW exits HCGS and heads north, traversing approximately 5 mi (8 km) of emergent marsh and swamp paralleling the New Jersey coast, before it crosses 8 mi (13 km) of agricultural, sparsely forested, and rural residential property. The Keeney corridor then continues west across the Delaware River for approximately 3.25 mi (5.25 km) until it reaches the Red Lion substation. From the substation, the Red Lion-Keeney portion of the line within the Keeney ROW remains exclusively within Delaware, crossing primarily highly developed, residential land.

For approximately the last one-quarter of the length, the New Freedom ROWs, before their termination at the New Freedom substation, traverse the New Jersey Pinelands National Reserve (PNR) (National Park Service [NPS] 2006a). Temperate broadleaf forest is the major ecosystem type of the reserve, which was designated a U.S. Biosphere Reserve in 1988 by the United Nations Educational, Scientific and Cultural Organization (UNESCO). 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). PNR is protected and its future development is guided by the Pinelands Comprehensive Management Plan, which is implemented by the New Jersey Pinelands Commission. The commission is also responsible for regulating the maintenance of all bulk electric transmission (> 69 kV) ROWs in the Pinelands area and, therefore, oversees maintenance of the portions of the north and south Salem/HCGS New Freedom ROWs that fall within the PNR (New Jersey Pinelands Commission 2009). The two New Freedom corridors 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, New Jersey and meanders for approximately 60 mi (97 km), gradually widening as tributaries enter, until terminating at the Atlantic Ocean.

The Endangered and Nongame Species Program of the NJDFW identifies critical habitat for bald eagles, including areas the species uses for foraging, roosting, and nesting. All three ROWs traverse land classified as critical bald eagle foraging habitat (NJDEP 2006). Typical foraging habitat for this species consists of tall trees for perching near large bodies of water. The tideland marshes of southern New Jersey are particularly good locations for winter foraging (NJDFW 2010a).

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 2010b). These six species also have a State listing status of threatened or endangered in New Jersey and/or Delaware (NJDEP 2008b, DNREC 2008). These species are discussed below.

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

Scientific Name	Common Name	Status[1]		
		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				
Acipenser brevirostrum	shortnose sturgeon	E	E	-
A. oxyrinchus oxyrinchus	Atlantic sturgeon	C	-	E

[1] E = Endangered; T = Threatened; C = Candidate

<u>Kemp's Ridley, Loggerhead, Green, and Leatherback Sea Turtles</u>

Sea turtles are air-breathing reptiles with large flippers and streamlined bodies. They inhabit tropical and subtropical marine and estuarine waters around the world. Of the seven species in the world, six occur in waters of the U.S., and all are listed as threatened or endangered. The four species identified by the 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*) sea turtles. Kemp's ridley, loggerhead, and green sea turtles have been documented in the Delaware Estuary at or near the Salem and HCGS facilities, while 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 about 100 lbs (45 kg) with a carapace length of 24 to 28 inches (61 to 71 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 2000 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. 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 (NMFS 2010c).

All four of these sea turtle species nest on sandy beaches; none nest on the Delaware River (NMFS 2010c). They are distributed generally in tropical and subtropical waters worldwide, and there is evidence that they return to their natal beaches to nest. The leatherback has the widest distribution of all the species, as it has physiological adaptations that allow survival and foraging in much colder water than the other species (NMFS, FWS 2007a). 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, NMFS and FWS 2007b, NMFS and FWS 2007c, NOAA 2010h).

Shortnose Sturgeon

The shortnose sturgeon *(Acipenser brevirostrum)* is a primitive fish, similar in appearance to other sturgeon (NOAA 2010i), and has not evolved significantly for the past 120 million years (Northeast Fisheries Science Center [NEFSC] 2006). This species was not specifically targeted as a commercial fishery species, but has been taken as bycatch in the Atlantic sturgeon 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 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.

In 1967, the shortnose sturgeon was listed as endangered under the recently implemented Endangered Species Preservation Act of 1966. After the Endangered Species Act was passed in 1973, NMFS assumed responsibility for the species in 1974. NMFS established a recovery plan in 1998 listing actions that would assist in increasing population sizes (NOAA 2010i). The overall objective of the recovery plan is to maintain genetic diversity and avoid extinction of the species (NEFSC 2006). The recovery plan recognizes 19 different populations along the Atlantic Coast due to the fact that sturgeon in each population return to their natal rivers to spawn, making genetic intermingling unlikely. The populations are still managed together, however, as not enough data currently exist to definitively separate the breeding populations (NMFS 1998). The ASMFC currently manages the shortnose sturgeon along with the Atlantic sturgeon under a management plan that was implemented in 1990. An amendment was added in 1998 prohibiting all sturgeon harvesting in response to a rapid decline in abundance. This amendment requires 20 year classes of females to be present in any population before any fishing is considered. As of 2006, no shortnose sturgeon had been caught in the NMFS bottom trawl survey program (NEFSC 2006).

The shortnose sturgeon is found along the Atlantic coast from Canada to Florida in a variety of habitats. They occur in fast-flowing riverine waters, 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 the non-spawning periods. They do not appear to make long distance offshore migrations like other anadromous fishes (NOAA 2010i). Migration into freshwater to spawn occurs between late winter and early summer, dependent on latitude (NEFSC 2006). Spawning occurs in deep, rapidly flowing water over gravel, rubble, or boulder substrates (FWS 2001a). Eggs are deposited on hard surfaces to which they adhere before hatching after 9 to 12 days. The yolk sac is absorbed in an additional 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). Shortnose sturgeon can live up to 30 years (males) to 67 years (females), can grow up to 4.7 ft (143 cm) long, and can 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 2010i). Shortnose sturgeon are demersal and feed on benthos. Juveniles feed on benthic insects such as *Hexagenia* sp., *Chaoborus* sp., *Chironomus* sp., and small crustaceans (*Gammarus* sp., *Asellus* sp., *Cyathura polita*) (NMFS 1998). Adults feed over gravel and mud substrates, in deep channels and nearshore ocean waters (USWFS 2001a), where they consume mostly mollusks and larger crustaceans (NOAA 2010i). Prey species for adults include *Physa* sp., *Heliosoma* sp., *Corbicula manilensis*, *Amnicola limnosa*, *Valvata* sp., *Pisidium* sp., *Elliptio complanata, Mya arenaria*, *Macoma balthica*, gammarid amphipods, and zebra mussels (*Dreissena polymorpha*) (NMFS 1998). Additional food items for both juveniles and adults include worms, plants, and small fish (NEFSC 2006).

In the Delaware Estuary, shortnose sturgeon most often occur in the Delaware River and may be found occasionally in the nearshore ocean. Their abundance is greatest between Trenton, New Jersey and Philadelphia, Pennsylvania. Adults overwinter in large groups between Trenton and Bordentown, New Jersey, but little is known of the distribution of juveniles in the Delaware estuary (USACE 2009). A review of the status of the shortnose sturgeon was initiated in 2007 and was still underway as of 2008, when the latest biennial report to Congress regarding the Endangered Species Act was completed. Due to its distinct populations, the status of the species varies depending on the river in question. The population estimate for the Delaware Estuary (1999-2003) was 12,047 adults. Current threats to the shortnose sturgeon also vary among rivers. Generally, over the entire range, most threats are related to dams, pollution, and general industrial growth in the 1800s. Drought and climate change are considered aggravators of 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. The Delaware River population is most threatened by dredging operations and water quality issues (NMFS 2008).

Atlantic Sturgeon

Atlantic sturgeon (*Acipenser oxytinchus oxyrinchus*) are an evolutionarily ancient fish, remaining relatively unchanged for the past 70 million years. They were originally considered a junk fish, used as fertilizer and fuel. As the demand for caviar grew, they were harvested for human consumption. By 1870, a large commercial fishery for Atlantic sturgeon was established. This fishery crashed in approximately 100 years due to overfishing, exacerbated by the fact that this species takes a very long time to reach sexual maturity. They were caught for many reasons:

their flesh and eggs were processed for human consumption, their skin was made into leather products such as book bindings, and their swim bladders were used to make gelatin and small windows. Landings at the turn of the century averaged seven million pounds per year. They declined to 100,000 to 250,000 lbs by the 1990s. The ASMFC adopted a Fishery Management Plan (FMP) in 1990 that implemented harvest quotas. The FMP was amended in 1998 with a coast-wide moratorium on Atlantic sturgeon harvest that will remain in place until 2038. This moratorium was mirrored by the Federal government in 1999, prohibiting harvest in the exclusive economic zone offshore (ASMFC 2009c). Recommendations in the FMP with respect to habitat conservation include identifying, characterizing, and protecting critical spawning and nursery areas, identifying critical habitat characteristics of spawning staging and oceanic areas, determining environmental tolerance levels (dissolved oxygen, pH, temperature, river flow, salinity, etc.) for all life stages, and determining the effects of contaminants on all life stages, especially eggs, larvae, and juveniles (ASMFC 2010c).

The current status of the Atlantic sturgeon stock is unknown due to little reliable data. In 1998, a coast wide stock assessment determined that biomass was much lower than it had been in the early 1900s. This assessment resulted in the coast wide moratorium in an effort to accumulate 20 years worth of breeding stock. Concurrent with the assessment, it was decided that listing the Atlantic sturgeon as threatened or endangered was not warranted. The NMFS reviewed the status again in 2005 and concluded that the stock should be broken into five distinct populations, the Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic stocks. Three of these are likely to become endangered (Carolina, Chesapeake Bay, and New York Bight). The other two populations have a moderate chance of becoming endangered. Due to a lack of appropriate data, the NMFS could not list the species as threatened or endangered at that time. Threats to the Atlantic sturgeon and its habitat include bycatch mortality, poor water quality, lack of adequate State and/or Federal regulatory mechanisms, dredging activities, habitat impediments (dams blocking spawning areas) and ship strikes (ASMFC 2009c). As of 2009, the Atlantic sturgeon over its entire range is listed as a species of concern and a candidate species by the NMFS. Reasons for the listing include genetic diversity (distinct populations) and lack of population size estimates (only the Hudson and Altamaha River populations are adequately documented) (NOAA 2009b).

Atlantic sturgeon are found along the Atlantic coast in the ocean, large rivers, and estuaries from Labrador to northern Florida. They have been extirpated from most coastal systems except for the Hudson River, the Delaware River, and some South Carolina systems (ASMFC 2010c). They are anadromous, migrating inshore to coastal estuaries and rivers to spawn in the spring. A single fish will only spawn every 2 to 6 years (ASMFC 2009c). Spawning is accomplished by broadcasting eggs in fast-flowing, deep water with hard bottoms (ASMFC 2010c). Eggs are demersal and stick to the substrate after 20 minutes of dispersal time. Larvae are pelagic, swimming in the water column, becoming benthic juveniles within 4 weeks (ASMFC 2009a). 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) long and 800 lbs (363 kg). Sexual maturity is reached by females between 7 and 30 years of age and by males between 5 and 24 years (ASMFC 2009c).

Atlantic sturgeon are benthic predators and feed on mussels, worms, shrimps, and small fish (ASMFC 2009c). Juveniles are known to consume sludgeworms, annelid worms, polycheate worms, isopods, amphipods, chironomid larvae, mayfly and other insect larvae, small bivalve mollusks, mysids, and amphipods. 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. Juveniles and adults may compete for food with other benthic feeders such as shortnose sturgeon, suckers (*Moxotoma* sp.), winter flounder (*Pleuronectes americanus*), tautog (*Tautoga onitis*), cunner (*Tautagolabrus adspersus*), porgies (Sparidae), croakers (Sciaenidae), and stingrays (*Dasyatis* sp.). Juveniles are preyed upon by sea lampreys (*Petromyzon marinus*), gar (*Lepisosteus* sp.), striped bass, common carp (*Cyprinus carpio*), northern pikeminnow (*Ptychocheilus oregonensis*), channel catfish (*Ictalurus punctatus*), smallmouth bass (*Micropterus dolomieu*), walleye (*Sander vitreus*), fallfish (*Semotilus corporalis*), and grey seal (*Halichoerus grypus*) (ASMFC 2009d).

The Delaware River and associated estuarine habitats may have historically supported the largest Atlantic sturgeon stock on the east coast. Juveniles were once caught as bycatch in numbers large enough to be a nuisance in the American shad fishery. It has been estimated that over 180,000 females spawned annually in the Delaware River before 1870. 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 and Cherry Island Flats. 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 (ASMFC 2009d).

2.2.7.2 Terrestrial and Freshwater Aquatic Species

There are seven terrestrial species with a Federal listing status of threatened or endangered that have recorded occurrences or the potential to occur either in the county in Salem County, in which the Salem and HCGS facilities are located, or the additional counties crossed by the three ROWs (Gloucester and Camden Counties in New Jersey, New Castle County in Delaware). These species include a turtle, a beetle, and five plants (Table 2-9) (FWS 2010b). Six of these species (all except one plant) also have a State listing status of endangered in New Jersey, and the turtle has a state status of endangered in both states (NJDEP 2008c, 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 2009a, FWS 2009b). However, two of the species Federally listed as threatened were identified by the New Jersey Field Office of FWS (FWS 2009a) as having known occurrences or other areas of potential habitat along the New Freedom North and South transmission line ROWs: the bog turtle (*Clemmys muhlenbergii*) and the swamp pink (*Helonias bullata*). These species are discussed below.

<u>Bog Turtle</u>

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

Affected Environment

Table 2-9. Threatened and Endangered Terrestrial and Freshwater Aquatic Species Recorded in Salem County and Counties Crossed by Transmission Lines

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
Mammals					
Lynx rufus	bobcat	-	E	Salem	Rock outcrops, caves, swamps, bogs dense thickets of briars; and conifers in contiguous forest; and forests fragmented by agricultural areas.[1]
Birds					
Accipiter cooperii	Cooper's hawk	-	T/T	Gloucester, Salem	Deciduous, coniferous, and mixed riparian or wetland forests; specifically remote red maple or black gum swamps.[1]
Ammodramus henslowii	Henslow's sparrow	-	E	Gloucester	Open fallow fields with high, thick herbaceous vegetation (not woody) with a few scattered shrubs; and grassy fields between salt marsh and uplands along the Delaware Bay coast.[1]
A. savannarum	grasshopper sparrow	-	T/S	Salem	Grasslands, pastures, agricultural lands, and other habitats with short- to medium-height grasses scattered with patches of bare ground.[1]
Bartramia longicauda	upland sandpiper	-	E	Gloucester, Salem	Open meadows and fallow fields often associated with pastures, airports or farms with a mixture of tall and short grasses.[1]
Buteo lineatus	red-shouldered hawk	-	E/T	Gloucester	Deciduous, riparian, or mixed woodlands in remote, old growth forests; and hardwood swamps with standing water, or vast

Table 2-9. Threatened and Endangered Terrestrial and Freshwater Aquatic Species Recorded in Salem County and Counties Crossed by Transmission Lines

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
					contiguous, freshwater wetlands.[1]
Circus cyaneus	northern harrier	-	E/U	Salem	Freshwater, brackish, and saline tidal marshes; emergent wetlands; fallow fields; grasslands; meadows; airports; and agricultural areas.[1]
Cistothorus platensis	sedge wren	-	E	Salem	Wet meadows, freshwater marshes, bogs, and drier portions of salt or brackish coastal marshes.[1]
Dolichonyx oryzivorus	bobolink	-	T/T	Salem	Hayfields, pastures, grassy meadows, and other low-intensity agricultural areas; may occur in coastal and freshwater marshes during migration.[1]
Falco peregrinus	peregrine falcon	-	E	Camden, Gloucester, Salem	Nest on buildings, bridges, man-made structures and forage in open area near water[1]
Falco sparverius	American kestrel		SC	Camder, Gloucester, Salem	Open fields and pastures with scattered trees for perching and nesting sites, power line ROWs.[24]
Haliaeetus leucocephalus	bald eagle	-	E	Gloucester, Salem	Large, perch trees in forested areas associated with water and tidal areas.[1]
Hylocichla mustelina	wood thrush	-	SC/S	Camder, Gloucester, Salem	Moist woodlands, hillsides, parks, orchards, and woodlots in suburbs.[21]
Melanerpes	red-headed	-	T/T	Camden, Gloucester,	Upland and wetland open woods

Table 2-9. Threatened and Endangered Terrestrial and Freshwater Aquatic Species Recorded in Salem County and Counties Crossed by Transmission Lines

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
erythrocephalus	woodpecker			Salem	that contain dead or dying trees, and sparse undergrowth.[1]
Pandion haliaetus	osprey	-	T/T	Gloucester, Salem	Dead trees or platforms near coastal/inland rivers, marshes, bays, inlets, and other areas associated with bodies of water that support adequate fish populations.[1]
Passerculus sandwichensis	savannah sparrow	-	T/T	Salem	Open habitats such as alfalfa fields, grasslands, meadows, fallow fields, airports, along the coast; and within salt marsh edges as well.[1]
Podilymbus podiceps	pied-billed grebe	-	E/S	Salem	Freshwater marshes associated with bogs, lakes, or slow-moving rivers.[1]
Pooecetes gramineus	vesper sparrow	-	E	Gloucester, Salem	Pastures, grasslands, cultivated fields containing crops, and other open areas.[1]
Strix varia	barred owl	-	T/T	Gloucester, Salem	Remote, contiguous, old growth wetland forests, including deciduous wetland forests; and Atlantic white cedar swamps associated with stream corridors.[1]

Table 2-9. Threatened and Endangered Terrestrial and Freshwater Aquatic Species Recorded in Salem County and Counties Crossed by Transmission Lines

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
Reptiles and Amphibians					
Ambystoma tigrinum	eastern tiger salamander	-	E	Gloucester, Salem	Uplands and wetlands containing breeding ponds, forests, and burrowing-appropriate soil types such as old fields, and deciduous or mixed woods.[1]
Bufo woodhousii fowleri	Fowler's toad	-	SC	Camden, Gloucester, Salem	Wooded areas, river valleys, floodplains, agricultural areas, areas with deep friable soils; burrows underground or hides under rocks, plants, or other cover when inactive; eggs and larvae develop in shallow water of marshes, rain pools, ponds, lakes, reservoirs, and flooded areas. [16]
Clemmys guttata	spotted turtle	-	SC	Camden, Gloucester, Salem	Wetlands with clean, shallow, slow-moving water with muddy or mucky bottoms including aquatic and emergent vegetation, shallow ponds, wet meadows, swamps, bogs, fens, sedge meadows, wet prairies, shallow cattail marshes, sphagnum seepages, small woodland streams, and roadside ditches; during mating and nesting seasons: open fields and woodlands, and along roads. [12]
Clemmys insculpta	wood turtle	-	E	Gloucester	Forests, meadows, or open fields near freshwater streams, creeks, or relatively remote rivers.[1]

Table 2-9. Threatened and Endangered Terrestrial and Freshwater Aquatic Species Recorded in Salem County and Counties Crossed by Transmission Lines

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
C. muhlenbergii	bog turtle	T	E DE: E	Camden, Gloucester, Salem, New Castle	Open, wet, grassy pastures or bogs with soft, muddy bottoms.[1]
Crotalus horridus horridus	timber rattlesnake	-	E	Camden	Deciduous upland forests or pinelands habitats, often near cedar swamps and along streambanks.[1]
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.[1]
Malaclemys terrapin terrapin	northern diamondback terrapin	-	SC	Camden, Gloucester, Salem	Marshes bordering salt or brackish tidal waters, mudflats, shallow bays, coves, tidal estuaries with adjacent sandy uplands for nesting.[22]
Pituophis melanoleucus	northern pine snake	-	T	Camden, Gloucester, Salem	Dry pine-oak forest types growing on infertile sandy soils.[1]
Terrapene carolina carolina	eastern box turtle	-	SC	Camden, Gloucester, Salem	Forested habitats with sandy soils and a source of water such as a stream, pond, lake, marsh or swamp; thickets; old fields; pastures; vegetated dunes; and nesting sites - sandy, open areas.[12]
Invertebrates					
Alasmidonta undulata	triangle floater	-	T	Gloucester	Stable substrates in waters of moderate flow in small rivers and headwater streams.[26]
Callophrys irus	frosted elfin	-	T	Camden	Dry clearings and open areas, savannas, power-line ROWs, roadsides.[1]

Table 2-9. Threatened and Endangered Terrestrial and Freshwater Aquatic Species Recorded in Salem County and Counties Crossed by Transmission Lines

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
Lampsilis cariosa	yellow lampmussel	-	T	Gloucester	Medium to large rivers, lakes and ponds; substrate types - sand, silt, cobble, and gravel; larval hosts - white perch and yellow perch.[22]
Lampsilis radiata	eastern lampmussel	-	T	Camden, Gloucester, Salem	Small streams, large rivers, ponds, and lakes; prefers sand or gravel substrates.[22]
Leptodea ochracea	tidewater mucket	-	T	Camden, Gloucester	Freshwater water with tidal influence on the lower coastal plain, pristine rivers.[32]
Ligumia nasuta	eastern pond mussel	-	T	Camden, Gloucester	Lakes, ponds, streams and rivers of variable depths with muddy, sandy, or gravelly substrates.[32]
Lycaena hyllus	bronze copper		E	Salem	Brackish and freshwater marshes, bogs, fens, seepages, wet sedge meadows, riparian zones, wet grasslands, and drainage ditches.[1]
Nicrophorus americanus	American burying beetle	E	E	Camden, Gloucester	Open areas, primarily coastal grassland/scrub.[1]
Pontia protodice	checkered white	-	T	Camden	Open areas, savannas, old fields, vacant lots, power-line ROWs, forest edges.[1]
Pyrgus wyandot	Appalachian grizzled skipper	-	E	Gloucester	Semi-open shale slopes with exposed crumbly rock or soil, sparse herbaceous vegetation, surrounded by scrub oak or oak-hickory woodlands; larval host plant - Canada cinquefoil (*Potentilla canadensis*); tufted grasses like broomsedge (*Andropogon virginicus*), spring beauty (*Claytonia* spp.), phlox

Table 2-9. Threatened and Endangered Terrestrial and Freshwater Aquatic Species Recorded in Salem County and Counties Crossed by Transmission Lines

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
					(*Phlox subulata*), and birdsfoot violet (*Viola pedata*). [22]
Plants					
Aeschynomene virginica	sensitive joint vetch	T	E	Camden, Gloucester, Salem	Fresh to slightly salty (brackish) tidal marshes.[2]
Aplectrum hyemale	putty root	-	E	Gloucester	Moist, deciduous upland to swampy forests.[3]
Aristida lanosa	wooly three-awn grass	-	E	Camden, Salem	Dry fields, uplands, pink-oak woods, primarily in sandy soil.[4]
Asimina triloba	pawpaw	-	E	Gloucester	Shady, open-woods areas in wet, fertile bottomlands, or upland areas on rich soils.[5]
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.[6]
Bouteloua curtipendula	side oats grama grass	-	E	Gloucester	Rocky, open slopes, woodlands, and forest openings up to an elevation of approximately 7000 ft.[5]
Cacalia atriplicifolia	pale Indian plantain	-	E	Camden, Gloucester	Dry, open woods, thickets, and rocky openings.[6]
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.[7]
Cardamine longii	Long's bittercress	-	E	Gloucester	Shady tidal creeks, swamps, and mudflats.[8]

Table 2-9. Threatened and Endangered Terrestrial and Freshwater Aquatic Species Recorded in Salem County and Counties Crossed by Transmission Lines

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
Carex aquatilis	water sedge	-	E	Camden	Swamps, bogs, marshes, very wet soil, ponds, lakes, marshy meadows, and other wetland-type sites.[9]
C. bushii	Bush's sedge	-	E	Camden	Dry to mesic grasslands, and forest margins.[3]
C. cumulata	clustered sedge	-	E	Camden	Damp, open rocky areas with shallow, sandy soils[8]
C. limosa	mud sedge	-	E	Gloucester	Fens, sphagnum bogs, wet meadows, and shorelines.[3]
C. polymorpha	variable sedge	-	E	Gloucester	Dry, sandy, open areas of scrub, forests, swampy woods, and along banks and marsh edge.[8]
Castanea pumila	chinquapin	-	E	Gloucester, Salem	High ridges and slopes within mixed hardwood forests, dry pinelands, and ROWs.[5]
Cercis canadensis	redbud	-	E	Camden	Rich, moist wooded areas in the forest understory, streambanks, and abandoned farmlands.[5]
Chenopodium rubrum	red goosefoot	-	E	Camden	Moist, often salty soils along the Atlantic coast.[10]
Commelina erecta	slender dayflower	-	E	Camden	Along roadsides, streambanks, in gardens and prairies in sandy, or clayey soils.[5]
Cyperus lancastriensis	Lancaster flat sedge	-	E	Camden, Gloucester	Riverbanks, floodplains, and other disturbed, sunny or partly sunny places in mesic, or dry-mesic soils.[3]
C. polystachyos	coast flat sedge	-	E	Salem	Along shores, in ditches, and

Table 2-9. Threatened and Endangered Terrestrial and Freshwater Aquatic Species Recorded in Salem County and Counties Crossed by Transmission Lines

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
					swales between dunes.[3]
C. pseudovegetus	marsh flat sedge	-	E	Salem	Open mesic forests, stream edges, swamps, moist sandy areas, and bottomland prairies.[11]
C. retrofractus	rough flat sedge	-	E	Camden, Gloucester	Sandy, disturbed areas, openings of dry upland forests and prairies.[11]
Dalibarda repens	robin-run-away	-	E	Gloucester	Swamps, moist woodlands, and other cool, wet areas.[12]
Diodia virginiana	larger buttonweed	-	E	Camden	Wet meadows in wet soils, and pond margins.[11]
Draba reptans	Carolina Whitlow-grass	-	E	Camden, Gloucester	Rocky or sandy soils in prairies and other disturbed areas.[13]
Eleocharis melanocarpa	black-fruit spike-rush	-	E	Salem	Fresh, oligotrophic, often drying, sandy shores, ponds, and ditches.[3]
E. equisetoides	knotted spike-rush	-	E	Gloucester	Fresh lakes, ponds, marshes, streams, and cypress swamps.[3]
E. tortilis	twisted spike-rush	-	E	Gloucester	Bogs, ditches, seeps, and other freshwater, acidic places.[3]
Elephantopus carolinianus	Carolina elephant-foot	-	E	Gloucester, Salem	Full sun to partial shade in dry to medium, sandy soils.[14]
Eriophorum gracile	slender cotton-grass	-	E	Gloucester	Peaty, acidic substrates such as bogs, meadows, and shores.[3]
E. tenellum	rough cotton-grass	-	E	Camden, Gloucester	Bogs and other wet, peaty substrates.[3]
Eupatorium capillifolium	dog fennel	-	E	Camden	Coastal meadows, fallow fields,

Table 2-9. Threatened and Endangered Terrestrial and Freshwater Aquatic Species Recorded in Salem County and Counties Crossed by Transmission Lines

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
	thoroughwort				flatwoods, marshes, and disturbed sites.[15]
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, beaver ponds, and shrub swamps.[17]
Euphorbia purpurea	Darlington's glade spurge	-	E	Salem	Rich, cool woods along seeps, streams, or swamps.[17]
Glyceria grandis	American manna grass	-	E	Camden	Grassy areas.[6]
Gnaphalium helleri	small everlasting	-	E	Camden	Dry woods, often in sandy soil.[13]
Gymnopogon brevifolius	short-leaf skeleton grass	-	E	Gloucester	Dryish clay-loam soils, calcareous glades, and relict prairies.[23]
Helonias bullata	swamp pink	T	E	Camden, Gloucester, Salem, New Castle	Swamps and groundwater influenced, and perennially water-saturated forested wetlands.[17]
Hemicarpha micrantha	small-flower halfchaff sedge	-	E	Camden	Emergent shorelines, but rarely freshwater tidal shores.[3]
Hottonia inflata	featherfoil	-	E	Salem	Quiet, shallow water of pools, streams, ditches, and occasionally in wet soil.[20]
Hydrastis canadensis	golden seal	-	E	Camden	Mesic, deciduous forests, often on clayey soil.[3]
Hydrocotyle ranunculoides	floating marsh-pennywort	-	E	Salem	Ponds, marshes, and wet ground.[19]
Hypericum adpressum	Barton's St. John's-	-	E	Salem	Pond shore.[7]

Table 2-9. Threatened and Endangered Terrestrial and Freshwater Aquatic Species Recorded in Salem County and Counties Crossed by Transmission Lines

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
	wort				
Isotria meleoloides	small-whorled pogonia	T	-	-	Mixed deciduous forests in second- or third-growth successional stages, coniferous forests; typically light to moderate leaf litter, open herb layer, moderate to light shrub layer, and relatively open canopy; flats or slope bases near canopy breaks.[3]
Juncus caesariensis	New Jersey rush	-	E	Camden	Borders of wet woods, wet springy bogs, and swamps.[3]
J. torreyi	Torrey's rush	-	E	Camden	Edge of sloughs, wet sandy shores; along slightly alkaline watercourses; swamps; sometimes on clay soils, alkaline soils, and calcareous wet meadows.[3]
Kuhnia eupatorioides	false boneset	-	E	Camden	Limestone edges of bluffs, rocky wooded slopes, and rocky limestone talus.[11]
Lemna perpusilla	minute duckweed	-	E	Camden, Salem	Mesotrophic to eutrophic, quiet waters with relatively mild winters.[3]
Limosella subulata	awl-leaf mudwort	-	E	Camden	Freshwater marshes.[18]
Linum intercursum	sandplain flax	-	E	Camden, Salem	Open, dry, sandplain grasslands or moors; sand barrens; mown fields; and swaths under powerlines, usually in small colonies.[23]
Luzula acuminate	hairy wood-rush	-	E	Gloucester, Salem	Grassy areas.[6]
Melanthium virginicum	Virginia bunchflower	-	E	Camden, Gloucester, Salem	Fens, bottomland prairies; mesic upland forests; mesic upland prairies; along streams,

Table 2-9. Threatened and Endangered Terrestrial and Freshwater Aquatic Species Recorded in Salem County and Counties Crossed by Transmission Lines

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
					roadsides, and railroads.[11]
Micranthemum micranthemoides	Nuttall's mudwort	-	E	Camden, Gloucester	Possibly extinct - last seen anywhere in 1941; freshwater tidal shores of northeast and mid-Atlantic rivers, including Hudson, Delaware, Potomac, and Anacostia.[16]
Muhlenbergia capillaries	long-awn smoke grass	-	E	Gloucester	Sandy, pine openings; dry praires; and exposed ledges.[6]
Myriophyllum tenellum	slender water-milfoil	-	E	Camden	Sandy soil, water to 5 ft deep.[13]
M. pinnatum	cut-leaf water-milfoil	-	E	Salem	Floodplain marsh; associated with *Asclepias perrenis*, *Salix caroliniana*, and *Ludwigia repens*.[16]
Nelumbo lutea	American lotus	-	E	Camden, Salem	Mostly floodplains of major rivers in ponds, lakes, pools in swamps and marshes, and backwaters of reservoirs.[3]
Nuphar microphyllum	small-yellow pond-lily	-	E	Camden	Lakes, ponds, sluggish streams, ditches, sloughs, and occasionally tidal waters.[3]
Onosmodium virginianum	Virginia false-gromwell	-	E	Camden, Gloucester, Salem	Sandy soil, and dry open woods.[10]
Ophioglossum vulgatum pycnostichum	southern adder's tongue	-	E	Salem	Rich wooded slopes, shaded secondary woods, forested bottomlands, and floodplain woods, south of Wisconsin glaciations.[3]
Panicum aciculare	bristling panic grass	-	E	Gloucester	Sandy, coastal plains that undergo rises and falls in water levels, coastal plain ponds, limestone depression ponds, and shallow cypress ponds .[17]
Penstemon laevigatus	smooth beardtongue	-	E	Gloucester	Rich woods and fields.[6]

Table 2-9. Threatened and Endangered Terrestrial and Freshwater Aquatic Species Recorded in Salem County and Counties Crossed by Transmission Lines

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
Plantago pusilla	dwarf plantain	-	E	Camden	Dry sand prairies, hill prairies, cliffs, rocky glades, sandy fields, and areas of gravel along railroads or roadsides.[27]
Platanthera flava flava	southern rein orchid	-	E	Camden	Floodplain forests; white cedar, hardwood, and cypress swamps; riparian thickets; and wet meadows. [3]
Pluchea foetida	stinking fleabane	-	E	Camden	Swamps, marshes, ditches, coastal savannahs.[28]
Polemonium reptans	Greek-valerian	-	E	Salem	Moist, stream banks; and deciduous woods. [6]
Polygala incarnate	pink milkwort	-	E	Camden, Gloucester	Fields, prairies, and meadows. [6]
Prunus angustifolia	chickasaw plum	-	E	Camden, Gloucester, Salem	Woodland edges, forest openings, open woodlands, savannahs, prairies, plains, meadows, pastures, roadsides, and fence rows. [6]
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. [11]
P. torrei	Torrey's mountain mint	-	E	Gloucester	Open, dry, including red cedar barrens, rocky summits, roadsides and trails, and dry upland woods.[8]
Quercus imbricaria	shingle oak	-	E	Gloucester	Rich bottomlands, and dry to moist uplands. [6]
Q. lyrata	overcup oak	-	E	Salem	Lowlands, bottoms, wet forests, streamside forests, and periodically inundated areas. [3]
Rhododendron atlanticum	dwarf azalea	-	E	Salem	Moist, flat, pine woods, and savannas. [6]
Rhynchospora globularis	coarse grass-like	-	E	Camden, Gloucester,	Sandy and rocky stream banks,

Table 2-9. Threatened and Endangered Terrestrial and Freshwater Aquatic Species Recorded in Salem County and Counties Crossed by Transmission Lines

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
	beaked-rush			Salem	sink-hole ponds, upland prairies, open rocky, and sandy areas. [11]
R. knieskernii	Knieskern's beaked-rush	T	E	Camden	Moist to wet pine barrens, borrow pits, and sand pits.[3]
Sagittaria teres	slender arrowhead	-	E	Camden	Swamps of acid waters and sandy pool shores, and mostly along Atlantic Coastal Plain. [3]
Scheuchzeria palustris	arrow-grass	-	E	Camden, Gloucester	Lake margins, bogs, and marshes. [3]
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, and xeric sandy soils.[17]
Scirpus longii	Long's woolgrass	-	E	Camden	Marshes. [3]
S. maritimus	saltmarsh bulrush	-	E	Camden	Water body margins, marshes, alkali, and saline wet meadows. [6]
Scutellaria leonardii	small skullcap	-	E	Salem	Fields, meadows, and prairies. [6]
Spiranthes laciniata	lace-lip ladies' tresses	-	E	Gloucester	Primarily on coastal plain marshes, swamps, dry to damp roadsides, meadows, ditches, fields, cemeteries, lawns; and occasionally in standing water. [3]
Stellaria pubera	star chickweed	-	E	Camden	Alluvial bottomlands, and rich deciduous woods. [3]
Triadenum walteri	Walter's St. John's wort	-	E	Camden	Buttonbush swamps, swamp woods, thickets, and streambanks.[21]
Utricularia biflora	two-flower	-	E	Gloucester, Salem	Shores and shallows.[13]

Table 2-9. Threatened and Endangered Terrestrial and Freshwater Aquatic Species Recorded in Salem County and Counties Crossed by Transmission Lines

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
	bladderwort				
Valerianella radiata	beaked cornsalad	-	E	Gloucester	Pastures, prairies, valleys, creek beds, wet meadows, roadsides, glades, and railroads. [11]
Verbena simplex	narrow-leaf vervain	-	E	Camden, Gloucester	Fields, meadows, and prairies.[6]
Vernonia glauca	broad-leaf ironweed	-	E	Gloucester, Salem	Dry fields, clearings, and upland forests.[21]
Vulpia elliotea	squirrel-tail six-weeks grass	-	E	Camden, Gloucester, Salem	Grass-like, or grassy habitats.[6]
Wolffiella floridana	sword bogmat	-	E	Salem	Quiet waters in warm-temperature regions with relatively mild winters, and mesotrophic.[3]
Xyris fimbriarta	fringed yellow-eyed grass	-	E	Camden	Low pine savanna, bogs, seeps, peats and mucks of pond shallows, and sluggish shallow streams.[3]

Table 2-9. Threatened and Endangered Terrestrial and Freshwater Aquatic Species Recorded in Salem County and Counties Crossed by Transmission Lines

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		

[1] E = Endangered; T = Threatened; C = Candidate; - = Not Listed. Source of listing status: FWS 2009c, NJDEP 2008c, and DNREC 2009.

[b] State status shown is for the counties shown. All are for New Jersey except where a Delaware status (DE:) is shown for New Castle County.
New Jersey: State status for birds separated by a slash (/) indicates a dual status. First status refers to the breeding population in the state, and the second status refers to the migratory or winter population in the state. 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) (NJDEP 2008c).
Delaware: Delaware does not maintain T&E species lists by county. Upon request, Delaware 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 (DNREC 2009). State Rank S1- extremely rare in the state (typically 5 or fewer occurrences); S2- very rare within the state (6 to 20 occurrences); S3-rare to uncommon in Delaware; B - Breeding; N – Nonbreeding (DNREC 2009).

[c] Camden, Gloucester, and Salem Counties are in New Jersey; New Castle County is in Delaware. Source of county occurrence data: FWS 2009c, NJDEP 2008c, and DNREC 2009.

[d] Habitat Information Sources:

1 NJDEP 2004b
2 FWS 2008a.
3 eFloras.org. 2003.
4 Utah State University 2010.
5 USDA 2006.
6 University of Texas at Austin 2010.
7 New England Wild Flower Society 2003.
8 NYNHP 2010.
9 USDA 2010.
10 neartica.com 2010.
11 Missouriplants.com 2010.
12 Michigan Natural Features Inventory 2010.
13 University of Wisconsin 2010.
14 Missouri Botanical Gardens 2010.
15 Alabamaplants.com 2010.
16 NatureServe. 2009.
17 Center for Plant Conservation (CPC) 2010.
Calflora 2010.
18 University of Washington Burke Museum of Natural History and Culture 2006.
19 Ohio Department of Natural Reources 1983.
20 Pennsylvannia Natural Heritage Program 2007.
21 Massachusetts Division of Fisheries and Wildlife 2009.
22 Georgia Department of Natural Resources 2008.
23 USDA 1999.
24 University of Georgia 2010.

Table 2-9. Threatened and Endangered Terrestrial and Freshwater Aquatic Species Recorded in Salem County and Counties Crossed by Transmission Lines

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		

[25] South Carolina Department of Natural Resources 2010.
[26] Hilty 2010.
[27] Wernert 1998..

Affected Environment

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 southern population occurs mainly in the Appalachian Mountains from southern Virginia through the Carolinas to northern Georgia and eastern Tennessee. 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 2001). The northern population was listed as endangered by the state of New Jersey in 1974 (NJDFW 2010b). In New Jersey, bog turtles are mainly restricted to rural areas of the State, including Salem, Sussex, Warren, and Hunterdon Counties. Nevertheless, New Jersey is home to one of the largest strongholds in the bog turtle's range, and as of 2003, there were over 200 individual wetlands that supported this species (NJDFW 2010c).

The bog turtle is one of the smallest turtles in North America. Its upper shell is 3 to 4-inches (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, but may be 40 years or longer. In New Jersey, the bog turtle usually is active from April through October (mating occurs mostly between May and June) and hibernates the remainder of the year, often within the ground water-washed root systems of woody plants (FWS 2004, NJDFW 2010c). Hibernation usually occurs in more densely vegetated areas in the interfaces between open areas and wooded swamps with small trees and shrubs such as alder, gray birch, red maple, and tamarack. After mating, the female turtle typically digs a hole in which to deposit her eggs, though in some areas, eggs are laid on top of the ground in sedge tussocks. Clutches vary from one to five eggs, and hatchlings usually emerge in September, but there is evidence that the eggs also can overwinter and hatch the next spring (FWS 2001).

The bog turtle is diurnal and semi-aquatic, and forages on land and in water for its varied diet of plants (seeds, berries, duckweed), animals (insect larvae, snails, beetles), and carrion. The most abundant and preferred food source found in their habitat is the common slug (FWS 2001, FWS 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 have shallow, cool water that flows slowly and vegetation that is early successional, with open canopies and wet meadows of sedges (*Carex* spp.). Other herbs commonly present include spike rushes (*Eleocharis* spp.) and bulrushes (*Juncus* spp. and *Scirpus* spp.) (FWS 2001). Bog turtle habitats in New Jersey are typically 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 (*Typha* spp.), and Japanese stiltgrass (*Microstegium vimineum*) (NJDFW 2010d). Later successional species may discourage bog turtle occupation as they shade the basking areas in a habitat. Livestock grazing maintains the early successional stage, providing favorable conditions for bog turtles (NJDFW 2010b).

Bog turtles once existed in 18 counties in New Jersey but are now known from only 13 (FWS 2001). There were 168 known bog turtle populations in New Jersey in 2001, and 28 of these were considered metapopulations, which are defined as two or more bog turtle colonies that are connected by a complex of wetlands or other suitable habitat. These populations are extremely important as they can provide pathways for the recovery of the species through dispersal, gene flow, and colonization of adjacent habitats. Current conservation efforts in New Jersey include developing positive relationships with private landowners, acquiring sites threatened by adjacent land uses, habitat management practices protective of the turtles, and community outreach (NJDFW 2010c).

Swamp Pink

Swamp pink historically occurred between New York State and the southern Appalachian Mountains of Georgia. It currently is found in Georgia, North Carolina, South Carolina, Delaware, Maryland, New Jersey, New York, and Virginia, but the largest concentrations are found in New Jersey (CPC 2010b). Swamp pink was federally listed as a threatened species in 1988 due to population declines and threats to its habitat (FWS 1991). It was also listed as endangered by the State of New Jersey in 1991 and currently is also designated as endangered in Delaware and six other states (Center for Plant Conservation 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 2010c).

Swamp pink is a member of the lily family and has smooth evergreen leaves that are shiny when young and can turn purplish when older. The flower stem is 1 to 3 ft (30 to 91 cm) tall and has small leaves along it. Swamp pink flowers in April and May. The flowers are clustered (30 to 50 flowers) at the top of the stalk and are pink with blue anthers (FWS 2010c). Fruits are trilobed and heart shaped, with many ovules. Seeds are linear shaped with fatty appendages that are presumably eaten by potential distributors, or aid with flotation for water-based dispersal (Center for Plant Conservation 2010, FWS 1991). Seeds are released by June (FWS 2010c, Center for Plant Conservation 2010). Swamp pink is not very successful at dispersing through seeds, however, and rhizomes are the main source of new plants. During the winter, the leaves of the plant lie flat on the ground, often covered by leaf litter, and the next year's flower is visible as a bud in the center of the leaf rosette (FWS 1991). Swamp pink exhibits a highly clumped distribution where it is found, possibly due to the short distance over which its seeds are dispersed because of their weight or to the prevalence of non-sexual propagation. Populations could also be considered colonies due to the rhizomatous connections, possibly allowing physiological cooperation within a colony. Populations can vary from a few individuals to several thousand plants (FWS 1991).

Swamp pink is a wetland plant that is thought to be limited to shady areas. It needs soil that is saturated but not persistently flooded. It usually grows on hummocks in wetlands, which keep the roots moist but not submerged. Specific habitats include Atlantic white-cedar swamps, swampy forested wetlands that border small streams, meadows, and spring seepage areas. It is most commonly found with other wetland plants such as Atlantic white cedar (*Chamaecypa tisthyoides*), red maple (*Acer rubrum*), sweet pepperbush (*Clethra alnifolia*), sweetbay magnolia (*Magnolia virginiana*), sphagnum moss (*Sphagnum* spp.), cinnamon fern (*Osmunda cinnamomea*), skunk cabbage (*Symplocarpus foetidus*), pitch pine (*Pinus rigida*), American larch (*Larix laricina*), black spruce (*Picea mariana*), and laurel (*Kalmia* spp.). The overstory plants can also provide some protection from grazing by deer (FWS 2010c, Center for Plant Conservation 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 139 records and 71 confirmed occurrences. It was considered locally abundant in Camden County, with most of the occurrences on the coastal plain in pinelands fringe areas in the Delaware River drainage. Fifteen sites were confirmed in Delaware, also in the coastal plain province in the counties of New Castle, Kent, and Sussex (FWS 1991). A five year review was completed in 2008 to assess progress on the recovery plan. Due to field investigations, there are now 227 known occurrences of swamp pink; however, several prior populations are now considered historic and many of the new and previously existing populations are now ranked poorly and many are in decline. New Jersey completed several preserve designs or conservation plans to conserve 21 existing populations between 1991 and 2001. In addition, 11 agreements with landowners have been reached between FWS and individuals in New Jersey, though these agreements do not provide permanent protection (FWS 2008b).

As of 2008, Salem County had 20 confirmed occurrences of swamp pink, Gloucester County had 13, and Camden County had 28. There is one recognized occurrence of swamp pink in New Castle County, Delaware. Delaware does not have any regulations specifically for threatened or endangered plant species (FWS 2008b).

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 at HCGS. Salem and 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 of HCGS depends on their ability to respond to changing environmental, social, economic, and demographic conditions.

The socioeconomics region of influence (ROI) for Salem is defined as the areas in which Salem employees and their families reside, spend their income, and use their benefits, thereby affecting the economic conditions of the region. The Salem ROI consists of a four-county region where approximately 85 percent of Salem employees reside: Salem, Gloucester, and Cumberland Counties in New Jersey and New Castle County in Delaware. The ROI for HCGS is defined as the areas in which HCGS employees and their families reside. The HCGS ROI consists of the same four-county region, where 82 percent of HCGS employees reside. Salem and HCGS staff include shared corporate and matrixed employees, 79 percent of whom reside in the four-county region. 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 2010c). 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, New Jersey, and New Castle County, 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 and HCGS 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 2010c.

Refueling outages at Salem and HCGS generally occur at 18-month intervals. During refueling outages, site employment increases by as many as 600 workers for approximately 23 days at Salem and as many as 600 workers for approximately 23 days at HCGS (PSEG 2009a, PSEG 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 three-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	Region of Influence
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.
Sources: USCB 2000a; USCB 2009.

2.2.8.2 Public Services

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

Water Supply

Approximately 85 percent of Salem employees, 82 percent of HCGS employees, and 79 percent of shared PSEG corporate and matrixed employees reside in Salem, Gloucester, and Cumberland Counties, New Jersey, and New Castle County, Delaware (PSEG 2010c). 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, Delaware, 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.

Table 2-12. Major Public Water Supply Systems in Cumberland, Gloucester, and Salem 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 2010e (population served and primary water source); NJDEP 2009d (peak annual demand and available capacity).

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, 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 (New Jersey Department of Education [NJDOE] 2010). There are five public school districts in New Castle County, Delaware; total enrollment in the 2009-2010 school year is 66,679 students (Delaware Department of Education [DDE] 2010).

Transportation

Figures 2.1-1 and 2.1-2 show the Salem and HCGS location and highways within a 50-mile radius and a 6-mile 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 miles 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 miles 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 mile 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, PSEG 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 1052, while within the City of Salem they range from 4218 to 9003. At the traffic count location closest to Salem and HCGS, located on CR 623, the annual average daily traffic count is 895 (New Jersey Department of Transportation [NJDOT] 2009). Level of service data, which describe operational conditions on a roadway and their perception by motorists, are not collected by New Jersey (PSEG 2009a, PSEG 2009b).

2.2.8.3 Offsite Land Use

This section describes offsite land use in the four-county region of influence (ROI), including Salem, Gloucester, and Cumberland Counties, New Jersey, and New Castle County, 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.

<u>Salem County, New Jersey</u>

Salem County is rural in nature, consisting of more than 338 square miles of land with an estimated 66,141 residents, a 2.9 percent increase since 2000 (USCB 2009). 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 acres, or 12 percent of the county, which have been preserved in Salem County under the New Jersey Farmland Preservation Program (State Agricultural Development Committee [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 I-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 (Lower Alloways Creek Township 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 square miles of land along 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 2009). 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 (Delaware Valley Regional Planning Commission [DVRPC] 2009). Under the New Jersey Farmland Preservation Program, 117 farms, including a total of 14,569 acres 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 (Ortho-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 square miles of land and in 2008 had an estimated population of 287,860 residents, which represents a 12.6 percent increase since 2000 (USCB 2009). It is the fastest growing county in New Jersey 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 acres (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 (Gloucester County Planning Division [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 square miles 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 2009). 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 acres 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 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 [57.9 to 60.9-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 away and the turbines were each estimated to produce 95 dBA at 3 ft 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 miles mi from the Salem and HCGS facilities, was estimated to be approximately 27dBA. 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. Therefore, noise from the Salem generating units was considered acceptable to nearby receptors (AEC 1971). Additional pre-operational studies were conducted for HCGS. An ambient noise survey, within a radius of 5 mi, established that most of the existing sound levels were within New Jersey's limits for industrial operations, as measured at residential property boundaries. The exceptions were sound levels measured at five locations in unpopulated areas near the facility, presumably reflecting construction activities at HCGS and vehicular traffic on the facility access road. Additional noise sources from aircraft could also have contributed to these high readings (PSEG 1983).

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 square mile (mi^2). This density translates to a Category 4 (greater than or equal to 120 persons per mi^2 within 20 miles) 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, PSEG 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 miles [80 km]). Therefore, according to the sparseness and proximity matrix presented in the GEIS, a Category 4 value for sparseness and for proximity indicate that Salem and HCGS are located in a high population area.

Table 2-14 shows population projections and growth rates from 1970 to 2030 in Cumberland, Gloucester, and Salem Counties, New Jersey, and New Castle County, 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 2030

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	121374	—	172681	—	60346	---	385856	----
1980	132866	9.5	199917	15.8	64676	7.2	398115	3.2
1990	138053	3.9	230082	15.1	65294	1.0	441946	11.0
2000	146438	6.1	254673	10.7	64285	-1.5	500265	13.2
2010	157745	7.7	289920	13.8	66342	3.2	535572	7.1
2020[b]	164617	4.4	307688	6.1	69433	4.7	564944	5.5
2030[b]	176784	7.4	338672	10.1	74576	7.4	586387	3.8

— = 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.

Sources: Population data for 1970 through 1990 (USCB 1995a, USCB 1995b); population data for 2000 (USCB 2000d); New Jersey counties estimated population for 2009 (USCB 2010); New Castle County projected population for 2010 to 2040 (Delaware Population Consortium [DPC] 2009); New Jersey counties projected population for 2018 and 2028 (Center for Urban Policy Research [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 and HCGS Region of Influence in 2000

	Cumberland, NJ	Gloucester, NJ	Salem, NJ	New Castle, DE	Region of Influence
Total Population	146,438	254,673	64,285	500,265	965,661
Race (percent of total population, Not-Hispanic or Latino)					
White	72.1	88.0	82.8	74.6	78.5
Black or African American	23.7	9.1	15.0	21.0	17.7
American Indian and Alaska Native	0.9	0.2	0.3	1.7	0.3
Asian	1.1	1.5	0.6	2.7	2.0
Native Hawaiian and Other Pacific Islander	0.03	0.02	0.02	0.03	0.03
Some other race	0.1	0.09	0.09	0.1	0.12
Two or more races	2.0	1.1	1.2	1.3	1.3
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.

Comment [C8]: Should this percentage added to the "Percent minority" in the last row equal 100%?

Comment [C9]: No. THe White population is the Majority. Minority populations should not equal 100%

Transient Population

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 2-16 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 (National Center for Educational Statistics [NCES] 2009).

Table 2-16. Seasonal Housing in the Salem and HCGS Region of Influence in 2000

County [a]	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
Region of Influence	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 USCB minority and low income population counts.

The 2007 Census of Agriculture collected information on migrant farm and temporary labor. Table 2-17 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 1747 farms within 50 mi (80 km) of Salem and HCGS. The county with the largest number of temporary farm workers (4979 persons on 118 farms) was Atlantic County, New Jersey (USDA 2007). Salem County had 804 temporary farm workers on 121 farms; Cumberland County had 1857 temporary workers on 141 farms, and Gloucester County had 1228 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, Pennsylvania, 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 2-17. Migrant Farm Worker and Temporary Farm Labor within 50 mi of Salem and HCGS

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	**1048**	**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	**1852**	**476**	**51**	**673**
New Jersey:				
Atlantic	4979	118	74	163
Camden	470	43	17	52
Cape May	173	38	8	46
Cumberland	1857	141	65	192
Gloucester	1228	110	56	163
Salem	804	121	33	172
County Subtotal	**9511**	**571**	**253**	**788**
Pennsylvania:				
Chester	2687	403	101	580
Delaware	106	19	2	25
Montgomery	560	115	14	155
Philadelphia	-	5	-	5
County Subtotal	**3353**	**542**	**117**	**765**
County Total	**15,764**	**1747**	**453**	**2746**

[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.

Employment and Income

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, Delaware, the civilian labor force increased slightly (0.9 percent) to 284,647 between 2000 and 2007 (USCB 2010a).

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 (New Jersey Department of Labor and Workforce Development [NJDLWD] 2010a, NJDLWD 2010b, NJDLWD 2010c). The trade, transportation, and utilities sector employed the most people in New Castle County, Delaware, in 2008 followed closely by the professional and business services sector (Delaware Department of Labor [DDL] 2009). A list of some of the major employers in Salem County is provided in Table 2-18. The largest employer in the county in 2006 was PSEG with over 1300 employees.

Table 2-18. Major Employers in Salem County in 2007

Firm	Number of Employees
PSEG	1300+ [a]
E.I. duPont	1250
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 1165 employees and share an additional 340 PSEG corporate and 109 matrixed employees, for a total of 1614 employees.

Income information for the four-county ROI is presented in Table 2-19. 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, while the State average was 10.4 percent.

Table 2-19. Income Information for the Salem and HCGS 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

Source: USCB 2008.

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 New Jersey. Conversely, the annual unemployment average of 5.6 for New Castle County was lower than the Delaware average of 6.0 percent (USCB 2008).

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 2-20). 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 revenues during that time period. 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, PSEG 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 2-21).

Table 2-20. Salem and HCGS Property Tax Paid and Percentage of Lower Alloways Creek Township and Salem County Tax Revenues, 2003 to 2009

	Property Tax Paid by PSEG and/or Exelon (dollars)			Lower Alloways Creek Township: Total Property Tax Revenue in Township (dollars)	Lower Alloways Creek Township: PSEG and/or Exelon Property Tax as Percentage of Total Property Tax Revenue (percent)			Salem County: Total Property Tax Revenue in County (dollars)	Salem County: 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 2010d.

Affected Environment

Table 2-21. 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,PSEG 2009b, PSEG 2010d.

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 2-20. 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/Hope Creek 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 environmental report (PSEG 2009a, PSEG 2009b).

2.2.9.1 Cultural Background

The prehistory of New Jersey includes four 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:

- 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).

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 peoples 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 1981).

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 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 the Archaic peoples were more efficiently exploiting the natural environment (Kraft 1981).

An example of a typical Archaic Period site in southern New Jersey is the Indian Head Site, located about 35 miles Northeast of the Salem/Hope Creek Site. The Indian Head Site is a large multicomponent 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 peoples, 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/Hope Creek 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/Hope Creek site occurred in 1638, when a Swedish fort was established along the Delaware River in the present day town of Elsinborough (~~Barber 1844~~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 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 2010).

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 (Discover Salem County [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 1970's. In addition to generation of electric power at the Salem and Hope Creek generating stations, 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 ~~(Gallo 2010)~~.[2]

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

Previously Identified Resources

The NJSM houses the State's archaeological site files and the New Jersey 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/Hope Creek property. Online sources were used to identify National Register of Historic Places (NRHP) listed properties in Salem County, New Jersey and New Castle County, Delaware (NRHP 2010).

Comment [C10]: Not listed in References section.

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 miles 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 miles to the Northeast, in Hancock's Bridge. To date, 6 properties within a 10-mile radius of the Salem/Hope Creek site in Salem County, New Jersey have been listed on the NRHP. A total of 17 NRHP listed sites in New Castle County, Delaware fall within a 10-mile radius of Salem/Hope Creek.

Potential Archaeological Resources

The Salem and Hope Creek generating stations are located on a manmade 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 NRC 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 NRC 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 of Salem and HCGS are listed below.

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

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

- 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. 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 intends to submit an early site permit application to the NRC regarding possible construction of a new nuclear power plant unit at the Salem and HCGS site on Artificial Island (PSEG 2010).

The NRC is required under Section 102(2)(c) of the National Environmental Policy Act of 1969, as amended (NEPA) to consult with and obtain the comments of any Federal agency that has jurisdiction by law or special expertise with respect to any environmental impact involved. Th~~He~~ 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

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 United States Code [USC] 1802(10);

Comment [C11]: 16 USC 1801 et seq is cited in the text, not 1802?

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

40 CFR Parts 239 through 259. *Code of Federal Regulations*, Title 40, *Protection of the Environment*. "Non-hazardous Waste Regulations."

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

40 CFR Part 262. *Code of Federal Regulations*, Title 40, *Protection of the Environment*. "Standards Applicable to Generators of Hazardous Waste."

50 CFR 600. *Code of Federal Regulations*, Title 50, *Wildlife and Fisheries*. "Magnuson-Stevens Act Provisions."

73 FR 13032. Nuclear Regulatory Commission. Washington D.C. "PSEG Nuclear, LLC; Hope Creek Generating Station Final Assessment and Finding of No Significant Impact; Related to the Proposed License Amendment to increase the Maximum Reactor Power Level." Federal Register: Vol. 73, No. 48, pp 13032 – 13044. March 11, 2008.

Alabamaplants.com. 2010. Photographs and Information for the plants of Alabama, USA. Accessed at: http://alabamaplants.com/ on April 7, 2010.

Alaimo Group. 2005. 2005 Master Plan Reexamination Report, Township of Lower Alloways Creek, Salem County, New Jersey. Approved by the Lower Alloways CreekTownship Planning Board June 22, 2005.

Arcadis. 2006. Site Investigation Report, Salem Generating Station. Newtown, Pennsylvania. Publication date: July 15, 2006.

Atlantic States Marine Fisheries Commission (ASMFC). 1998a. Fishery Management Report No. 32 of the Atlantic States Marine Fisheries Commission. Interstate Fishery Management Plan for Horseshoe Crab. December 1998.

~~Atlantic States Marine Fisheries Commission (ASMFC). 1998b. Amendment 1 To The Interstate Fishery Management Plan for Shad & River Herring. Approved October 1998.~~

Atlantic States Marine Fisheries Commission (ASMFC). 1998c. Amendment 1 To The Bluefish Fishery Management Plan (Includes Environmental Impact Statement and Regulatory Review) Volume I. October 1998. Mid-Atlantic Fishery management Council and ASMFC in Cooperation with NMFS, New England Fishery Management Council and South Atlantic Fishery Management Council.

Atlantic States Marine Fisheries Commission (ASMFC). 1999. "Amendment 1 to the Interstate Fishery Management Plan for Shad & River Herring." April 1999. Accessed at: http://www.asmfc.org/speciesDocuments/shad/fmps.shadam1.pdf on April 9, 2010.

Atlantic States Marine Fisheries Commission (ASMFC). 2001. Fishery Management Report No. 37 of The Atlantic States Marine Fisheries Commission. Amendment 1 to the Interstate Fishery Management Plan for Atlantic Menhaden July 2001.

Atlantic States Marine Fisheries Commission (ASMFC). 2002. Fishery Management Report No. 39 of The Atlantic States Marine Fisheries Commission. Amendment 4 to the Interstate Fishery Management Plan for Weakfish. November 2002.

Atlantic States Marine Fisheries Commission (ASMFC). 2003. Fishery Management Report No. 41 of The Atlantic States Marine Fisheries Commission. Amendment 6 to the Interstate Fishery Management Plan for Atlantic Striped Bass February 2003.

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

Atlantic States Marine Fisheries Commission (ASMFC). 2005a. Species Profile: Atlantic Menhaden. Species Profile: Atlantic Menhaden Stock Healthy Coastwide, But Questions Remain Regarding Localized Stock Condistions." ~~Stock Healthy Coastwide, But Questions Remain Regarding Localized Stock Conditions.~~ Accessed at: http://fishtheisland.com/Species/Menhaden/menhadenProfile.pdf ~~http://www.asmfc.org/speciesDocuments/menhaden/menhadenProfile.pdf on February~~ June 21~~19~~, 2010.

Comment [C12]: The title of this reference in the below URL is " Species Profile: Atlantic Menhaden
New Benchmark Assessment Indicates Stock is Not Overfished but Shows Signs of Concern"

Atlantic States Marine Fisheries Commission (ASMFC). 2005b. Fishery Management Report No. 44 of the Atlantic States Marine Fisheries Commission. Amendment 1 to the Interstate Fishery Management Plan for Atlantic Croaker. November 2005

Atlantic States Marine Fisheries Commission (ASMFC). 2006a. 2006 Review of The Fishery Management Plan for Spot *(Leiostomus xanthurus)* Prepared by: The Spot Plan Review Team: Herb Austin, Ph.D., Virginia Institute of Marine Science. John Schoolfield, North Carolina Division of Marine Fisheries. Harley Speir, Maryland Department of Natural Resources. Nichola Meserve, Atlantic States Marine Fisheries Commission, Chair. Board Approved: October 24, 2006. Accessed at: http://www.asmfc.org/speciesDocuments/southAtlanticSpecies/spot/fmpreviews/spot06FMPreview.pdf on February 19 2010.

Atlantic States Marine Fisheries Commission (ASMFC). 2006b. Species Profile: Bluefish Joint Plan Seeks to Restore Premier Fighting Fish

Atlantic States Marine Fisheries Commission (ASMFC). 2007a. Species Profile: Shad & River Herring: Atlantic States Seek to Improve Knowledge of Stock Status and Protect Populations Coastwide

Atlantic States Marine Fisheries Commission (ASMFC). 2007b. Species Profile: Atlantic Croaker Amendment Seeks to Maintain Healthy Mid- Atlantic Stock Component

Atlantic States Marine Fisheries Commission (ASMFC). 2008a. Species Profile: Horseshoe Crab Horseshoe Crab Populations Show Positive Response to Current Management Measures. Accessed at: www.asfmc.org on April 9, 2010.

Atlantic States Marine Fisheries Commission (ASMFC). 2008b. Fishery Management Report No. 32e of the Atlantic States Marine Fisheries Commission. Addendum V to the Interstate Fishery Management Plan for Horseshoe Crab. September 2008.

Atlantic States Marine Fisheries Commission (ASMFC). 2008c. Species Profile: Spot. Short-Lived Fish Supports South Atlantic Fisheries & Serves as Important Prey Species

Atlantic States Marine Fisheries Commission (ASMFC). 2008d. Species Profile: Atlantic Striped Bass New Stock Assessment Indicates a Healthy Stock and Continued Management Successd

Atlantic States Marine Fisheries Commission (ASMFC). 2008e. Species Profile: Summer Flounder. Positive Assessment Results Yield Higher Quotas.

Atlantic States Marine Fisheries Commission (ASMFC). 2009a. Amendment 2 to the Interstate Fishery Management Plan for Shad and River Herring (River Herring Management)

Atlantic States Marine Fisheries Commission (ASMFC). 2009b. Species Profile: Weakfish Board Initiates Addendum to Address All Time Low in Weakfish Biomass

Atlantic States Marine Fisheries Commission (ASMFC). 2009c. Species Profile: Atlantic Sturgeon. Ancient Species' Slow Road to Recovery. Accessed at: www.asfmc.org on April 13, 2010.

Atlantic States Marine Fisheries Commission (ASMFC). 2009d. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs Habitat Management Series #9. January 2009. ATLANTIC STURGEON (*Acipenser oxyrinchus oxyrinchus*). Accessed at: http://www.link75.org/mmb/Cybrary/pages/hms9_diadro_habitat_2009_9.pdf on April 7, 2010.

Atlantic States Marine Fisheries Commission (ASMFC). 2010a. Horseshoe crab (*Limulus polyphemus*). Life History and Habitat Needs. Accessed at: www.asmfc.org on April 12, 2010.

Atlantic States Marine Fisheries Commission (ASMFC). 2010b. Atlantic Striped Bass. Morone saxatilis. Life History and Habitat needs. Accessed at: http://www.asmfc.org/ on February 23, 2010.

Atlantic States Marine Fisheries Commission (ASMFC). 2010c. Atlantic States Marine Fisheries Commission Habitat Factsheet. Atlantic Sturgeon. *Acipenser oxyrhynchus oxyrhynchus.* Accessed at: http://www.asmfc.org/speciesDocuments/sturgeon/habitatFactsheet.pdf on April 13, 2010.

Atomic Energy Commission (AEC). 1971. Salem Nuclear Generating Station Units 1 And 2. Supplemental Environmental Report, Operating License Stage. Docket Nos. 50-272 and 50-311. Washington, D.C.

Atomic Energy Commission (AEC). 1973. Final Environmental Statement Related to the Salem Nuclear Generating Station Units 1 and 2, Public Service Electric and Gas Company. Docket Nos. 50-272 and 50-311. Washington DC. April 1973.

Brown, J. 2007. A Brief History of Salem County, New Jersey. Accessed at: http://www.rootswed.com/~njsalem/ on April 6, 2010.

Bozeman, E.L., Jr., and M.J. VanDen Avyle. 1989. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (South Atlantic) -Alewife and Blueback Herring. U.S. Fish and Wildlife Service Biological Report. 82(11.111). U.S. Army Corps of Engineers, TR EL-82-4. pp 17.

Buckley, J. 1989. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (North Atlantic)--Winter Flounder. U.S. Fish and Wildlife Service Biological Report. 82(11.87). U.S. Army Corps of Engineers, TR EL-82-4. pp 12.

Burrell, V.G., Jr. 1986. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (South Atlantic)-American Oyster. U.S. Fish and Wildlife Service Biological Report. 82(11.57). U.S. Army Corps of Engineers TR EL-82-4. pp 17

Calflora. 2010. Calflora: Information on California plants for education, research and conservation, based on data contributed by the Consortium of Calif. Herbaria and dozens of other public and private institutions and individuals. Berkeley, California. Accessed at http://www.calflora.org/cgi-bin/species_query.cgi?where-calrecnum=4845 on April 8,2010.

Center for Plant Conservation (CPC). 2010a. National Collection Plant Profile. Accessed at: http://www.centerforplantconservation.org/collection/cpc_viewprofile.asp on April 8, 2010.

Center for Plant Conservation (CPC). 2010b. Swamp Pink (Helonias bullata). Accessed at: http://www.centerforplantconservation.org/collection/cpc_viewprofile.asp?CPCNum=2210 on May 10, 2010.

Center For Urban Policy Research (CUPR). 2009. Impact Assessment of the New Jersey State Development and Redevelopment Plan. Prepared for New Jersey Department Of Community Affairs. December 11, 2009. Accessed at: http://www.nj.gov/dca/divisions/osg/docs/dfplan_projections.pdf on May 12, 2010.

Chesapeake Bay Ecological Foundation, Inc. 2010. Ecological Depletion Of Atlantic Menhaden & Bay Anchovy. Effects On Atlantic Coast Striped Bass. First Year-Round Ecological Study of Large Chesapeake Bay Striped Bass. Accessed at: http://www.chesbay.org/articles/striped%20bass%20study(1-09).asp on February 18, 2010

Chesapeake Bay Program. 2009. American Shad Harvest. Last Modified November 2009. Accessed at: http://www.chesapeakebay.net/americanshadharvest.aspx?menuitem=15315 on February 18, 2010.

Colonial Swedish Society (CSS). 2010. *A Brief History of New Sweden in America.* Accessed at: http://www.colonialswedes.org/History/History.html on April 12, 2010.

Delaware Department of Education (DDE). 2010. School Profiles, Fall Student Enrollment (School Year 2009-2010), School Districts in New Castle County, Delaware. Accessed at: http://profiles.doe.k12.de.us/SchoolProfiles/State/Default.aspx on May 11, 2010.

Delaware Department of Labor (DDL). 2009. Delaware State and County Level Employment and Wages by Industry for 2008. Published September 2, 2009. Office of Occupational and Labor Market Information. Accessed at http://www.delawareworks.com/oolmi/Services/Researchers/QCEW/QCEW-Annual.aspx on April 27, 2010.

Delaware Department of Natural Resources and Environmental Control (DNREC). 2003. Division of Water Resources. Public Water Supply Source Water Assessment for Artesian Water Company (Bayview), PWS ID DE0000553. New Castle County, Delaware. October 2003. Accessed at http://www.wr.udel.edu/swaphome_old/phase2/final_assess/artesianother/awc_bayview.pdf on February 24, 2010.

Delaware Department of Natural Resources and Environmental Control (DNREC). 2006a. Weakfish Tagging Project. Accessed at: http://www.fw.delaware.gov/SiteCollectionDocuments/FW%20Gallery/WeakfishTagging.pdf on February 19, 2010.

Delaware Department of Natural Resources and Environmental Control (DNREC). 2006b. Striped Bass Food Habits Project. Accessed at: http://www.fw.delaware.gov/SiteCollectionDocuments/FW%20Gallery/StripedBassFoodHabits.pdf on February 19, 2010.

Delaware Department of Natural Resources and Environmental Control (DNREC). 2008. Endangered Species of Delaware. Accessed on at: http://www.dnrec.state.de.us/nhp/information/endangered.shtml on May 4, 2010.

Delaware Department of Natural Resources and Environmental Control (DNREC). 2009. Letter from E. Stetzar, biologist/environmental review coordinator, Natural Heritage and Endangered Species, Division of Fish and Wildlife, to E. J. Keating, PSEG Nuclear LLC. Letter responded to request from PSEG for information on rare, threatened, and endangered species and other significant natural resources relevant to operating license renewal for Salem and HCGS, and it specifically addressed the ROW alignment extending from Artificial Island, NJ across the Delaware River to end in New Castle County, DE. April 21. Copy of letter provided in Appendix C of Applicant's Environmental Report (PSEG 2009a).

Delaware Department of Natural Resources and Environmental Control (DNREC). 2010. Delaware's Oyster Management Program. Accessed at: http://www.fw.delaware.gov/SiteCollectionDocuments/FW%20Gallery/Research/oyster%20doc.pdf on April, 14 2010.

Delaware Division of Fish and Wildlife. 2010a. Augustine Wildlife Area (2,667 acres), Silver Run. Dover, Delaware. Accessed at: www.fw.delaware.gov/Hunting/Documents/WMA%20Maps/9.pdf on May 18, 2010.

Delaware Division of Fish and Wildlife. 2010b. Striped Bass Spawning Stock Survey. Accessed at: http://www.fw.delaware.gov/SiteCollectionDocuments/FW%20Gallery/Striped%20Bass%20Spawning%20Stock%20Survey%20Flyer.pdf on February 19, 2010

Delaware Estuary Program. 1996~~5~~. The Delaware Estuary – Discover Its Secrets, A Management Plan for the Delaware Estuary. Accessed at: http://www.delawareestuary.org/pdf/CCMP.pdf on February 18, 2010.

Delaware Estuary Program. 2010. History of the Eastern Oyster. Accessed at: http://www.delawareestuary.org/publications/factsheets/Oysterw.pdf on April 14, 2010.

Delaware Population Consortium (DPC). 2009. 2009 Delaware Population Projections Summary Table, Total Projected Population, 2000 – 2040. Accessed at: http://stateplanning.delaware.gov/information/dpc_projections.shtml on May 12, 2010.

Delaware River Basin Commission (DRBC). 1961. Delaware River Basin Compact. U.S. Public Law 87-328. West Trenton, New Jersey, Delaware River Basin Commission. Reprinted 2007.

Delaware River Basin Commission (DRBC). 1977. Contract No. 76-EP-482 Covering to Provide the Supply of Cooling Water from the Delaware River, Required for Operation of Salem Units 1 and 2 at Salem Nuclear Generating Station. Parties to the contract: Delaware River Basin Commission and Public Service Electric and Gas Company. January 1977.

Delaware River Basin Commission (DRBC). 1984a. Docket No. D-73-193 CP (Revised). Revision of the Hope Creek Generating Station Project Previously Included in the Comprehensive Plan. West Trenton, New Jersey. May 1984.

Delaware River Basin Commission (DRBC). 1984b. Water Supply Contract Between DRBC and PSEG Concerning the Water Supply at Hope Creek Generating Station. West Trenton, New Jersey. December 1984.

Delaware River Basin Commission (DRBC). 2000. Groundwater Withdrawal. Docket No. D-90-71 Renewal. West Trenton, New Jersey, Delaware River Basin Commission. November 2000.

Delaware River Basin Commission (DRBC). 2001. Docket No. D-68-20 (Revision 20). Approval to Revise Delaware Basin Compact. West Trenton, New Jersey, Delaware Basin River Commission. September 2001.

Delaware River Basin Commission (DRBC). 2005. Year 2005 Water Withdrawal and Consumptive Use by Large Users on the Tidal Delaware River. Accessed at http://www.state.nj.us/drbc/wateruse/largeusers_05.htm, on February 15, 2010.

Delaware River Basin Commission (DRBC). 2008a. Delaware River State of the Basin Report. West Trenton, New Jersey, Delaware River Basin Commission.

Delaware River Basin Commission (DRBC). 2008b. Nutrient Criteria Strategy for the Tidal and Non-tidal Delaware River. Accessed at: http://www.state.nj.us/drbc/DRBC-NutrientStrategy042508.pdf on April 15, 2010.

Delaware River Basin Commission (DRBC). 2010. The Delaware River Basin. Accessed at http://www.state.nj.us/drbc/thedrb.htm, on February 24, 2010.

Delaware Valley Regional Planning Commission (DVRPC). 2007. Analytical Data Report. Regional, County, and Municipal Population and Employment Forecasts, 2005-2035. Accessed at: http://www.dvrpc.org/reports/ADR14.pdf on May 13, 2010.

Delaware Valley Regional Planning Commission (DVRPC). 2009. 2009 Farmland Preservation Plan for the County of Cumberland, New Jersey. Prepared for Cumberland County Agriculture Development Board. Accessed at: http://www.co.cumberland.nj.us/content/173/251/761/2947/3098/2969/6996.aspxon May 17, 2010.

Discover Salem County (DSC). 2010. History of Salem County. Accessed at: http://www.discoversalemcounty.com/history/colonialhistory.asp on April 6, 2010.

Eaton, H.P. 1899. Jersey City and Its Historic Sites. The Women's Club. Jersey City, New Jersey.

eFloras.org. 2003. Floras of North America online. Accessed at: http://www.efloras.org/flora_page.aspx?flora_id=1 on April 2, 2010

Energy Information Administration (EIA). 2008. Status of Electricity Restructuring by State, New Jersey Restructuring Active. EIA, U.S. Department of Energy. Last updated September

2008. Accessed at: http://www.eia.doe.gov/cneaf/electricity/page/restructuring/new_jersey.html on April 29, 2010

Fay, C.W., R.J. Neves, and G.B. Pardue. 1983a. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic)—Atlantic Silverside. U.S. Fish and Wildlife Service, Division of Biological Services, FWS/OBS-82/11.10. U. S. Armly Corps of Engineers, TR EL-82-4. pp 15.

Fay, C.W., R.J. Neves, and G.B. Pardue. 1983b. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic)--Striped Bass. U.S. Fish and Wildlife Service, Division of Biological Services, FWS/OBS-82/11.8. U.S. Army Corps of Engineers, TR EL-82-4. pp 36.

Georgia Department of Natural Resources. 2008. Wildlife Resources Division. Special Concern Plant Sepcies in Georgia. Accessed at: http://georgiawildlife.dnr.state.ga.us/content/specialconcernplants.asp on April 8,210.

Gloucester County. 2009. Gloucester County Online Web Book. Accessed at: http://www.co.gloucester.nj.us/plan/webbook/lud est02.htm on December 17, 2009.

Gloucester County. 2010. Gloucester County, New Jersey, Economic Development homepage. Accessed at: http://www.co.gloucester.nj.us/Government/Departments/EconomicDev/mainnew.cfm on February 5, 2010.

Gloucester County Planning Division (GCPD). 2005. Final County of Gloucester, NJ, Cross Acceptance Report, Preliminary State Development and Redevelopment Plan. Prepared for Gloucester County Planning Board. Accessed at: http://www.state.nj.us/dca/divisions/osg/plan/ca.html on May 17, 2010.

Grimes, B.H., M.T. Huish, J.H. Kerby, and D. Poran. 1989. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic)-Summer and Winter Flounder. U.S. Fish and Wildlife Service Biological Report. 82(11.112). U.S. Army Corps of Engineers, TR EL-82-4. pp 18.

Hill, J., D.L. Fowler, and M.J. Van Den Avyle. 1989. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic)-Blue Crab. U.S Fish and Wildlife Service Biological Report. 82(11.100). U.S. Army Corps o f Engineers, TR EL-82-4. pp 18.

Hilty, J. 2010. Illinois Wildflowers. Accessed at: http://www.illinoiswildflowers.info/ on 14 May 2010.

Kraft, H.C. 1982. *The Archaic Period in Northern New Jersey.* In New Jersey's Archaeological Resources from the Paleo-Indian to the Present: A review of Research Problems and Priorities, edited by Olga Chesler. New Jersey Department of Environmental Protection, Office of Cultural and Environmental Sciences, Trenton, NJ.

~~Kraft, H.C. 1986. *The Lenape: Archaeology, History and Ethnography.* New Jersey Historical Society.~~

Kraft, H.C. 2001. *The Lenape-Delaware Indian Heritage*: 10,000 BC to AD 2000. Lenape Books.

Lower Alloways Creek Township (LACT). 1988a. Tax Map, Zone 8, Lower Alloways Creek Township. May 1988.

Lower Alloways Creek Township (LACT). 1988b. Tax Map, Zone 14, Lower Alloways Creek Township. May 1988.

Lower Alloways Creek Township. 1992. Master Plan. Adopted by Lower Alloways Creek Township Planning Board September 17, 1992.

Lassuy, D.R. 1983. Species Profiles: Life Histories and Environmental Requirements (Gulf of Mexico)--Atlantic Croaker. U.S. Fish and Wildlife Service, Division of Biological Services. FWS/ORS-82/11.3. U.S. Army Corps of Engineers, TR EL-82-4. pp 12.

MacKenzie, C., L. S. Weiss-Glanz, and J. R. Moring. 1985. Species profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic)--American shad. U. S. Fish and Wildlife Service Biol. Rep. 82(11.37). U.S. Army Corps of Engineers TR EL-82-4. pp 18.

Marshall, S. 1982. Aboriginal Settlement in New Jersey During the Paleo-Indian Cultural Period: ca. 10,000 BC to 6,000 BC. In *New Jersey's Archaeological Resources from the Paleo-Indian to the Present: A Review of Research Problems and Survey Priorities,* edited by Olga Chesler. New Jersey Department of Environmental Protection, Office of Cultural and Environmental Sciences, Trenton, NJ.

Maryland Department of Natural Resources (MDNR). 2008. White Perch Fisheries Management Plan. Accessed at: http://www.dnr.state.md.us/fisheries/management/FMP/FMPWhitePerch04.pdf on February 18, 2010.

Masser, J. 2005. *The White Horse Pike.* Arcadia Publishing, Tempus Publishing, Inc., Charleston, SC.

Massachusetts Division of Fisheries and Wildlife. 2009. Natural Heritage Endangered Species Program. List of Rare Species in Massachusetts. Accessed at: http://www.mass.gov/dfwele/dfw/nhesp/species_info/mesa_list/mesa_list.htm#PLANTS on April 8,2010.

Mercer, L. P. 1989. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic)--Weakfish. U.S. Fish and Wildlife Service Biological Report. 82(11.109). U. S. Army Corps o f Engineers, TR EL-82-4. pp 17.

Michigan Natural Features Inventory. 2010. Michigan's Special Animals and Plants. Accessed at http://web4.msue.msu.edu/Mnfi/ on April 7, 2010.

Missouri Botanical Gardens. 2010. Kemper Center for Home Gardening PlantFinder. Accessed at http://www.mobot.org/gardeninghelp/plantfinder/alpha.asp on April 7, 2010.

Missouriplants.com. 2010. Photographs and Descriptions of the flowering and non-flowering plants of Missouri, USA. Accessed at http://www.missouriplants.com/ on April 7, 2010.

Morris Land Conservancy. 2006. *County of Salem Open Space and Farmland Preservation Plan, Volume 1: Open Space and Recreation Plan.* Compiled by Morris Land Conservancy with Salem County Open Space Advisory Committee. December 2006. Accessed at: http://www.salemcountynj.gov/cmssite/default.asp?contentID=1208 on December 9, 2009.

Morris Land Conservancy. 2008. *County of Salem Open Space and Farmland Preservation Plan, Volume 2: Farmland Preservation Plan, Update 2007.* August 2008. Accessed at: http://www.salemcountynj.gov/cmssite/default.asp?contentID=1208 on December 9, 2009.

Morse, Wallace W. and Able, Kenneth W. 1995. Distribution and life history of windowpane, *Scophthalmus aquosus,* off the northeastern United States. Fishery Bulletin 93:675-693

Morton, T. 1989. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic) --Bay Anchovy. U. S. Fish and Wildlife Service Biological Report. 82(11.97). pp 13.

Najarian Associates. 2004. "Hydrological modeling Analysis for the Hope Creek Generating Station Extended Power Uprate Project." Final Report. Submitted to PSEG, Environmental Health and Safety. Newark, New Jersey.

National Audubon Society. 2010. Important Bird Areas in the U.S. – Site Report for Mad Horse Creek and Abbots Meadow Wildlife Management Areas/Stowe Creek. Accessed at http://iba.audubon.org/iba/profileReport.do?siteId=2961&navSite=search&pagerOffset=0&page=1 on February 12, 2010.

National Center for Educational Statistics (NCES). 2009. College Navigator. Institute of Education Sciences, U.S. Department of Education. Accessed at: http://nces.ed.gov/collegenavigator/?s=NJ&zc=08079&zd=50&of=3&ct=1 on December 22, 2009.

National Marine Fisheries Service (NMFS). 1998. Final Recovery Plan for the Shortnose Sturgeon *Acipenser brevirostrum*

National Marine Fisheries Service (NMFS). 1999. Highly Migratory Species Management Division 1999, Final Fishery Management Plan for Atlantic Tuna, Swordfish, and Sharks, Including the Revised Final Environmental Impact Statement, the Final Regulatory Impact Review, the Final Regulatory Flexibility Analysis, and the Final Social Impact Assessment. April1999.

National Marine Fisheries Service (NMFS). 2008. Biennial Report to Congress on the Recovery Program for Threatened and Endangered Species. October 1, 2006 – September 30, 2008

National Marine Fisheries Service (NMFS). 2009. Species of Concern. NOAA National Marine Fisheries Service. River herring. (Alewife and Blueback Herring) *Alosa pseudoharngus and A. aestivalis.* Accessed at: http://www.nmfs.noaa.gov/pr/pdfs/species/riverherring_detailed.pdf on February 17, 2010

National Marine Fisheries Service (NMFS). 2010a. Letter from S. W. Gorski, Field Offices Supervisor, Habitat Conservation Division, James J. Howard Marine Sciences Laboratory, Highlands, NJ to B. Pham, Office of Nuclear Reactor Regulation, NRC, Washington, DC. Letter responded to NRC request for information on essential fish habitat designated in the vicinity of the Salem and HCGS facilities. February 23.

National Marine Fisheries Service (NMFS). 2010b. Letter from M. A. Colligan, Assistant Regional Administator for Protected Resources, Northeast Region, to B. Pham, Office of Nuclear Reactor Regulation, US Nuclear Regulatory Commission, Washington, DC. Letter responded to NRC request for information on the presence of species listed by NMFS as threatened or endangered that may occur in the vicinity of the Salem and HCGS facilities. Part of ESA Section 7 consultation pursuant to federally protected species under the jurisdiction of NMFS. February 11.National Marine Fisheries Service (NMFS). 2010b. "Marine Turtles." Accessed at http://www.nmfs.noaa.gov/pr/species/turtles/ on February 23.

National Marine Fisheries Service (NMFS). 2010b. "Marine Turtles." Accessed at: http://www.nmfs.noaa.gov/pr/species/turtles/ on February 23, 2010.

Comment [C13]: Should this be an "NOAA" reference, according to the URL link?

National Marine Fisheries Service and U.S. Fish and Wildlife Service (NMFS and FWS). 2007a. Leatherback Sea Turtle (*Dermochelys coriacea)*. Five Year Review: Summary and Evaluation. Accessed at: http://www.nmfs.noaa.gov/pr/pdfs/species/leatherback_5yearreview.pdf on May 6 2010.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (NMFS and FWS). 2007b. Kemp's Ridley Sea Turtle (*Lepidochelys kempii)*. Five Year Review: Summary and Evaluation. Accessed at: http://www.nmfs.noaa.gov/pr/pdfs/species/kempsridley_5yearreview.pdf on May 5 2010.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (NMFS and FWS). 2007c. Green Sea Turtle (*Chelonia mydas)*. Five Year Review: Summary and Evaluation. Accessed at: http://www.nmfs.noaa.gov/pr/pdfs/species/greenturtle_5yearreview.pdf on May 5 2010.

National Oceanic and Atmospheric Administration (NOAA). 1999a. NOAA Technical Memorandum NMFS-NE-138. *Essential Fish Habitat Source Document:* Winter Flounder, *Pseudopleuronectes americanus*, Life History and Habitat Characteristics. U. S. DEPARTMENT OF COMMERCE. National Oceanic and Atmospheric Administration. National Marine Fisheries Service. Northeast Region. Northeast Fisheries Science Center. Woods Hole, Massachusetts. September 1999. Accessed at : http://www.nefsc.noaa.gov/publications/tm/tm138/tm138.pdf on May 5, 2010.

National Oceanic and Atmospheric Administration (NOAA). 1999b. NOAA Technical Memorandum NMFS-NE-137. *Essential Fish Habitat Source Document:* Windowpane, *Scophthalmus aquosus*, Life History and Habitat Characteristics. U. S. Department of Commerce. National Oceanic and Atmospheric Administration. National Marine Fisheries Service. Northeast Region. Northeast Fisheries Science Center. Woods Hole, Massachusetts. September 1999. Accessed at: http://www.nefsc.noaa.gov/publications/tm/tm137/tm137.pdf on May 5, 2010.

National Oceanic and Atmospheric Administration (NOAA). 1999c. NOAA Technical Memorandum NMFS-NE-151. Essential Fish Habitat Source Document: Summer Flounder, *Paralichthys dentatus*, Life History and Habitat Characteristics. U. S. Department of Commerce. National Oceanic and Atmospheric Administration. National Marine Fisheries Service. Northeast Region. Northeast Fisheries Science Center. Woods Hole, Massachusetts. September 1999. Accessed at: http://www.nefsc.noaa.gov/publications/tm/tm151/tm151.pdf on May 5, 2010.

Comment [C14]: These NOAA Tech Memo references are listed two different ways in the references section. These are listed by NOAA; page 2-131 lists them by author for the clearnose skate and little skate.

National Oceanic and Atmospheric Administration (NOAA). 2003a. "NOAA Technical Memorandum NMFS-NE-174: Essential Fish Habitat Source Document: Clearnose Skate, *Raja eglanteria*, Life History and Habitat Characteristics," U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Region, Northeast Fisheries Science Center, Woods Hole, MA, March 2003. Accessed at : http://www.nefsc.noaa.gov/publications/tm/tm174/index.htm on May 6, 2010.

National Oceanic and Atmospheric Administration (NOAA). 2003b. "NOAA Technical Memorandum NMFS-NE-175: Essential Fish Habitat Source Document: Little Skate, *Leucoraja erinacea*, Life History and Habitat Characteristics," U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Region, Northeast Fisheries Science Center, Woods Hole, MA, March 2003. Accessed at: http://www.nefsc.noaa.gov/publications/tm/tm175/index.htm on May 6, 2010.

National Oceanic and Atmospheric Administration (NOAA). 2003b. "NOAA Technical Memorandum NMFS-NE-179: Essential Fish Habitat Source Document: Winter Skate, *Leucoraja ocellata*, Life History and Habitat Characteristics," U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Region, Northeast Fisheries Science Center, Woods Hole, MA, March 2003. Accessed at: http://www.nefsc.noaa.gov/nefsc/publications/tm/tm179/ on June 21, 2010.

Formatted: SEIS References, Space Before: 0 pt, After: 0 pt

National Oceanic and Atmospheric Administration (NOAA). 2004. *Climatography of the United States No. 20, Monthly Station Climate Summaries, 1971-2000.* National Climatic Data Center.

NOAA Center for Coastal Monitoring and Assessment. 2005. Estuarine Living Marine Resources query results for summer flounder, all life stages in Delaware Bay and Delaware Inland Bays. Last updated August 2005. Accessed at: http://www8.nos.noaa.gov/biogeo_public/elmr.aspx on March 2, 2010.

National Oceanic and Atmospheric Administration (NOAA). 2006. NOAA Technical Memorandum NMFS-NE-198 *Essential Fish Habitat Source Document:* Bluefish, *Pomatomus saltatrix*, Life History and Habitat Characteristics. *Second Edition.* U. S. Department Of Commerce. National Oceanic and Atmospheric Administration. National Marine Fisheries Service. Northeast Fisheries Science Center. Woods Hole, Massachusetts. June 2006

National Oceanic and Atmospheric Administration (NOAA). 2008. *Climate of New Jersey, Introduction.* National Climatic Data Center.

National Oceanic and Atmospheric Administration (NOAA). 2009a. Forecast for the 2009 Gulf and Atlantic Menhaden Purse-Seine Fisheries and Review of the 2008 Fishing Season. March 2009. Sustainable Fisheries Branch, NMFS Beaufort, NC

National Oceanic and Atmospheric Administration (NOAA). 2009b. National Marine Fisheries Service Species of Concern. Atlantic sturgeon (*Acipenser oxytinchus oxyrinchus*). Accessed on 13 April 2010 at: http://www.nmfs.noaa.gov/pr/pdfs/species/atlanticsturgeon_detailed.pdf.

National Oceanic and Atmospheric Administration (NOAA). 2010a. *Locate Weather Station, Salem County, New Jersey.* National Climatic Data Center. Accessed at: http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwDI-SelectStation-USA-NJ, on February 26, 2010.

National Oceanic and Atmospheric Administration (NOAA). 2010b. Butterfish *(Peprilus triacanthus).* Essential Fish Habitat (EFH) for Butterfish. Accessed at: http://www.nero.noaa.gov/hcd/butterfish.htm on March 1, 2010.

National Oceanic and Atmospheric Administration (NOAA). 2010b. *Query Results, Storm Events in Salem County, New Jersey.* National Climatic Data Center. Accessed at: http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms on February 26, 2010.

National Oceanic and Atmospheric Administration (NOAA). 2010c. *Event Record Details, Salem County, New Jersey.* National Climatic Data Center. Accessed at: http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent-ShowEvent~435196 on February 26, 2010.

National Oceanic and Atmospheric Administration (NOAA). 2010d. *NCDC Station List, within 25 Miles of Woodstown, New Jersey.* National Climatic Data Center. Accessed at: http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwDI-StnsNear~20018793~25 on February 26, 2010.

National Oceanic and Atmospheric Administration (NOAA). 2010e. Summary of Essential Fish Habitat (EFH) Designation: 10' x 10' Square Coordinates. NOAA Fisheries Service, Habitat Conservation Division. Accessed at: http://www.nero.noaa.gov/hcd/STATES4/new_jersey/39207530.html on May 16, 2010.

National Oceanic and Atmospheric Administration (NOAA). 2010f. Summary of Essential Fish Habitat (EFH) Designation: Delaware Bay, New Jersey/Delaware. Accessed at: http://www.nero.noaa.gov/hcd/nj2.html on February 25, 2010.

National Oceanic and Atmospheric Administration (NOAA). 2010g. Summer Flounder *(Paralichthys dentatus).* Essential Fish Habitat (EFH) for Summer flounder. Accessed at: http://www.nero.noaa.gov/hcd/summerflounder.htm on March 1, 2010.

National Oceanic and Atmospheric Administration (NOAA). 2010h. Loggerhead Turtle (Caretta caretta) - Office of Protected Resources - NOAA Fisheries. Accessed at: http://www.nmfs.noaa.gov/pr/species/turtles/loggerhead.htm on May 5, 2010.

National Oceanic and Atmospheric Administration (NOAA). 2010i. Shortnose Sturgeon (Acipenser brevirostrum). Accessed at: http://www.nmfs.noaa.gov/pr/species/fish/shortnosesturgeon.htm on May 5, 2010.

National Park Service (NPS). 2006. Pinelands National Reserve – New Jersey website. Accessed at http://www.nps.gov/pine/index.htm on February 24, 2010.

National Register of Historic Places. New Castle County, Delaware. Accessed at: http://www.nationalregisterofhistoricplaces.com/de/New+Castle/state.html on April 9, 2010

Natural Resources Conservation Service (NRCS). 2010. Web Soil Survey – National Cooperative Soil Survey. Accessed at http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm on 10 February 2010.

NatureServe. 2009. NatureServe Explorer: An online encyclopedia of life (Web application). Version 7.1. NatureServe, Arlington, VA. Accessed at: http://www.natureserve.org/explorer/ on March 18, 2010.

Neartica.com. 2010. The Natural History of North America, Coast Blite (Chenopodium rubrum). Accessed at: http://www.nearctica.com/flowers/bandc/chenop/Crubrum.htm on April 5, 2010.

New Castle County. 2007. *2007 Comprehensive Development Plan Update; II. Future Land Use and Design*. New Castle County Department of Land Use. Adopted July 24, 2007. Accessed at: http://www2.neede.org/landuse/Planning/ComprehensivePlan/default.aspx December 17, 2009.

New England Fisheries Management Council (NEFMC). 1998a. Essential Fish Habitat Description Winter flounder (*Pleuronectes americanus*). Accessed at: http://www.nero.noaa.gov/hcd/winter.pdf on February 10, 2010.

New England Fisheries Management Council (NEFMC). 1998b. Essential Fish Habitat Description Windowpane flounder (*Scophthalmus aquosus*). Accessed at: http://www.nero.noaa.gov/hcd/windowpane.pdf on February 26, 2010.

New England Fishery Management Council (NEFMC). 1999. Essential Fish Habitat Overview. Accessed at http://www.nefmc.org/ on August 8, 2006.

New England Wild Flower Society. 2003. New England Plant Conservation Program, Calystegia spithamaea (L.) Pursh ssp. Spithamaea Low Bindweed: Conservation and Research Plan for New England. December. Accessed at: http://www.newenglandwild.org/docs/pdf/calystegiaspithamaea.pdf on April 5, 2010.

Northeast Fisheries Science Center (NEFSC). 2006. Status of Fishery Resources off the Northeastern US. NEFSC - Resource Evaluation and Assessment Division. Atlantic and Shortnose sturgeons. *Atlantic (Acipenser oxyrhynchus) Shortnose (Acipenser brevirostrum).* Gary Shepherd. Revised December 2006. Accessed at: http://www.nefsc.noaa.gov/sos/spsyn/af/sturgeon/ on May 5, 2010.

New England Fishery Management Council (NEFMC). 2010. Northeast Multispecies (Large Mesh/Groundfish) Fishery Management Plan. Accessed at: http://www.nefmc.org/nemulti/summary/large_mesh_multi.pdf on February 26,2010.

New Jersey American Water (NJAW) 2010. 2008 Annual Water Quality Report. Cherry Hill, New Jersey. Accessed at http://www.amwater.com/njaw/ensuring-water-quality/water-quality-reports.html, on February 24, 2010.

New Jersey Department of Education (NJDOE). 2010. 2008-2009 Enrollment, School Districts in Cumberland, Gloucester, and Salem Counties, New Jersey. Accessed at: http://www.nj.gov/education/data/enr/enr09/county.htm on January 15, 2010

New Jersey Department of Environmental Protection (NJDEP). 2001. Final Surface Water Renewal Permit Action for Industrial Wastewater, Salem Generating Station, NJPDES Permit Number NJ0005622. June 2001. Included as Appendix B to Applicant's Environmental Report.

New Jersey Department of Environmental Protection (NJDEP). 2002a. Fact Sheet for a Draft NJPDES Permit Including Section 316 (a) variance determination and Section 316(b) decision. Trenton, New Jersey. November 2002.

New Jersey Department of Environmental Protection (NJDEP). 2002. Hope Creek Generating Station Permit NJ0025411, Surface Renewal Water Permit Action, Draft Permit and Fact Sheet and Statement of Bases. Trenton, New Jersey, November 2002.

New Jersey Department of Environmental Protection (NJDEP). 2003. Final Consolidated Renewal Permit Action for Industrial Wastewater and Stormwater, Hope Creek Generating Station, NJPDES Permit Number NJ0025411. January 2003. Included as Appendix B to Applicant's Environmental Report.

New Jersey Department of Environmental Protection (NJDEP). 2004a. "Water Allocation Permit – Minor Modification." Permit No. WAP040001. December 2004.

New Jersey Department of Environmental Protection (NJDEP). 2004b. New Jersey's Endangered and Threatened Wildlife lists. Accessed at: http://www.state.nj.us/dep/fgw/tandespp.htm on April 1, 2010.

New Jersey Department of Environmental Protection (NJDEP). 2005a. Final Surface Water Major Mod Permit Action – Clarification of BOD and TSS Minimum Percent Removal Limits, Hope Creek Generating Station, NJPDES Permit Number NJ0025411. January 31, 2005.

New Jersey Department of Environmental Protection (NJDEP). 2005b. Estuarine Algal Conditions, Page 1- Updated 2/2008. Environmental Trends Report, NJDEP, Division of Science, Research & Technology, http://www.state.nj.us/dep/dsr/trends2005/.

New Jersey Department of Environmental Protection (NJDEP). 2005c. Annual Summary of Phytoplankton Blooms and Related Conditions in the New Jersey Coastal Waters. Summer of 2005.

New Jersey Department of Environmental Protection (NJDEP). 2005d. Locations of Anadromous American Shad and River Herring During Their Spawning Period in New Jersey's Freshwaters Including Known Migratory Impediments and Fish Ladders. March 2005. Division of Fish and Wildlife, Bureau of Freshwater Fisheries, Southern Regional Office

New Jersey Department of Environmental Protection (NJDEP). 2006. New Jersey Landscape Project Map Book. Department of Endangered and Nongame Species. New Jersey Department of Environmental Protection, Trenton, New Jersey. Accessed at http://www.state.nj.us/dep/fgw/ensp/mapbook.htm on May 14, 2008.

New Jersey Department of Environmental Protection (NJDEP). 2007a. Determination of Perfluorooctanoic Acid (PFOA) in Aqueous Samples, Final Report. Accessed at: http://www.state.nj.us/dep/watersupply/final_pfoa_report.pdf, on April 23, 2010.

New Jersey Department of Environmental Protection (NJDEP). 2007b. Environmental Surveillance and Monitoring Report – For the Environs of New Jersey's Nuclear Power Generating Stations. Accessed at www.state.nj.us/dep/rpp/bne/esmr.htm on April 19, 2010.

New Jersey Department of Environmental Protection (NJDEP). 2008a. Environmental Surveillance and Monitoring Report – For the Environs of New Jersey's Nuclear Power Generating Stations. Accessed at: www.state.nj.us/dep/rpp/bne/esmr.htm on April 19, 2010.

New Jersey Department of Environmental Protection (NJDEP). 2008b. Letter from H. A. Lord, Data Request Specialist, Natural Heritage Program, to L. Bryan, Tetra Tech NUS, Inc. Letter Responded to Request for Rare Species Information for the Salem and HCGS Site and Transmission Line ROWs in Camden, Gloucester, and Salem Counties.

New Jersey Department of Environmental Protection (NJDEP). 2008c. New Jersey's Endangered and Threatened Wildlife. Division of Fish & Wildlife. Last updated February 5, 2008. Accessed at: http://www.state.nj.us/dep/fgw/tandespp.htm on May 4, 2010.

New Jersey Department of Environmental Protection (NJDEP). 2009a. Ambient Air Monitoring Network Plan 2009, NJDEP Bureau of Air Monitoring. June 2009. Accessed at: www.state.nj.us/dep/airm on February 26, 2010.

New Jersey Department of Environmental Protection (NJDEP). 2009b. Operating Permit Renewal Application, Administrative Completeness – with Application Shield, Permit Activity Number BOP080003. December 2009.

New Jersey Department of Environmental Protection (NJDEP). 2009c. Environmental Surveillance and Monitoring Report – For the Environs of New Jersey's Nuclear Power Generating Stations. Accessed at: www.state.nj.us/dep/rpp/bne/esmr.htm on April 19, 2010.

New Jersey Department of Environmental Protection (NJDEP). 2009d. Public Water System Deficit/Surplus; Cumberland, Gloucester, and Salem Counties. Division of Water Supply, NJDEP. Accessed at: http://www.nj.gov/dep/watersupply/pws.htm on May 11, 2010

New Jersey Department of Environmental Protection (NJDEP). 2010a. Attainment Areas Status, Bureau of Air Quality Planning. Accessed at: http://www.state.nj.us/dep/baqp/aas.html on February 26, 2010.

New Jersey Department of Environmental Protection (NJDEP), 2010b. Division of Land Use Regulation. Accessed at http://www.nj.gov/dep/landuse/ on February 24, 2010.

New Jersey Department of Transportation (NJDOT). 2009. 2009 Short Term Counts Stations List with Annual Average Daily Traffic Data. Accessed at: http://www.state.nj.us/transportation/refdata/roadway/traffic.shtm (dated March 2, 2010) on March 23, 2010.

New Jersey Department of Labor and Workforce Development (NJDLWD). 2010a. Southern Regional Community Fact Book, Cumberland County Edition. February. Division of Labor Market and Demographic Research. Accessed at: http://lwd.dol.state.nj.us/labor/lpa/pub/factbook/factbook_index.html on April 28, 2010.

New Jersey Department of Labor and Workforce Development (NJDLWD). 2010b. Southern Regional Community Fact Book, Gloucester County Edition. February. Division of Labor Market and Demographic Research. Accessed at: http://lwd.dol.state.nj.us/labor/lpa/pub/factbook/factbook_index.html on April 28, 2010.

New Jersey Department of Labor and Workforce Development (NJDLWD). 2010c. Southern Regional Community Fact Book, Salem County Edition. February. Division of Labor Market and Demographic Research. Accessed at: http://lwd.dol.state.nj.us/labor/lpa/pub/factbook/factbook_index.html on April 28, 2010.

New Jersey Division of Fish and Wildlife (NJDFW). 2004. Bog Turtle – November 2003 Species of the Month. October 2004. Accessed at: http://www.state.nj.us/dep/fgw/ensp/somnov.htm on 26 February 2010.

New Jersey Division of Fish and Wildlife (NJDFW). 2009a. Wildlife Management Areas. Trenton, New Jersey. Accessed at: http://www.state.nj.us./dep/fgw/wmaland.htm on May 18, 2010.

New Jersey Division of Fish and Wildlife (NJDFW). 2009b. The 2009 Osprey Project in New Jersey. Endangered and Nongame Species Program. Accessed at http://www.conservewildlifenj.org/projects/documents/2009OspreyProjectnewsletter.pdf on February 18, 2010.

New Jersey Division of Fish and Wildlife (NJDFW). 2010a. Bald Eagle, *Haliaeetus leucocephalus*, fact sheet. Accessed at http://www.nj.gov/dep/fgw/ensp/pdf/end-thrtened/baldeagle.pdf on February 24, 2010.

New Jersey Division of Fish and Wildlife (NJDFW). 2010b. Bog Turtle, *Clemmys muhlenbergii*. Accessed at http://www.state.nj.us/dep/fgw/ensp/pdf/end-thrtened/bogtrtl.pdf on May 9, 2010.

New Jersey Division of Fish and Wildlife (NJDFW). 2010c. New Jersey Bog Turtle Project. Accessed at http://www.state.nj.us/dep/fgw/bogturt.htm on February 26, 2010.

New Jersey Division of Fish and Wildlife (NJDFW). 2010d. Bog Turtle Habitat Management and Restoration Slide Show. Accessed at: http://www.state.nj.us/dep/fgw/slideshows/bogturtle/bogtrtintro.htm on February 26, 2010.

New Jersey Pinelands Commission. 2009. New Jersey Pinelands Electric-Transmission Right-of-Way Vegetation-Management Plan, Final Draft. R.G. Lathrop, and J.F. Bunnell, Rutgers University, New Brunswick, New Jersey. February.

New Jersey State Atlas (NJSA). 2008. Interactive State Plan Map. Accessed at: http://njstateatlas.com/luc/ on February 8, 2010 dated 2008).

New Jersey Water Science Center (NJWSC). 2009. Major Aquifers in New Jersey. Accessed at: http://nj.usgs.gov/infodata/aquifers/ on February 24, 2010.

New York Natural Heritage Program (NYNHP). 2009. Atlantic silverside. Accessed at: http://www.acris.nynhp.org/report.php?id=7304 on February 25, 2010.

New York Natural Heritage Program (NYNHP). 2010. Animal and Plant Guides. Accessed at http://www.acris.nynhp.org/plants.php on April 5, 2010.

Newberger, T. A. and E. D. Houde. 1995. Population Biology of Bay Anchovy *Anchoa mitchilli* in The Mid Chesapeake Bay. Marine Ecology Progress Series. Vol. 116:25-37

Northeast Fisheries Science Center (NEFSC). 2004. Report of the 38th Northeast Regional Stock Assessment Workshop (38th SAW): Stock Assessment Review Committee (SARC) consensus summary of assessments. Northeast Fish. Sci. Cent. Ref. Doc. 04-03; 246 p. Accessed at: http://www.nefsc.noaa.gov/nefsc/publications/crd/crd0403/butterfish.pdf on March 2, 2010.

Northeast Fisheries Science Center (NEFSC). 2006a. Status of Fishery Resources off the Northeastern US. NEFSC - Resource Evaluation and Assessment Division. Summer flounder *(Paralichthys dentatus)*. by Mark Terceiro. Accessed at: http://www.nefsc.noaa.gov/sos/spsyn/fldrs/summer/ on March 2, 2010.

Northeast Fisheries Science Center (NEFSC). 2006b. Status of Fishery Resources off the Northeastern US. NEFSC - Resource Evaluation and Assessment Division Butterfish *(Peprilus triacanthus)*. by William Overholtz. Accessed on at: http://www.nefsc.noaa.gov/sos/spsyn/op/butter/ February 26, 2010.

Northeast Fisheries Science Center (NEFSC). 2008. Assessment of 19 Northeast Groundfish Stocks through 2007: Report of the 3rd Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 4-8, 2008. US Dep Commer, NOAA FIsheries, Northeast Fisheries Science Center Reference Document. 08-15; 884 p + xvii.

Nuclear News. 2009. "World List of Nuclear Power Plants." March 2009. Vol. 52, pp 54.

Ohio Department of Natural Reources. 1983. Hottonia Inflata Ell. Featherfoil Accessed at: http://www.dnr.state.oh.us/Portals/3/Abstracts/Abstract_pdf/H/Hottonia_inflata.pdf Triadenum walteri Gleason Walter's St. John's Wort. Accessed at: http://www.dnr.state.oh.us/Portals/3/Abstracts/Abstract_pdf/T/Triadenum_walteri.pdf on April 8,2010.

Ortho-Rodgers. 2002. Planning for the Future: A Summary of Cumberland County Planning Initiatives. Prepared for the Cumberland County Department of Planning and Development. October 2002.

~~Packer, D.B., C.A. Zetlin, and J.J. Vitaliano. 2003a. Essential Fish Habitat Source Document: Clearnose Skate, Leucoraja eglanteria, Life History and Habitat Characteristics. NOAA Technical Memorandum NMFS-NE-174. March 2003.~~

~~Packer, D.B., C.A. Zetlin, and J.J. Vitaliano. 2003b. Essential Fish Habitat Source Document: Little Skate, Leucoraja erinacea, Life History and Habitat Characteristics. NOAA Technical Memorandum NMFS-NE-175. March 2003.~~

Pennsylvania Fish and Boat Commission. 2010. Pennsylvania Fishes. Chapter *21.* Temperate Basses. *Family Moronidae*. Accessed at: http://fishandboat.com/pafish/fishhtms/chap21.htm on February 18, 2010.

Pennsylvannia Natural Heritage Program. 2007. Species Fact Sheets. Accessed at: http://www.naturalheritage.state.pa.us/Factsheets.aspx on April 8,2010.

Phillips, J.M., M.T. Huish, J.H. Kerby, and D.P. Moran. 1989. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic)--Spot. U. S. Fish and Wildlife Service Biological Report. 82(11.98). U. S. Army Corps of Engineers, TR EL-82-4. pp 13.

Pottern, G. B., M. T. Huish, and J. H. Kerby. 1989. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic)--Bluefish. U.S. Fish and Wildlife Service Biological Report. 82(11.94). U.S. Army Corps of Engineers, TR EL-82-4. pp 20. Accessed at: http://www.dnr.state.md.us/irc/docs/00000260_14.pdf on April 10, 2010. Entire publication available at: http://www.dnr.state.md.us/irc/digitaldocs.html#OTHERhabitatreq

PSEG Nuclear, LLC (PSEG). 1983. Hope Creek Generating Station. Applicant's Environmental Report – Operating License Stage, Volume 1. March.

PSEG Nuclear, LLC (PSEG). 1984. Salem Generating Station 316(b) Demonstration. NPDES permit # NJ0005622.

PSEG Nuclear, LLC (PSEG). 1999. Permit Renewal Application. NJPDES Permit No. NJ0005622. Salem Generating Station. March 1999.

PSEG Nuclear, LLC (PSEG). 2004a. Remedial Action Work Plan. PSEG Nuclear, LLC, Salem Generating Station, Hancock's Bridge, New Jersey. July 2004.

PSEG Nuclear, LLC (PSEG). 2004b. Alloway Creek Watershed Phragmites-Dominated Wetland Restoration Management Plan. Public Service Enterprise Group, Newark, New Jersey. 17 February.

~~PSEG Nuclear, LLC (PSEG). 2005a. 2004 Annual Radiological Environmental Operating Report January 1 to December 31, 2004. Lower Alloways Creek Township, New Jersey. April 2005. ADAMS No. ML051260140.~~

PSEG Nuclear, LLC (PSEG). 2005b. "Hope Creek Generating Station Environmental Report for Extended Power Uprate." Prepared for PSEG Nuclear LLC by PSEG Services Corporation, Salem, New Jersey. April 2005.

Comment [C15]: Reference not cited in the text.

~~PSEG Nuclear, LLC (PSEG). 2006a. 2005 Annual Radiological Environmental Operating Report January 1 to December 31, 2006. Lower Alloways Creek Township, New Jersey. May 2006. ADAMS No. ML061300067.~~

PSEG Nuclear, LLC (PSEG). 2006b. Hope Creek Generating Station – Updated Final Safety Analysis Report, Revision 15, Newark, New Jersey. October 2006.

PSEG Nuclear, LLC (PSEG). 2006c. Salem NJPDES Permit Renewal Application. NJPDES Permit No. NJ0005622. Newark, New Jersey, Public Service Enterprise Group. Issue date: February 2006.

PSEG Nuclear, LLC (PSEG). 2007a. 2006 Annual Radiological Environmental Operating Report January 1 to December 31, 2006. Lower Alloways Creek Township, New Jersey. April 2007. ADAMS No. ML071230112.

PSEG Nuclear, LLC (PSEG). 2007b. Salem Generating Station – Updated Final Safety Analysis Report, Document No. PSEG-0008, Revision 23. Newark, New Jersey, Public Service Enterprise Group. Publication date: October 2007.

PSEG Nuclear, LLC (PSEG). 2008a. 2007 Annual Radiological Environmental Operating Report January 1 to December 31, 2007. Lower Alloways Creek Township, New Jersey. April 2008. ADAMS No. ML081280737.

PSEG Nuclear, LLC (PSEG). 2008b. 2007 Hazardous Waste Report. Lower Alloways Creek Township, New Jersey. February 2008.

PSEG Nuclear, LLC (PSEG). 2008c. Hope Creek Generating Station. Accessed at: http://www.pseg.com/companies/nuclear/hopecreek.jsp. October 2008.

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 Nuclear, LLC (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

PSEG Nuclear, LLC (PSEG). 2009c. 2008 Annual Radiological Environmental Operating Report January 1 to December 31, 2009. Lower Alloways Creek Township, New Jersey. April 2009. ADAMS No. ML091200612.

PSEG Nuclear, LLC (PSEG). 2009d. Salem Generating Station – Updated Final Safety Analysis Report. Document No. PSEG-0008. Revision 24. May 11, 2009.

PSEG Nuclear, LLC (PSEG). 2009e. Quarterly Remedial Action Progress Report, Fourth Quarter 2008, PSEG Nuclear, LLC, Salem Generating Station. Developed by Arcadis for PSEG Nuclear LLC. May 26, 2009. ADAMS No. ML091690304.

~~PSEG Nuclear, LLC (PSEG). 2010a. 2009 Annual Radiological Environmental Operating Report January 1 to December 31, 2009. Lower Alloways Creek Township, New Jersey. April 2010. ADAMS No. 101241151.~~

PSEG Nuclear, LLC (PSEG). 2010b. Salem and Hope Creek Generating Stations Hazardous Waste Generator Status for 2009. Lower Alloways Creek Township, New Jersey. March 2010.

PSEG Nuclear, LLC (PSEG). 2010c. Table 2.6-2 Update, Residential Distribution of Salem Employees; Table 2.6-2 Update, Residential Distribution of Hope Creek Employees; and Table 2.6-2a, Residential Distribution of Salem/Hope Creek Staffs Who Are Matrixed and Corporate Employees. Provided in response to Salem/Hope Creek Environmental Audit Needs List as requested in NRC letter dated April 16, 2010. Document designations LUS-6 (Index No. Socioeconomics 7 and 8) and No LUS# (Index No. Socioeconomics 23).

PSEG Nuclear, LLC (PSEG). 2010d. Update to Tables 2.7-1, Tax Information for Salem and Hope Creek Generating Station and the Energy and Environmental Resource Center, 2003-2009. Provided in response to Salem/Hope Creek Environmental Audit Needs List as requested in NRC letter dated April 16, 2010. Document designation LUS-4 (Index No. Socioeconomics 4, 5, and 6).

PSEG Power, LLC (PSEG). PSEG. 2010e. Letter from W. Lewis (PSEG) to U.S. Nuclear Regulatory Commission, Document Control Desk, "Subject: PSEG Power, LLC and PSEG Nuclear, LLC Early Site Permit Application Expected Submission Date', February 11, 2010.

Rogers, S. G., and M. J. Van Den Avyle. 1989. Species profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic)--Atlantic Menhaden. U.S. Fish and Wildlife Service. Biol. Rep. 82(11.108). U.S. Army Corps o f Engineers TR EL-82-4. pp 23.

Rosenau, J.C., Lang, S.M., G.S., Hilton, and Rooney, J.G. 1969. Geology and ground-water resources of Salem County, New Jersey: New Jersey Department of Conservation and Economic Development Special Report 33, pp 142.

Rukenstein & Associates. 2004. *Smart Growth Plan, Delaware River and I-295/NJ Turnpike Planned Growth Corridor, Salem County, New Jersey*. Submitted for Final Adoption January 21, 2004. Ron Rukenstein & Associates, Titusville, NJ. Accessed at: http://www.salemcountynj.gov/cmssite/default.asp?contentID=1208 on December 9, 2009.

Salem County. 2007. Salem County, New Jersey: An Economic Resource Guide. Salem County Economic Development Department. Accessed at: http://www.salemcountynj.gov/cmssite/downloads/new%20tourism/Salem_Co_NJ06.pdf on April 27, 2010.

Salem County. 2008. Salem County Farmland Preservation Plan, August, 2008. Accessed at http://www.salemcountynj.gov/cmssite/default.asp?contentID=1103 on February 24, 2010.

Sellers, M.A., and J. G. Stanley. 1984. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (North Atlantic) - American Oyster. U.S. Fish and Wildlife Service. FWS/OBS-82/11.23. U.S. Army Corps of Engineers, TR EL-82-4. pp 15.

Smithsonian Marine Station. 2008. Species Name: *Anchoa mitchilli.* Common Name: Bay Anchovy. Accessed at: http://www.sms.si.edu/irlSpec/Anchoa_mitchilli.htm on February 18, 2010.

South Carolina Department of Natural Resources. 2010. Species Descriptions. Accessed at: http://www.dnr.sc.gov/cwcs/species.html#T on 9 May 2010.

South Jersey Transportation Planning Organization (SJTPO). 2008. 2035 RTP Update. Accessed at: http://www.sjtpo.org/2035-rtp-final.pdf on May 13, 2010.

Stanley, J.G., and D.S. Danie. 1983. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (North Atlantic)--White Perch. U.S. Fish and Wildlife Service, Division of Biological Services, FWS/OBS-82/11.7. U.S. Army Corps o f Engineers, TR EL-82-4. pp 12.

State Agriculture Development Committee (SADC). 2009. New Jersey Farmland Preservation Program. Accessed at: http://www.nj.gov/agriculture/sadc/farmpreserve/progress/stats/preservedsummary.pdf on December 10, 2009.

Sutton, C. C., J.C. O'Herron, II, and R.T. Zappalorti. 1996. The Scientific Characterization of the Delaware Estuary. Performed for the Delaware Estuary Program, Delaware River Basin Commission (DRBC) Project # 321.

TetraTech. 2009. Salem/Hope Creek Generating Station Calculation Package for Ground Water Pumpage, Salem & Hope Creek Generating Station. Aiken, SC, TetraTech NUS. Publication date: February 23, 2009.

Wernert, S.J. 1998. Reader's Digest North American Wildlife: An Illustrated Guide to 2,000 Plants and Animals. Accessed at http://books.google.com/books?id=YedAnP3k1IMC&printsec=frontcover&dq=reader's+digest+north+american+wildlife+susan+j+wernert&source=bl&ots=es2QFm3yqo&sig=s1OpQWxalri3k_Gvcm0Efppyttw&hl=en&ei=02TtS4NQhrKsB46qqJcG&sa=X&oi=book_result&ct=result&resnum=1&ved=0CAYQ6AEwAA#v=onepage&q=stinking%20fleabane&f=false on May14, 2010.

U. S. Army Corps of Engineers (USACE). 2007. Delaware Bay Oyster Restoration Project. Delaware and New Jersey. Final Environmental Assessment. US Army Corps of Engineers. Philadelphia District. June 2007.

U.S. Army Corps of Engineers (USACE). 2009. Delaware River Main Stem and Channel Deepening Project Environmental Assessment. April 2009. Accessed at: http://www.nap.usace.army.mil/cenap-pl/MainChannel_EA_3Apr09.pdf on February 19 2010.

U.S. Census Bureau (USCB). 1995a. New Jersey. Population of Counties by Decennial Census: 1900 to 1990. Accessed at: http://www.census.gov/population/cencounts/nj190090.txt on May 12, 2010.

U.S. Census Bureau (USCB). 1995b. Delaware. Population of Counties by Decennial Census: 1900 to 1990. Accessed at: http://www.census.gov/population/cencounts/de190090.txt on May 12, 2010.

U.S Census Bureau (USCB). 2000a. Census 2000 Demographic Profile for Cumberland, Gloucester, and Salem Counties, New Jersey, and New Castle County, Delaware. Accessed at: http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=ACS&_submenuId=&_lang=en&_ts= on December 8, 2009.

U.S Census Bureau (USCB). 2000b. Demographic Profile for Cumberland, Gloucester, and Salem Counties, New Jersey, and New Castle County, Delaware. Accessed at: http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=ACS&_submenuId=&_lang=en&_ts= on December 09, 2009.

U.S Census Bureau (USCB). 2000c. "H1. Housing Units [1] – Universe: Housing units. Data Set: Census 2000 Summary File 1 (SF1) 100-Percent Data" and "H5. Vacancy Status [7] – Universe: Vacant housing units. Data Set: Census 2000 Summary File 1 (SF1) 100-Percent Data" for Cumberland, Gloucester, Salem Counties, State of New Jersey, New Castle County, and State of Delaware. Accessed May 14, 2010 at http://factfinder.census.gov/.

U.S. Census Bureau (USCB). 2000d. "P4. Hispanic or Latino, and not Hispanic or Latino by Race [73] – Universe: Total population. Data Set: Census 2000 Summary File 1 (SF 1) 100-Percent Data." Accessed May 14, 2010 at http://factfinder.census.gov/.

U.S. Census Bureau (USCB). 2006. Nonemployer Statistics, 2006 Total For All Sectors Salem County, NJ. Accessed at: http://www.census.gov/epcd/nonemployer/2006/nj/NJ033/HTM on May 5, 2010.

United States Census Bureau (USCB). 2008. Selected Economic Characteristics: 2006-2008 American Community Survey 3-Year Estimates *for* Cumberland, Gloucester, and Salem Counties and New Jersey; New Castle County and Delaware. Accessed at: http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=ACS&_submenuId=&_lang=en&_ts= on April 28, 2010.

U.S Census Bureau (USCB). 2009. 2006 – 2008 American Community Survey 3 Year Estimates, Data Profile for Cumberland, Gloucester, and Salem Counties, New Jersey, and New Castle County, Delaware. Accessed at: http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=ACS&_submenuId=&_lang=en&_ts= on December 8, 2009.

United States Census Bureau (USCB). 2010a. State & County QuickFacts *for* Cumberland, Gloucester, and Salem Counties, New Jersey and New Castle County, Delaware. Accessed at: http://quickfacts.census.gov/qfd (dated April 22, 2010) April 27, 2010.

U.S. Census Bureau (USCB). 2010b. GCT-T1. Population Estimates, New Jersey—County, Data Set: 2009 Population Estimates. Accessed at: http://factfinder.census.gov on May 12, 2010.

U.S. Department of Agriculture (USDA). 1999. American Kestrel (Falco sparverius). Fish and Wildlife Habitat Management Leaflet. Accessed at: ftp://ftp-fc.sc.egov.usda.gov/WHMI/WEB/pdf/kestrel(1).pdf on May 9, 2010.

U.S. Department of Agriculture (USDA). 2006. Plants Database, Threatened and Endangered Plants of New Jersey, PLANTS Profile. Accessed at: http://plants.usda.gov/java/threat?statelist=states&stateSelect=US34 on April 2, 2010.

U.S Department of Agriculture (USDA). 2007. Census of Agriculture, Table 7. Hired Farm Labor – Workers and Payroll: 2007, County Level Data; Delaware, New Jersey, and Pennsylvania. Accessed at: http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_County_Level/index.asp on December 17, 2009.

U.S. Department of Agriculture (USDA). 2010. Fire Effects Information Network, Plant Species Life Form. Accessed at: http://www.fs.fed.us/database/feis/plants/ on April 5, 2010.

U.S. Environmental Protection Agency (EPA). 1988. New Jersey Coastal Plain Aquifer, Support Document, Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Mercer, Middlesex, Monmouth, Ocean, and Salem Counties, New Jersey. May, 1988. Accessed at http://www.epa.gov/Region2/water/aquifer/coast/coastpln.htm on February 24, 2010.

U.S. Environmental Protection Agency (EPA). 1998. Condition of the Mid-Atlantic Estuaries. EPA 600-R-98-147. Office of Research and Development, Washington, D.C.

U.S. Environmental Protection Agency (EPA). 2001. National Pollutant Discharge Elimination System; Regulations Addressing Cooling Water Intake Structures for New Facilities. 40 CFR Parts 9, 122, et al. 66 FR 65256. Washington D.C. December 2001.

U.S. Environmental Protection Agency (EPA). 2007. Level III Ecoregions of the Conterminous United States. Western Ecology Division. Accessed at: http://www.epa.gov/wed/pages/ecoregions/level_iii.htm on February 11, 2010.

U.S. Environmental Protection Agency (EPA). 2010a. Enforcement and Compliance History Online (ECHO). Detailed Facility Report. Accessed at: http://www.epa-echo.gov/cgi-bin/get1cReport.cgi?tool=echo&IDNumber=110000603142 on May 18, 2010.

U.S. Environmental Protection Agency (EPA). 2010b. Environmental Protection Agency, Safe Drinking Water Information System (SDWIS), Salem County, New Jersey. Accessed at http://oaspub.epa.gov/enviro/sdw_query_v2 on February 24, 2010.

U.S. Environmental Protection Agency (EPA). 2010c. Environmental Protection Agency, Safe Drinking Water Information System (SDWIS), New Castle County, New Jersey. Accessed at http://oaspub.epa.gov/enviro/sdw_query_v2, on February 24, 2010.

U.S. Environmental Protection Agency (EPA). 2010d. Partnership for the Delaware Estuary, National Estuary Program. Accessed at http://www.epa.gov/owow/estuaries/programs/de.html February 24, 2010.

U.S. Environmental Protection Agency (EPA). 2010e. Safe Drinking Water Information System (SDWIS). Results based on data extracted on October 16, 2009. Accessed at: http://www.epa.gov/safewater/dwinfo/nes.htm on January 20, 2010.

U.S. Fish and Wildlife Service (FWS). 2001a. Shortnose Sturgeon Habitat Model. Accessed on at: http://www.fws.gov/r5gomp/gom/habitatstudy/metadata/shortnose_sturgeon_model.htm May 5, 2010.

U.S. Fish and Wildlife Service (FWS). 2001b. "Bog Turtle (Clemmys muhlenbergii), Northern Population, Recovery Plan." Hadley, Massachusetts. pp 103. Accessed at: http://ecos.fws.gov/docs/recovery_plan/010515.pdf on February 26, 2010.

U.S. Fish and Wildlife Service (FWS). 1991c. Swamp Pink (*Helonias bullata*) Recovery Plan. Newton Corner, Massachusetts. pp 56. Accessed at: http://www.fws.gov/ecos/ajax/docs/recovery_plan/910930c.pdf on May 9 2010.

U.S. Fish and Wildlife Service (FWS). 2003. Delaware Bay Shorebird-Horseshoe Crab Assessment Report and Peer Review. U.S. Fish and Wildlife Service Migratory Bird Publication R9-03/02. Arlington, Virginia. pp 99. Accessed at: http://library.fws.gov/Bird_Publications/DBshorebird.pdf on April 9, 2010.

U.S. Fish and Wildlife Service (FWS). 2004. *The Bog Turtle* (*Clemmys muhlenbergii*): *Protecting New Jersey's Rarest Turtle*. February 2004. Accessed at http://www.fws.gov/northeast/njfieldoffice/Fact%20Sheets%20PDF%20holding/Bog_turtle.pdf on February 26, 2010.

U. S. Fish and Wildlife Service (FWS). 2006. The Horseshoe Crab. *Limulus polyphemus. A Living Fossil*. Accessed at: http://www.fws.gov/northeast/pdf/horseshoe.fs.pdf on April 9, 2010.

U.S. Fish and Wildlife Service (FWS). 2008a. Sensitive Joint-vetch – Endangered Species Program species profile. Accessed at: http://www.fws.gov/northeast/njfieldoffice/Endangered/jointvetch.html on May 13, 2010.

U.S. Fish and Wildlife Service (FWS). 2008b. Five Year Review, Swamp Pink (*Helonias bullata*). Summary and Evaluation. Accessed at: http://www.fws.gov/ecos/ajax/docs/five_year_review/doc2006.pdf on May 9 2010.

U.S. Fish and Wildlife Service (FWS). 2009a. Letter from the acting supervisor, New Jersey Field Office, Ecological Services, Pleasantville, NJ to E. J. Keating, PSEG Nuclear LLC, Hancocks Bridge, NJ. Letter addressed the potential for occurrence of Federally listed species in the vicinity of the Salem and HCGS facilities as well as four transmission lines in New Jersey. September 9.

U.S. Fish and Wildlife Service (FWS). 2009b. Letter from L. Miranda, Chesapeake Bay Field Office, Annapolis, MD to W. Walsh, New Jersey Field Office, Pleasantville, NJ. Letter addressed the potential for occurrence of Federally listed species in the vicinity of the Salem and HCGS facilities and the transmission line crosses river into Delaware. August 18.

U.S. Fish and Wildlife Service (FWS). 2009c. Federally Listed and Candidate Species Occurances in New Jersey by County and Municipality. Accessed at: http://www.fws.gov/njfieldoffice/Endangered/specieslist.pdf on February 26, 2010.

U.S. Fish and Wildlife Service (FWS). 2010a. National Wetlands Inventory website. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. Accessed at http://www.fws.gov/wetlands/ on February 10, 2010.

U.S. Fish and Wildlife Service (FWS). 2010b. Federally Listed and Candidate Species in New Jersey. Endangered Species Program, New Jersey Field Office. Last updated April 20, 2010. Accessed at: http://www.fws.gov/northeast/njfieldoffice/Endangered/index.html. on May 16, 2010.

U.S. Fish and Wildlife Service (FWS). 2010c. Swamp Pink (*Helonias bullata*). Accessed at: http://www.fws.gov/northeast/njfieldoffice/Endangered/Swamp Pink.htm on May 10, 2010.

U.S. Geological Survey (USGS). 1983. Walker, R.L., Evaluation of Water Levels in Major Aquifers of the New Jersey Coastal Plain, 1978. U.S. Department of the Interior, U.S. Geological Survey, Water-Resources Investigations Report 82-4077.

U.S. Geological Survey (USGS). 2007. W. Jones and D. Pope, Summary of the Ground Water Level Hydrologic Conditions in New Jersey 2006, Fact Sheet 2007-3049. West Trenton, New Jersey, U.S. Department of the Interior. New Jersey Water Science Center. June 2007.

U.S. Geological Survey (USGS). 2009. V.T. DePaul, R. Rosman, and P.J. Lacombe, Water-Level Conditions in Selected Confined Aquifers of the New Jersey and Delaware Coastal Plain, 2003. pp 135. Reston, Virginia. U.S. Department of the Interior, U.S. Geological Survey, Scientific Investigations Report 2008-5145.

U.S. Nuclear Regulatory Commission (NRC). 1984. "Final Environmental Statement Related to the Operation of Hope Creek Generating Station." Docket Number 50-354. NUREG-1074. Washington DC, December.

U.S. Nuclear Regulatory Commission (NRC). 2005. Order Modifying License. Washington D.C. May 2005. Docket No. 72-48.

U.S. Nuclear Regulatory Commission (NRC). 2007. "Essential Fish Habitat for an Extended Power Uprate at Hope Creek Generating Station. Docket No. 50-354. June 2007. ADAMS No. ML071520463.

U.S. Nuclear Regulatory Commission (NRC). 2010a. Pressurized Water Reactors. Accessed at: http://www.nrc.gov/reactors/pwrs.html on May 18, 2010.

U.S. Nuclear Regulatory Commission (NRC). 2010b. Boiling Water Reactors. Accessed at: http://www.nrc.gov/reactors/bwrs.htm on May 18, 2010.

United Nations Educational, Scientific, and Cultural Organization (UNESCO). 2010. Biosphere Reserve Information – New Jersey Pinelands. Accessed at: http://portal.unesco.org/science/en/ev.php-URL_ID=6797&URL_DO=DO_TOPIC&URL_SECTION=201.html on February 24, 2010.

University of Georgia. 2010. Snakes of Georgia and South Carolina. Reptiles and Amphibians of South Carolina and Georgia. Accessed at: http://www.uga.edu/srelherp/index.htm#Reptiles on 9 May 2010.

University of Texas at Austin. 2010. Lady Bird Johnson Wildflower Center, Native Plant Information Network (NPIN). Accessed at: http://www.wildflower.org/collections/collection.php?all=true on April 5, 2010.

University of Washington Burke Museum of Natural History and Culture. 2006. Accessed at http://biology.burke.washington.edu/herbarium/imagecollection.php?Genus=Hydrocotyle&Species=ranunculoides on April 8,210.

University of Wisconsin. 2010. Stevens Point Freckmann Herbarium, Plants of Wisconsin. Accessed at http://wisplants.uwsp.edu/WisPlants.html on April 7, 2010.

Utah State University. 2010. Grass Manual on the Web. Accessed at http://herbarium.usu.edu/webmanual/default.htm on April 2, 2010.

Versar, Inc. (Versar). 1991. An Assessment of Key Biological Resources in the Delaware Estuary. Performed for the Delaware Estuary Program. Accessed at: http://www.nap.usace.army.mil/cenap-pl/b13.pdf on February 11 2010.

Weiss-Glanz, L.S., J.G. Stanley, and J. R. Moring. 1986. Species profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (North Atlantic)--American Shad. U. S. Fish and Wildlife Service. Biol. Rep. 82(11.59). U.S. Army Corps o f Engineers, TR EL-82-4. pp. 16.

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) 51.71d).

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.

The Staff ultimately makes no decision as to which alternative (or the proposed action) to implement, since that decision falls to utility, State, or other Federal officials to decide. Comparing the environmental effects of these alternatives will assist the Staff in deciding whether the environmental impacts of license renewal are so great that preserving the option of license renewal for energy-planning decision-makers would be unreasonable (10 CFR 51.95[c][4]). If the NRC acts to issue renewed licenses, all of the alternatives, including the proposed action, will be available 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 whose costs or benefits do not justify 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.

In-Depth Alternatives:

- **Coal-fired supercritical**
- **Natural gas-fired combined-cycle**
- **Combination**

Other Alternatives Considered:

- **Offsite Coal-Fired and Natural Gas**
- **New nuclear**
- **Conservation/ Efficiency**
- **Purchased power**
- **Solar power**
- **Wood-fired combustion**
- **Wind (onshore/offshore)**
- **Hydroelectric power**
- **Wave and ocean energy**
- **Geothermal power**
- **Municipal solid waste**
- **Biofuels**
- **Oil-fired power**
- **Fuel cells**
- **Delayed retirement**

The Staff initially considered 17 discrete potential 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 precisely 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.

The in-depth alternatives that the Staff considered include a supercritical coal-fired plant in section 8.1.1, a natural gas-fired combined-cycle power plant in 8.1.2, and a combination of alternatives in 8.1.3 that includes natural gas-fired 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."

8.1 ALTERNATIVE ENERGY SOURCES

8.1.1 Supercritical Coal-Fired Generation

The GEIS indicates that a 3656 megawatt-electric (MWe) supercritical coal-fired power plant (a plant equivalent in capacity to each individual Salem Unit 1, Salem Unit 2, and HCGS plants) could require 6,233 acres (2,523 hectares) of available land area, and thus would not fit on the existing 1,480 acres 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, a greater share of U.S. electrical power generation 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 3656 net MWe that Salem and HCGS currently supply, the coal-fired alternative would need to produce roughly 3889 gross MWe, 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 3889 gross MWe would be achieved using standard-sized units, which are assumed to be approximately equivalent to six units of 630 MWe each.

The 3656 net MWe power plants would consume approximately 12.2 million tons 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 of ash annually (EIA, 2010b), and roughly 245,300 tons 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.

Table 8-1. Summary of 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
Waste Management	MODERATE	Not Applicable

8.1.1.1 Air Quality

Air quality impacts from coal-fired generation can be substantial increased because they emit significant quantities of sulfur oxides (SOx), nitrogen oxides (NOx), particulates, carbon monoxide (CO), and hazardous air pollutants such as mercury. However, many of these pollutants can be substantially reduced using various pollution control technologies.

Salem and HCGS are located in Salem County, New Jersey. Salem County is designated as in attainment/unclassified with respect to the NAAQSs for PM2.5, SO2, 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 (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)), sulfur dioxide (SO_2) (40 CFR 60.43(a)), and NOx (40 CFR 60.44(a)). Regulations issued by NJDEP adopt the EPA's CAA rules (with modifications) to limit power plant emissions of SOx, NOx, 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. 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 areas in the State of New Jersey, which is the Brigantine National Wildlife Refuge (40 CFR 81.420), located approximately 58 miles (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 miles (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 NOx for the year 2015. CAIR will aid New Jersey sources in reducing SO_2 emissions by 25,000 tons (or 49 percent), and NOx emissions by 11,000 tons (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 (SOx) – 12,566 tons (11,423 MT) per year
- Nitrogen oxides (NOx) – 3050 tons (2773 MT) per year
- Particulate matter (PM) PM_{10} – 85.4 tons (77.6 MT) per year
- Particulate matter (PM) $PM_{2.5}$ – 22.6 tons (20.5 MT) per year
- Carbon monoxide (CO) – 3050 tons (2773 MT) per year

Sulfur Oxides

The coal-fired alternative at the Salem and HCGS site would likely use wet, limestone-based scrubbers to remove SOx. The EPA indicates that this technology can remove more than 95 percent of SOx from flue gases. The Staff projects total SOx emissions after scrubbing would be 12,566 tons (11,423 MT) per year. SOx 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 NOx, 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 NOx-control technologies, which can be grouped into two main categories: combustion modifications and post-combustion processes. Combustion modifications include low-NOx 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 NOx emissions by up to 95 percent (EPA, 1998). PSEG indicated in its ER that the technology would use low NOx burners, overfire air, and selective catalytic reduction to reduce NOx emissions by approximately 95 percent from uncontrolled emissions. As a result, the NOx emissions associated with a coal-fired alternative at the Salem and HCGS site would be approximately 3,050 tons (2,773 MT) per year.

Section 407 of the CAA establishes technology-based emission limitations for NOx 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 49453), limits the discharge of any gases that contain nitrogen oxides (NO_2) to 200 nanograms (ng) of NOx per joule (J) of gross energy output (equivalent to 1.6 lb/MWh), 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 (77.6 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 particulate emissions with an aerodynamic diameter of 2.5 microns or less ($PM_{2.5}$). 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 (2,773 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) (EPA, 2000a). The EPA determined that coal plants emit arsenic, beryllium, cadmium, chromium, dioxins, hydrogen chloride, hydrogen fluoride, lead, manganese, and mercury (EPA, 2000a). 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 (EPA, 2000a).

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 (30,455,500 MT) per year of CO_2.

Summary of Air Quality

While the GEIS analysis mentions global warming from unregulated CO_2 emissions and acid rain from SOx and NOx 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 SOx, NOx, 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 paragraph. 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 impacts from coal-fired plant located at 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 waterbodies 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.

Aquatic resources distant from the site also have the potential to be affected by a coal-fired alternative. Disposal of waste by landfilling offsite could affect the aquatic ecology of waterbodies downgradient from the disposal site; however, regulatory requirements for such facilities are expected to minimize or prevent such effects. Aquatic ecology in offsite coal mining areas also could be affected, such as by acid mine drainage, although waterbodies in the mining areas are likely to be disturbed already due to ongoing mining operations, and regulatory requirements are expected to limit these impacts. Acid rain resulting from NOx and SOx emissions, as well as the deposition of other pollutants, also could affect the aquatic ecology of waterbodies downwind of the site. The emission controls discussed in Section 8.1.1 are expected to reduce but not eliminate such effects.

Thus, impacts to aquatic ecology may occur as a result of the effects of facility operations on the adjacent Delaware Estuary as well as more distant effects from waste disposal, coal mining, and air emissions. 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 but could range from SMALL to MODERATE depending on the extent to which other aquatic resources may be affected.

Terrestrial Ecology

Constructing the coal-fired alternative onsite would require approximately 204 ha (505 ac) of land for construction of the power block with an additional 78–56 ha (193–386 ac) for waste disposal, which PSEG indicated could be accommodated on the existing site (see Section 8.1.1.6) (PSEG, 2009a; PSEG, 2009b). Terrestrial ecology in offsite coal mining areas also could be affected, although some of the land is likely to already be disturbed as a result of ongoing mining operations. Thus, impacts to terrestrial ecology may occur as a result of construction and operational activities both onsite and offsite.

Onsite impacts to terrestrial ecology would be minor because the site is on an artificial island and most of the site has been previously disturbed. If additional roads would need to be constructed through less disturbed areas, impacts would be greater 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. Overall, impacts to terrestrial resources at the site would be minimal and limited mostly to the period of construction.

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 NOx and SOx 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, 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 for the area of the site but could range from SMALL to MODERATE depending on the extent to which terrestrial resources at other locations may be affected.

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; SOx; NOx; 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 acres (700 ha) would be required for constructing a 1,000-MW(e) coal plant. Scaling from the GEIS estimate, approximately 6,233 acres (2,523 ha) would be required to replace the 3,660 MW(e) provided by Salem and HCGS. PSEG indicated that approximately 505 acres (204 ha) of land would be needed to support the power block for a coal-fired alternative capable of replacing the Salem and HCGS facilities (PSEG, 2009a), (PSEG, 2009b). The Staff notes than many coal-fired power plants with larger capacities have been located on smaller sites, and believes that the PSEG estimate is reasonable. PSEG indicated that an additional 193 acres (78 ha) of land area may be needed for waste disposal over the 20-year license renewal term, or 386 acres (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. In the GEIS, the Staff estimated that supplying coal to a 1,000-MW(e) plant would disturb approximately 22,000 acres (8,900 ha) of land for mining the coal and disposing of the wastes during the 40-year operational life. Scaling from GEIS estimates, approximately 80,500 acres (32,570 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. In the GEIS, the Staff estimated that approximately 3,660 acres (1,480 ha) of land would be affected by the mining and processing of uranium over the operating life of a plant with the capacity of Salem and HCGS.

Based on this information, land use impacts would be 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.

The GEIS projects a peak construction workforce of 1,200 to 2,500 for a 1,000 MW(e) plant (when extrapolated, a lower-end workforce of approximately 4,400 for a 3,660-MW(e) plant). PSEG projected a peak workforce of about 5,660 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 relocated workers to local business and tax revenues would vary over time.

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 MWe alternative (PSEG, 2009a), (PSEG 2009b). The area would experience a loss of approximately 1,100 permanent, 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 is, however, expected to be SMALL given the relatively large area from which Salem and HCGS personnel are currently drawn and the extensive timeframe over which construction of a new plant and decommissioning of the existing facility would occur. The coal-fired alternative would provide a new tax base in Lower Alloways Creek Township and Salem County to offset the loss of taxes that would occur assuming Salem and HCGS are decommissioned. While it is difficult to estimate the impact of this scenario on Lower Alloways Creek Township and Salem County resources, it would not be unreasonable to assume that, on balance, the township's and county's tax base would not be significantly altered and that resulting impacts could be best characterized as SMALL to MODERATE.

Transportation

During construction, up to 5,660 workers would be commuting to the site, as well as the current 1,614 workers already at Salem and HCGS. In addition to commuting workers, trucks would transport construction materials and equipment to the worksite 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 are likely to be MODERATE during construction.

Transportation 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. Deliveries of coal and limestone would be by barge. The coal-fired alternative would likely create SMALL transportation impacts 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 alternative would have boiler houses up to 200 feet (61 m) tall with exhaust stacks up to 500 feet (152 m) and would be visible offsite in daylight hours. The coal-fired 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 the use of multiple cooling towers instead of the current one tower, thus increasing the size of the condensate plume. Lighting on plant structures would be visible offsite at night. Overall, aesthetic impacts associated with the coal-fired alternative would likely be SMALL to MODERATE.

Coal-fired generation would introduce mechanical sources of noise that would be audible offsite, although given the low population near the plant's periphery, nuisance impacts are not expected. Sources contributing to total noise produced by plant operation would be classified as continuous or intermittent. Continuous sources include the mechanical equipment associated with normal plant operations. Intermittent sources include the equipment related to coal handling, solid-waste disposal, use of outside loudspeakers, and the commuting of plant employees. The nuisance impacts of plant noise emissions are expected to be SMALL due to the large area encompassed by the Salem and HCGS site and the fact that sensitive land uses do not occur in the immediate plant vicinity.

Historic and Archaeological Resources

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 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 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. For socioeconomic data regarding the analysis of environmental justice issues, the reader is referred to Section 4.9.7, Environmental Justice.

No environmental or human health impacts were identified that would result in disproportionately high and adverse environmental impacts on minority and low-income populations if a replacement coal-fired plant were built at the Salem and HCGS site. Some impacts on rental and other temporary housing availability and lease prices during construction might occur, and this could disproportionately affect low-income populations. Although the site is located in a rural area, it is near the Philadelphia and Wilmington metropolitan areas. Therefore, the demand for rental housing would be mitigated because workers would be likely to commute to the site from these areas instead of relocating closer to the construction site. Thus, the impact on minority and low-income populations would be SMALL.

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 MWe power plant comprised of six units of approximately 630 MWe each would generate annually a total of approximately 753,960 tons of ash (EIA, 2010b), and 245,300 tons of scrubber sludge (PSEG, 2009a) (PSEG, 2009b) About 340,00 tons or 45 percent of the ash waste and 194,000 tons or 79 percent of scrubber sludge would be recycled, based on industry-average recycling rates (ACAA, 2007). Therefore, approximately 413,900 tons of ash and 51,300 tons 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" (EPA, 2000b) 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.

8.1.2 Natural Gas 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 MWe 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 MWe per unit. Nine units would produce a total of 3600 MWe, 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 MWe. 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 MWe plant would require 409 acres (1,023 ha), which would be feasible on the 1,480 acre PSEG site.

This 3600 MWe power plant would consume 161.65 billion cubic feet (ft^3) (4,587 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 miles 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-mile 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.

Table 8-2. Summary of 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 to MODERATE
Surface Water	SMALL	SMALL
Aquatic and Terrestrial Resources	SMALL	SMALL
Human Health	SMALL	SMALL
Socioeconomics	SMALL to MODERATE	SMALL
Waste Management	SMALL	Not Applicable

8.1.2.1 Air Quality

Salem and HCGS are located in Salem County, New Jersey. Salem County is designated as in attainment/unclassified with respect to the NAAQSs for PM2.5, SO2, 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 (PA-NJ-DE-MD) non attainment area.

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 SOx, NOx, 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.

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. 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 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 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 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 areas in the State of New Jersey, which is the Brigantine National Wildlife Refuge (40 CFR 81.420), located approximately 58 miles (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 miles (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 NOx for the year 2015. CAIR will aid New Jersey sources in reducing SO_2 emissions by 25,000 tons (or 49 percent), and NOx emissions by 11,000 tons (or 48 percent) (EPA 2010).

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 (SOx) – 53 tons (48.2 MT) per year
- Nitrogen oxides (NOx) – 932 tons (847 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 (48.2 MT) per year of SOx (assumed to be all SO_2) (EPA, 2000c), (INGAA, 2000) and 932 tons (847 MT) per year of NOx based on the use of the dry low NOx combustion technology and use of the selective catalytic reduction (SCR) in order to significantly reduce NOx emissions (INGAA, 2000). The new plant would be subjected to the continuous monitoring requirements of SO_2, NO_x and CO_2 specified in 40 CFR Part 75. A new natural gas-fired plant would have to comply with Title IV of the CAA reduction requirements for SO_2 and NOx, which are the main precursors of acid rain and the major cause of reduced visibility. Title IV establishes maximum SO_2 and NOx 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, 2000c), 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, 2000c), 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 (EPA, 2000a) 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 of 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 carbon dioxide (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 of a new natural gas-fired plant located at the Salem and HCGS site would be SMALL to MODERATE.

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 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.

8.1.2.4 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. 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 52 ha (128 ac) of land according to PSEG estimates (PSEG, 2009a; PSEG, 2009b). Scaling from the GEIS estimate, approximately 162 ha (396 ac) 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 would be minor because the site is on an artificial island and most of the site has been previously disturbed. If additional roads would need to be constructed through less disturbed areas, impacts would be greater 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 were required to be constructed through less disturbed areas, this activity could fragment or destroy local ecological communities, thereby increasing impacts. Operation of the cooling tower would cause some deposition of dissolved solids 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 the 25-mi 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 not be expected to 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 NOx, 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. NOx emissions contribute to ozone formation, which in turn contributes to human health risks. Emission controls on this gas-fired alternative maintain NOx emissions well below air quality standards established for the purposes of protecting human health, and emissions trading or offset requirements mean that overall NOx in the region would not increase. Health risks to workers may also result from handling spent catalysts 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

As discussed in Section 8.1.1.6, the GEIS generically evaluates the impacts of nuclear power plant operations on land use both on and off each power plant site. The analysis of land use impacts focuses on the amount of land area that would be affected by the construction and operation of a nine-unit natural gas-fired combined-cycle power plant at the Salem and HCGS site.

Based on GEIS estimates, PSEG indicated that approximately 128 acres (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 396 acres (162 ha) would be required to replace the 3600 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 acres (5,400 ha) would be required for wells, collection stations, and a 25-mile 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, the Staff estimated that approximately 3,660 acres (1,480 ha) would not be needed for mining and processing uranium during the 40-year operating life of the plant. 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. Staff evaluated workforce requirements for construction and operation of the natural gas-fired power plant alternative 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 base would vary over time.

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 highly populated areas, 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. The area would experience a loss of approximately 1,070 to 1,480 permanent, 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 is, however, expected to be SMALL given the relatively large area from which Salem and HCGS personnel are currently drawn and the extensive timeframe over which construction of a new plant and decommissioning of the existing facility would occur. The gas-fired alternative would provide a new tax base in Lower Alloways Creek Township and Salem County to offset the loss of taxes that would occur assuming Salem and HCGS are decommissioned. While it is difficult to estimate the impact of this scenario on Lower Alloways Creek Township and Salem County resources, it would not be unreasonable to assume that, on balance, the township's and county's tax base would not be significantly altered and that resulting impacts could be best characterized as 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 construction, a peak workforce of between 2,900 and 4,300 workers would be commuting to the site, as well as the current 1,614 workers already at Salem and HCGS. In addition to commuting workers, trucks would transport construction materials and equipment to the worksite increasing the amount of traffic on local roads. The increase in vehicular traffic would peak during shift changes resulting in temporary 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. Transportation impacts are likely to be MODERATE during construction.

During plant operations, transportation impacts would be greatly reduced. According to PSEG, approximately 132 workers would commute to the Salem and HCGS site 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 use from plant operations. The gas-fired alternative would have a SMALL impact on transportation conditions in the region around the Salem and HCGS site 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 (60 m) and may be visible offsite in daylight hours. However, the gas-fired 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 mechanical draft tower would generate a condensate plume, which would be no more noticeable than the existing HCGS plume. Noise and light 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 impacts associated with the gas-fired alternative would likely be SMALL to MODERATE and noise impacts would likely be SMALL.

Historic and Archaeological Resources

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 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. For socioeconomic data regarding the analysis of environmental justice issues, the reader is referred to Section 4.9.7, Environmental Justice.

No environmental or human health impacts were identified that would result in disproportionately high and adverse environmental impacts on minority and low-income populations if a replacement gas-fired plant were built at the Salem and HCGS site. Some impacts on rental and other temporary housing availability and lease prices during construction might occur, and this could disproportionately affect low-income populations. Although the site is located in a rural area, it is near the Philadelphia and Wilmington metropolitan areas. Therefore, the demand for rental housing would be mitigated because workers would be likely to commute to the site from these areas instead of relocating closer to the construction site. Thus, the impact on minority and low-income populations would be SMALL.

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.

8.1.3 Combination Alternative

Even though individual alternatives to license renewal might not be sufficient on their own to replace the 3656 MWe 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 seven 400 MWe combined-cycle natural gas plants at Salem
- Obtaining 400 MWe from renewable energy sources (primarily offshore wind)
- Implementing 400 MWe of efficiency and conservation programs, from among the 3,300 MW of energy efficiency and conservation goals identified by the Northeast Energy Efficiency Partnerships (NEEP, 2009).

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. A summary of the impacts from the combined alternative option is presented in Table 8-3.

8.1.3.1 Impacts of Combination Alternative

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 2,800 MWe 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-mile 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 NRC staff has not yet addressed in any depth in this SEIS the impacts of wind power or conservation. A wind installation capable of yielding 400 MWe of capacity would likely entail placing wind turbines off of the New Jersey coast. A wind installation capable of delivering 400 MWe on average would require approximately 112 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 the NRC staff indicated in the GEIS (NRC, 1996). The primary concerns NRC staff identified in the GEIS related to indoor air quality and waste disposal. In the GEIS, NRC staff indicated that air quality appeared to become an issue when weatherization initiatives exacerbated existing problems, and were expected not to present significant effects. The NRC staff also indicated that waste disposal concerns related to energy-saving measures like fluorescent lighting could be addressed by recycling programs. The NRC staff considers the overall impact from conservation to be SMALL in all resource areas, though measures that provide weatherization assistance to low-income populations may have positive effects on environmental justice.

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. The construction and operation of the wind farm would have only minor impacts on air quality.

Overall, the NRC staff considers that the air quality impacts from the combination alternative would be SMALL.

Water Use and Quality

The primary water use and quality issues from this alternative would occur from the gas-fired units at Salem and HCGS. While construction impacts could occur from a wind farm, particularly if located offshore, these impacts are likely to short lived. An offshore windfarm is unlikely to located immediately adjacent to any water users, though construction may increase turbidity. An onshore wind farm could create additional erosion during construction, as would 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, however, and this would limit the effects on water resources. As the NRC 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 NRC 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.

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 (based on nine units) in Section 8.1.2.4. Therefore, ecological impacts would similarly be SMALL.

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 NRC assumes that the appropriate agencies would monitor and regulate such activities. Overall, the impacts to aquatic resources would be SMALL.

Based on data in the GEIS, an onshore wind farm component of the combination alternative producing 400 MWe of electricity would require approximately 24,400 ha (60,000 ac) 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 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.

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, and may impact threatened and endangered species. 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.

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 NRC staff concludes that the overall human health impact from the first combination alternative would be SMALL.

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 offsite land. In addition to onsite land requirements, land would be required offsite for natural gas wells and collection stations. The elimination of uranium fuel for the Salem and HCGS facilities could partially offset offsite land requirements. The land use impacts of the gas-fired component of the combination alternative would be expected to be similar to the impacts described in Sections 8.1.2.6, that is, 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 incur greater land use impacts than offshore facilities, simply because all towers and supporting infrastructure would be located on land. NRC observations provided in the GEIS indicate that onshore installations could require approximately 60,000 acres (24,400 ha), though turbines and infrastructure would actually occupy only a small percentage (less than 10 percent) of that land area. Land around wind installations could remain in use for activities like agriculture (a practice consistent with wind farm siting throughout the U.S.).

Although the offsite wind component of this alternative would require a large amount of land, only a small component of that land would be in actual use. Overall, the NRC staff considers that the land use impacts from the combination alternative would be SMALL to MODERATE.

Socioeconomics

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 associated construction workforce and number of operational workers, and the property taxes paid to the local jurisdiction, would be similar to the gas-fired alternative. Accordingly, the socioeconomic impacts from the gas-fired component of the combination alternative would be SMALL to MODERATE.

Socioeconomic impacts from the wind component of this alternative were evaluated based on construction and operations workforce requirements. Additional estimated construction workforce requirements for this combination alternative would include 300 workers for the wind farm. The number of additional workers would cause a short-term increase in demand for services and temporary (rental) housing in the region around the construction site(s). Following 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 would also experience increased vacancies and decreased prices. Considering the relatively low levels of employment associated with construction of this component of the combination alternative, the impact on socioeconomic conditions would be SMALL. Also, employment effects would likely be spread over a larger area, as the wind farms may be constructed in more than one location.

Additional estimated operations workforce requirements for the wind farm component of the combination alternative would include 50 workers. Given the small number of operations workers, socioeconomic impacts associated with operation of the wind farm would be SMALL.

Socioeconomics (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. Transportation impacts would be SMALL to MODERATE.

During plant operations, transportation impacts would lessen. Given the small numbers of operations workers at these facilities, overall operational impacts on levels of service 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 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. Aesthetic impacts, associated with visibility of the gas-fired units and exhaust stacks, and the existing HCGS cooling tower, would be SMALL to MODERATE. The impact associated with noise from plant operations, which may be detectable offsite, would be SMALL.

The wind farm component would have the greatest aesthetic effect of this combination alternative. Several hundred wind turbines at over 300 feet (100 m) in height and spread over 60,000 acres (24,400 ha) may dominate the view and, in the absence of larger topographic features, would be the major focus of viewer attention. The overall impact would depend on the sensitivity of the site. Therefore, overall aesthetic impacts from the construction and operation of a wind farm would be MODERATE, or LARGE if the wind farm is built at a site where aesthetics is an important element of the natural environment.

Historic and Archeological Resources

Onsite impacts to historical and cultural resources from the construction of a gas turbine plant are expected to be SMALL. The offsite impacts from the construction of a wind farm are also expected to be small given the opportunity to evaluate and select the sites in accordance with applicable regulations and the ability to minimize impacts before construction. Therefore, the NRC staff concludes that the overall impacts on historic and archeological resources from the first combination alternative would 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 power plant and a new wind farm, and from energy efficiency and conservation programs. No environmental or human health impacts were identified that would result in disproportionately high and adverse environmental impacts on minority and low-income populations if a replacement gas-fired plant were built at the Salem and HCGS site and a wind farm was built in the area. Some impacts on rental and other temporary housing availability and lease prices during construction may occur, and this could disproportionately affect low-income populations. The demand for rental housing would be mitigated because workers would be likely to commute to the construction sites from metropolitan areas in the region instead of relocating closer to the construction sites. Thus, the impact of the gas-fired and wind farm components of the combination alternative on minority and low-income populations would be SMALL.

Weatherization programs associated with the conservation component of this alternative 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. According to the Office of Management and Budget, low income populations experience energy burdens more than four times as large as those of average households (OMB, 2007). Impacts to minority and low-income populations from the energy efficiency and conservation programs component of this alternative, although dependent on program design and enrollment, would be SMALL.

Waste

The primary source of waste would be associated with the construction of the new gas turbine facility and the wind farm. Waste impacts could be substantial but likely not noticeably alter or destabilizing the resource during construction of the alternatives, 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 NRC staff concludes that the overall impact from waste from the first combination alternative would be SMALL.

Table 8-3 Summary of Environmental Impacts of Combination Alternative

Impact Category	Combination Alternative	
	Impact	**Comments**
Land Use	SMALL to MODERATE	Although the offsite wind farm component requires a la of land, only a small portion would be in actual use.
Ecology	SMALL to MODERATE	Impacts would be greatest to terrestrial resources from an onshore wind farm.
Water Use and Quality	SMALL	Minor impacts occur if the wind farm is located offshore.
Air Quality	SMALL	Air emissions of the gas-fired unit would be minor considering their size. A wind farm would not impact air quality.
Waste	SMALL	Waste volumes could be substantial during construction. Operational waste volumes would be SMALL
Human Health	SMALL	Occupational health and safety risks would be managed in accordance with applicable regulations.

Impact Category	Combination Alternative	
	Impact	Comments
Socioeconomics	SMALL to MODERATE	Most of the socioeconomic impacts are associated with the gas-fired component.
Socioeconomics (Transportation)	SMALL to MODERATE	Traffic impacts would be greater during construction, with minor impacts during operations.
Aesthetics	SMALL to LARGE	The greatest aesthetic effects are associated with the wind farm component.
Historic and Archeological Resources		
Environmental Justice	SMALL	Impacts would be similar to those experienced by the general population in the region.

8.1 ALTERNATIVES CONSIDERED BUT DISMISSED

In this section, the Staff presents the 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 Gas-Fired Capacity

While it is possible that coal- and 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). However, this could not 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). 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 or measures than 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 protected 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 kilowatt hour (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 acres (56,000 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 Waste

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 (NREL, 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 MWe. 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, NRC staff will not consider wind power as a stand-alone alternative to license renewal. However, given the potential for development of offshore resources, the NRC 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, 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 MWe, or an average of 29 MWe per plant (Energy Recovery Council, 2010). This includes five plants in New Jersey generating a total of 173 MWe. 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.

Table 8-4. Summary of 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 to MODERATE
Aquatic and Terrestrial Resources	SMALL	SMALL
Human Health	SMALL	SMALL
Socioeconomics	SMALL to LARGE	SMALL
Waste Management	SMALL	Not Applicable

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, 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 supplemental EIS, 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. Plant shutdown would eliminate approximately 1,614 jobs and would reduce tax revenue in the region. The loss of these contributions, which may not entirely cease until after decommissioning, could have a MODERATE impact within Salem County and a LARGE impact within Lower Alloways Creek Township, which receives approximately 57 percent of its total property tax revenue from Salem and HCGS. 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 reduced after plant shutdown. Most of the reduction in traffic volume would be associated with the loss of jobs at the facilities. Deliveries of materials and equipment to the plant would be reduced until decommissioning. Transportation impacts would be SMALL as a result of plant shutdown.

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 plant operation 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 townsip would range from MODERATE to LARGE should Salem and HCGS be shutdown and closed. Therefore, minority and low-income populations in the township could experience a disproportionately high and adverse socioeconomic impact 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.

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 on the following page.

Socioeconomic and groundwater impacts could 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.

In the Staff's professional opinion, the coal-fired alternative would have the greatest over all adverse environmental impact. This alternative would result in MODERATE waste management, land use, and air quality impacts. Its impacts upon socioeconomic and biological resources could range from SMALL to MODERATE. This alternative is not an environmentally preferable alternative due to air quality impacts from nitrogen oxides, sulfur oxides, particulate matter, PAHs, carbon monoxide, carbon dioxide, and mercury (and the corresponding human health impacts), as well as construction impacts to aquatic, terrestrial, and potential historic and archaeological resources.

With the exception of land use, socioeconomic, and air quality impacts, the gas-fired alternative would result in SMALL impacts. Socioeconomic, land use, and air quality impacts could 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 land use, 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 eliminate approximately 1,614 jobs and would reduce tax revenue in the region. The loss of these contributions, which may not entirely cease until after decommissioning, would have a MODERATE to LARGE impact. However, the no-action alternative does 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 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 to MODERATE	SMALL	SMALL	SMALL	SMALL
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

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

40 CFR Part 60. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 60, "Standards of Performance for New Stationary Sources."

40 CFR Part 51. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 51, "Requirements for Preparation, Adoption, and Submittal of Implementation Plans."

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

63 FR 49453, Revision of Standards of Performance for Nitrogen Oxide Emissions From New Fossil-Fuel Fired Steam Generating Units. September 16, 1998.

64 FR 35714, Regional Haze Regulations. July 1, 1999.

American Wind Energy Association (AWEA). 2010. U.S. Wind Energy Projects, New Jersey, Delaware, and Pennsylvania. Available URL: http://www.awea.org/projects/Projects.aspx?s=New+Jersey (Accessed April 16, 2010).

Energy Information Administration (EIA). 2009a. *Annual Energy Outlook 2009 With Projections to 2030.* DOE/EIA 0383(2009). Washington, D.C. Available URL: http://www.eia.doe.gov/oiaf/aeo/pdf/0383(2009).pdf (accessed April 15, 2010).

EIA. 2009b. Table A4. Approximate Heat Content of Natural Gas, 1949–2008 (Btu per Cubic Foot). Available URL: http://www.eia.doe.gov/emeu/aer/txt/ptb1304.html (accessed April 15, 2010).

EIA. 2010a. *Electric Power Annual with data for 2008.* Available URL: http://www.eia.doe.gov/cneaf/electricity/epa/epates.html (accessed April 12, 2010).

EIA. 2010b. *Cost and Quality of Fuels for Electric Plants 2007 and 2008.* DOE/EIA-0191(2008). Available URL: http://www.eia.doe.gov/cneaf/electricity/cq/cqa2008.pdf (Accessed April 12, 2010).

Energy Recovery Council. 2010. The 2007 IWSA Directory of Waste-to-Energy Plants. Available URL: http://www.energyrecoverycouncil.org/userfiles/file/IWSA_2007_Directory.pdf (Accessed April 15, 2010).

Environmental Protection Agency (EPA). 1998. *Compilation of Air Pollutant Emission Factors*, Volume 1: *Stationary Point and Area Sources*: AP 42, Fifth Edition. "Section 1.1: Bituminous and Subbituminous Coal Combustion: Final Section Supplement E." Washington, D.C.

EPA. 2000a. "Regulatory Finding on the Emissions of Hazardous Air Pollutants from Electric Utility Steam Generating Units." *Federal Register*, Vol. 65, No. 245, pp. 79825–79831. Washington, D.C. December 20, 2000.

EPA. 2000b. "Notice of Regulatory Determination on Wastes from the Combustion of Fossil Fuels." *Federal Register*, Vol. 65, pp.32214–32237. Washington, D.C.

EPA. 2000c. Emissions Factors & AP 42. Available URL: http://www.epa.gov/ttn/chief/ap42/ch03/final/c03s01.pdf. (Accessed April 15, 2010).

EPA. 2006. *Final report: Environmental Footprints and Costs of Coal-Based Integrated Gasification Combined Cycle and Pulverized Coal Technologies.* EPA-430/R-06/006. July, 2006. Available URL: http://www.epa.gov/air/caaac/coaltech/2007_01_epaigcc.pdf (Accessed April 15, 2010).

EPA. 2009a. Clean Air Mercury Rule. Available URL: http://www.epa.gov/mercuryrule/ (Accessed April 17, 2010).

EPA. 2009b. Proposed Mandatory Greenhouse Gas Reporting Rule. Available URL: http://www.epa.gov/climatechange/emissions/ghgrulemaking.html (Accessed April 15, 2010).

EPA. 2010. Clean Air Interstate Rule: New Jersey. Available URL: http://www.epa.gov/CAIR/nj.html (accessed April 5, 2010).

GE Power Systems (GE). 2001. "Advanced Technology Combined Cycles." May 2001.

Geo-Heat Center (GHC). 2008. U.S. Geothermal Projects and Resource Areas. Available URL: http://geoheat.oit.edu/dusys.htm (Accessed April 16, 2010.

Idaho National Engineering and Environmental Laboratory (INEEL). 1996. "U.S. Hydropower Resource Assessment for New Jersey." DOE/ID-10430(NJ). Available URL: http://hydro2.inel.gov/resourceassessment/pdfs/states/nj.pdf (Accessed April 15, 2010).

INGAA Foundation. 2008. *Implications of Reduced Gas Use on Emissions from Power Generation.* Available URL: http://www.ingaa.org/File.aspx?id=282 (Accessed April 15, 2010).

Minerals Management Service (MMS). 2010. *Renewable Energy Program, Cape Wind project, Project Overview.* Available URL: http://www.mms.gov/offshore/RenewableEnergy/CapeWind.htm (Accessed April 16, 2010).

National Energy Efficiency Partnerships (NEEP). 2009. *An Energy Efficiency Strategy for New Jersey: Achieving the 2020 Master Plan Goals.* Available URL: http://neep.org/uploads/About%20NEEP/News%20Media/an-energy-efficieny-plan-for-nj.pdf (Accessed April 16, 2010).

National Renewable Energy Laboratory (NREL). 2005. *A Geographic Perspective on the Current Biomass Resources Availability in the United States.* Technical Report NREL/TP-560-39181. December 2005. Available URL: http://www.nrel.gov/docs/fy06osti/39181.pdf (Accessed April 16, 2010).

NREL. 2010. "United States Atlas of Renewable Resources." Interactive Map. Available URL: http://mapserve2.nrel.gov/website/Resource_Atlas/viewer.htm (accessed April 15, 2010).

New Jersey Department of Environmental Protection (NJDEP). 2009a. *State Implementation Plan for Regional Haze.* Available URL: http://www.state.nj.us/dep/baqp/2008%20Regional%20Haze/Complete%20Regional%20Haze%20SIP.pdf (Accessed April 15, 2010).

NJDEP. 2009b. *Large Scale Wind Turbine Siting Map Report.* Available URL: http://www.state.nj.us/dep/landuse/forms/wind_report090908f.pdf (Accessed April 16, 2010).

PSEG Nuclear, LLC (PSEG). 2009a. Salem Nuclear Generating Station, License Renewal Application, Appendix E – Applicant's Environmental Report – Operating License Renewal Stage, Salem Nuclear Generating Station. July 2009. ADAMS Accession No. ML092400532.

PSEG 2009b. Hope Creek Generating Station, License Renewal Application, Appendix E – Applicant's Environmental Report – Operating License Renewal Stage, Hope Creek Generating Station. July 2009. ADAMS Accession No. ML092430389.

PSEG 2010. PSEG Response to NRC Audit Question #ENV-106.

PJM Interconnection Association (PJM). 2009. *Regional Transmission Expansion Plan.* Available URL: http://www.pjm.com/documents/reports/rtep-report.aspx (Accessed April 16, 2010).

State of New Jersey. 2006. *Blue Ribbon Panel on Development of Wind Turbine Facilities in Coastal Waters, Final Report.* April 2006. Available URL: http://www.state.nj.us/njwindpanel/docs/finalwindpanelreport.pdf (Accessed April 16, 2010).

State of New Jersey. 2008. *New Jersey Energy Master Plan.* Available URL: http://www.nj.gov/emp/docs/pdf/081022_emp.pdf (Accessed April 16, 2010).

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

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, Vol. 1, Add. 1. Washington, D.C.

NRC. 2002. *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities: Supplement 1, Regarding the Decommissioning of Nuclear Power Reactors.* NUREG-0586, Supplement 1, Vols. 1 and 2. Washington, D.C.