Klementowicz, Stephen

From: Imboden, Andy
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To: Imboden, Andy; Travers, Allison; Beissel, Dennis; Logan, Dennis; Rikhoff, Jeffrey; Moser, Michelle; Perkins, Leslie; Bulavinetz, Richard; Klementowicz, Stephen; Davis (FSME), Jennifer; Folk, Kevin; Susco, Jeremy; Perkins, Leslie; Pham, Bo; Cooper, Paula; Doyle, Daniel; Balsam, Briana
Subject: Salem/Hope Creek afternoon of excellence - Chapter 4 Attached
Attachments: Chapter 4 -V 3 FINAL (2).docx

For Tuesday's meeting we will all be working off of this version of Chaper 4:

I know there are some differences between the roles below and the roles that were established at project's beginning. However, circumstances dictate a bit of a shake-up...

1) Roles and Responsibilities
    a. PM's – version control and tracking
    b. RERBers
        i. Aquatic – Logan/Moser
        ii. Terrestrial – Balsam/Bulavinetz
        iii. Radiological – Klementowicz
        iv. Cultural/Historic – Travers/Davis
        v. Socio/EJ/Land Use – Rikhoff/BeBault
        vi. Hydrology – Beissel/Folk
        vii. Air/Meteorology – Imboden/Folk

D-152

4.0 ENVIRONMENTAL IMPACTS OF OPERATION

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

4.1 Land Use

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

4.2 Air Quality

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

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

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

4.3 Ground Water

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

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

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

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

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

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

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

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

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

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

The reason for the declining water levels in the Upper PRM Aquifer in the 2000s cannot be determined from the limited data set, but they could indicate that long-term production is resulting in dewatering of the aquifer, which could potentially cause groundwater use conflicts. The results could also be due to continuing development of the cone of depression for the withdrawal system before it stabilizes, to long-term precipitation trends that are not associated with production, or to the limited duration of the monitoring period.

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

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

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

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

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

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

4.4 Surface Water

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

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

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

4.5 Aquatic Resources

4.5.1 Categorization of Aquatic Resources Issues

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

Table 4-5. Aquatic Resources Issues.

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

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

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

Category 1 issues, the GEIS concluded that the impacts are SMALL, and additional site-specific mitigation measures are not likely to be warranted.

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

4.5.2 Entrainment of Fish and Shellfish in Early Life Stages

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

Regulatory Background

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

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

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

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

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

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

Entrainment Studies

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

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

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

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

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

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

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

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

2001; PSEG, 2002; PSEG, 2003; PSEG, 2004; PSEG, 2005; PSEG, 2006b; PSEG, 2007a; PSEG, 2008a; PSEG, 2009c).

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

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

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

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

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

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

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

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

where

M_T = total entrainment mortality rate

M_n = nonthermal mortality rate

M_n = thermal mortality rate

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

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

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

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

where

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

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

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

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

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

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

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

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

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

F_i = estimated total entrainment density on the i th day

R = recirculation factor

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

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

where

E = entrainment (number of organisms)

i = i^{th} water system, i.e., Unit 1 CWS, Unit 1 SWS, Unit 2 CWS, and Unit 2 SWS

j = j^{th} day of the year

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

C = collection efficiency

F_{ij} = daily through-plant mortality

R = recirculation factor

Q_y = average daily plant flow for i^{th} water system (m^3)

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

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

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

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

Entrainment Reductions

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

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

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

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

(1) Silversides were not identified to species.

Source: NJPDES Application (PSEG, 1999a).

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

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

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

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

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

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

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

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

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

Common Name	Scientific Name	Average Density (n/100 m³)
Threespine stickleback	*Gasterosteus aculeatus*	0.01
Atlantic needlefish	*Strongylura marina*	0.01
Unidentifiable		0.01
Blackcheek tonguefish	*Symphurus plagiusa*	0.01
Oyster toadfish	*Opsanus tau*	0.01
Common carp	*Cyprinus carpio*	0.01
American shad	***Alosa sapidissima***	**0.01**
Striped cusk-eel	*Ophidion marginatum*	0.01
Windowpane	*Scophthalmus aquosus*	0.004
Green goby	*Microgobius thalassinus*	0.004
Northern puffer	*Sphoeroides maculatus*	0.004
Feather blenny	*Hypsoblennius hentz*	0.004
American sand lance	*Ammodytes americanus*	0.004
Bluefish	***Pomatomus salatrix***	**0.003**
Unidentifiable juvenile		0.003
Striped searobin	*Prionotus evolans*	0.003
Conger eel	*Conger oceanicus*	0.003
Inshore lizardfish	*Synodus foetens*	0.003
Unidentifiable drum	Sciaenidae	0.003
Eastern silvery minnow	*Hybognathus regius*	0.003
Perches	Percidae	0.003
Northern kingfish	*Menticirrhus saxatilis*	0.003
Bluegill	*Lepomis macrochirus*	0.002
Banded killifish	*Fundulus diaphanus*	0.002
Unidentifiable sucker	Catostomidae	0.002
Striped anchovy	*Anchoa hepsetus*	0.002
Northern stargazer	*Astroscopus guttatus*	0.002
White crappie	*Pomoxis annularis*	0.002
Tautog	*Tautoga onitis*	0.002
Unidentifiable porgy	Sparidae	0.001
Spanish mackerel	*Scomberomorus maculatus*	0.001
Black sea bass	*Centropristis striata*	0.001
Sheepshead minnow	*Cyprinodon variegauts*	0.001
Striped killifish	*Fundulus majalis*	0.001
Unidentifiable sunfish	Centrarchidae	0.001
White sucker	*Catostomus commersoni*	0.001
Channel catfish	*Ictalurus punctatus*	0.001

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

(2) Average density expressed as number of organisms entrained (n) per 100 cubic meters (m³) of water withdrawn through the intake screens.

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

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

	Density (n/100 m³)														
Taxon	1978	1979	1980	1981	1982	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Alewife	–	–	0.03	–	–	–	0.01	–	0.01	–	–	–	–	–	–
Alosa sp.	–	–	–	–	–	–	–	–	–	0.14	0.01	–	0.02	0.15	0.11
American shad	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Atlantic croaker	0.10	0.02	0.02	1.24	–	0.02	0.07	–	0.07	2.76	0.72	3.47	2.51	2.71	1.19
Atlantic menhaden	–	0.02	0.25	1.13	0.27	–	–	–	–	–	–	–	–	–	–
Atlantic silverside	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Bay anchovy	349.64	1848.55	845.68	706.22	148.12	1799.26	2527.17	2094.53	618.68	314.27	243.26	416.78	111.59	416.25	27.22
Blueback herring	0.06	–	0.07	0.12	–	0.03	–	–	0.04	–	–	–	–	–	–
Blueback herring/alewife	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Morone sp.	–	–	–	–	–	–	–	–	–	0.21	0.01	–	0.03	0.90	0.01
Bluefish	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Silversides	6.32	15.33	4.77	4.04	0.86	–	–	–	–	–	–	–	–	–	–
Spot	0.07	0.10	1.53	0.86	3.69	0.04	0.01	–	1.64	0.02	0.16	0.09	–	0.01	1.17
Striped bass	0.05	–	–	–	–	–	–	–	–	1.87	0.01	0.03	0.06	3.63	0.29
Weakfish	16.31	3.35	5.15	1.20	2.63	1.77	4.50	3.09	1.11	0.08	0.28	1.43	0.25	1.91	2.46
White perch	–	–	0.09	–	0.26	–	0.01	0.01	0.10	4.16	0.03	0.01	0.07	0.46	0.81
White perch/striped bass	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

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

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

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

4.5.3 Impingement of Fish and Shellfish

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

Regulatory Background

Impingement and entrainment are both regulated by Section 316(b) of the CWA through the NPDES permit renewal process. A history of NPDES permitting at Salem can be found in Section 4.5.2 under the heading Regulatory Background.

Impingement Studies

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

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

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

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

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

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

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

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

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

Source: PSEG, 1984.

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

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

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

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

Source: PSEG, 1999a.

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

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

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

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

Source: PSEG, 2006a.

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

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

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

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

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

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

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

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

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

(2) Average density expressed as number of fish impinged (n) per million (10^6) cubic meters (m^3) of water withdrawn through the intake screens.

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

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

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

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

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

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

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

Impingement Reductions

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

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

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

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

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

		Original Screens		Modified Screens	
Taxon	**Month**	**1978-1982**	**1995**	**1995**	**1997-1998**
Weakfish	June	39	33	17	79
	July	51	31	18	82
	August	52	51	25	38
	September	40	-	-	12
	October	53	-	-	-
White perch	January	13	-	-	-
	February	16	-	-	-
	March	12	-	-	-
	April	15	-	-	7
	October	21	-	-	-
	November	16	-	-	7
	December	8	-	-	2
Bay anchovy	April	-	-	-	54
	May	81	-	-	55
	June	89	-	-	78
	July	90	-	-	80
	August	85	-	-	-
	September	72	-	-	-
	October	65	-	-	35
	November	32	-	-	28
Atlantic croaker	April	-	-	-	42
	May	-	-	-	34
	June	-	-	-	28
	July	-	-	-	35
	October	-	-	-	5
	November	-	-	-	2
	Dec-Jan	49	-	-	15
Spot	June	31	-	-	-
	July	48	-	-	-
	August	47	-	-	-

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

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

4.5.4 Heat Shock

Heat shock is defined as "acute thermal stress caused by exposure to a sudden elevation of water temperature that adversely affects the metabolism and behavior of fish and can lead to death" (NRC, 2009a). Heat shock can occur at power plants when the cooling water discharge elevates the temperature of the surrounding water.

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

Regulatory Background

The Delaware River Basin Commission (DRBC) is a federal interstate compact agency charged with managing the water resources of the Delaware River Basin without regard to political boundaries. It regulates water quality in the Delaware River and Delaware Estuary through DRBC Water Quality Regulations, including temperature standards. The temperature standards for Water Quality Zone 5 of the Delaware Estuary, where the Salem discharge is located, state that the temperature in the river outside of designated heat dissipation areas (HDAs) may not be raised above ambient by more than 4 degrees Fahrenheit (°F; 2.2 degrees Celsius [°C]) during non-summer months (September through May) or 1.5°F (0.8°C) during the summer (June through August), and a maximum temperature of 86°F (30.0°C) in the river cannot be exceeded year-round (DRBC, 2001; DRBC, 2008). HDAs are zones outside of which the DRBC temperature-increase standards shall not be exceeded. HDAs are established on a case-by-case basis. The thermal mixing zone requirements and HDAs that had been in effect for Salem since it initiated operations in 1977 were modified by the DRBC in 1995 and again in 2001 (DRBC, 2001), and the 2001 requirements were included in the 2001 NJPDES permit. The HDAs at Salem are seasonal. In the summer period (June through August), the Salem HDA extends 25,300 ft (7,710 m) upstream and 21,100 ft (6,430 m) downstream of the discharge and does not extend closer than 1,320 ft (402 m) from the eastern edge of the shipping channel. In the non-summer period (September through May), the HDA extends 3,300 ft (1,000 m) upstream and 6,000 ft (1,800 m) downstream of the discharge and does not extend closer than 3,200 ft (970 m) from the eastern edge of the shipping channel (DRBC, 2001).

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

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

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

Characteristics of the Thermal Plume

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

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

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

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

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

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

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

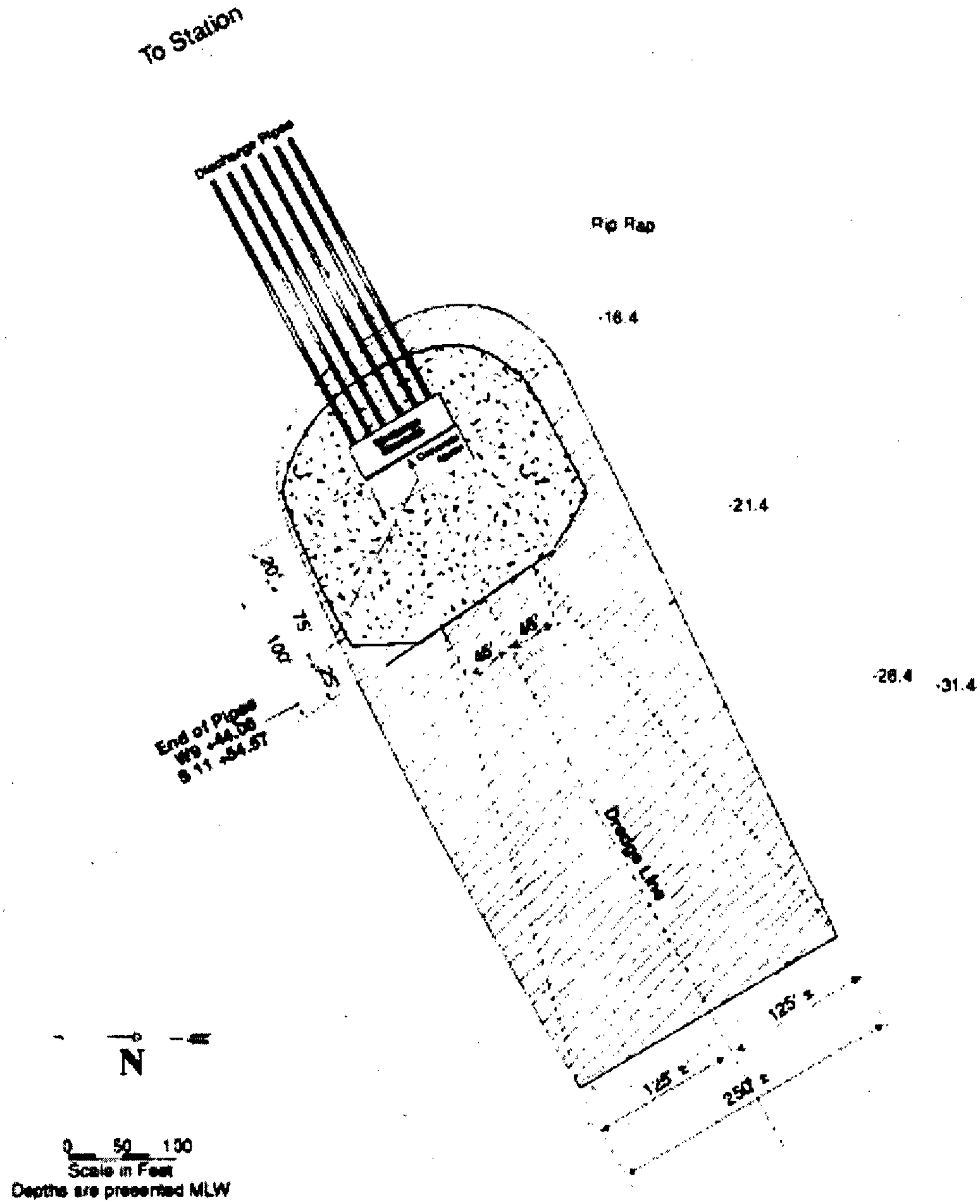


Figure 4-1. Plan View of Salem discharge pipes (Source: PSEG, 1999c).

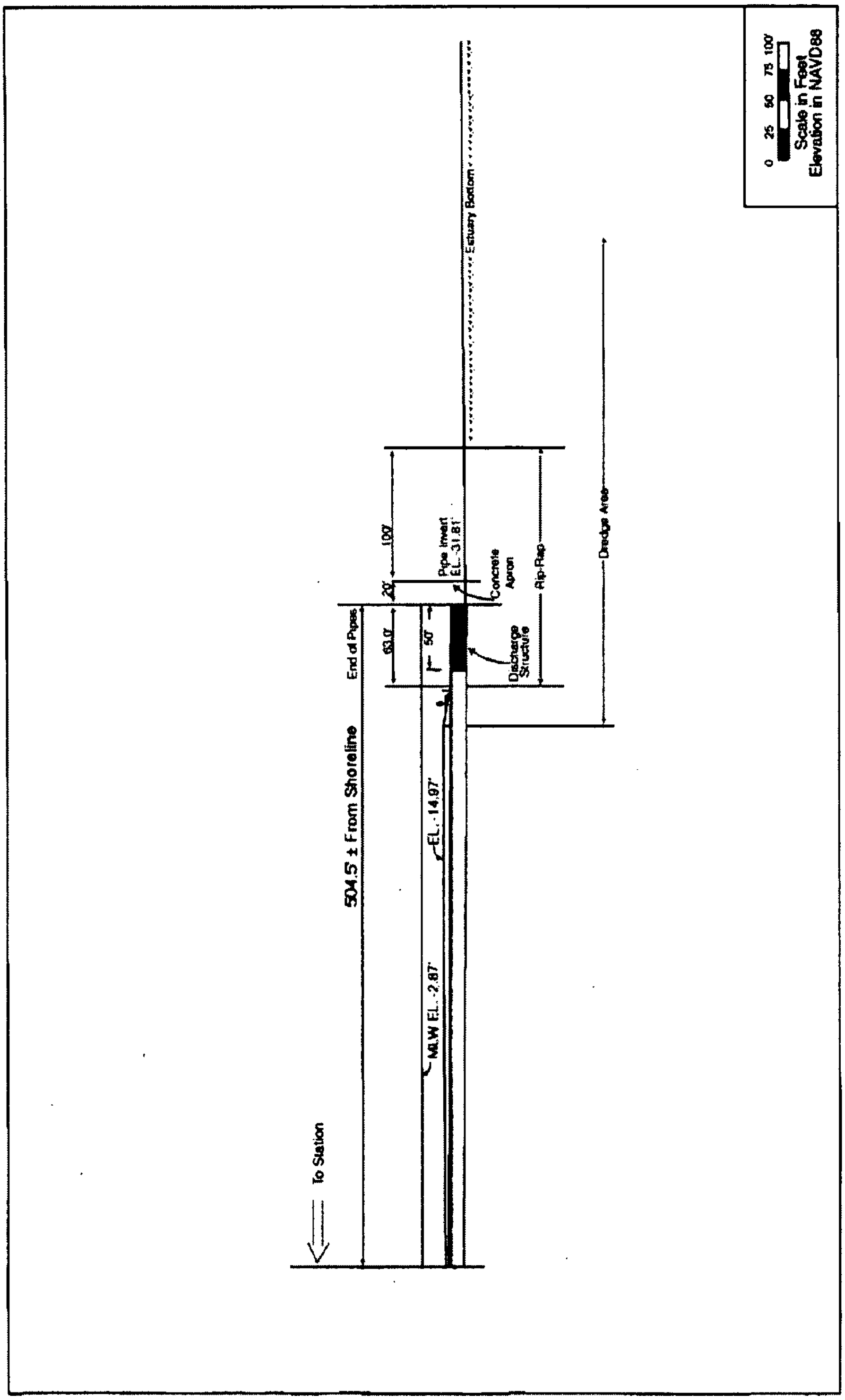


Figure 4-2. Section View of Salem discharge pipes (Source: PSEG, 1999c).

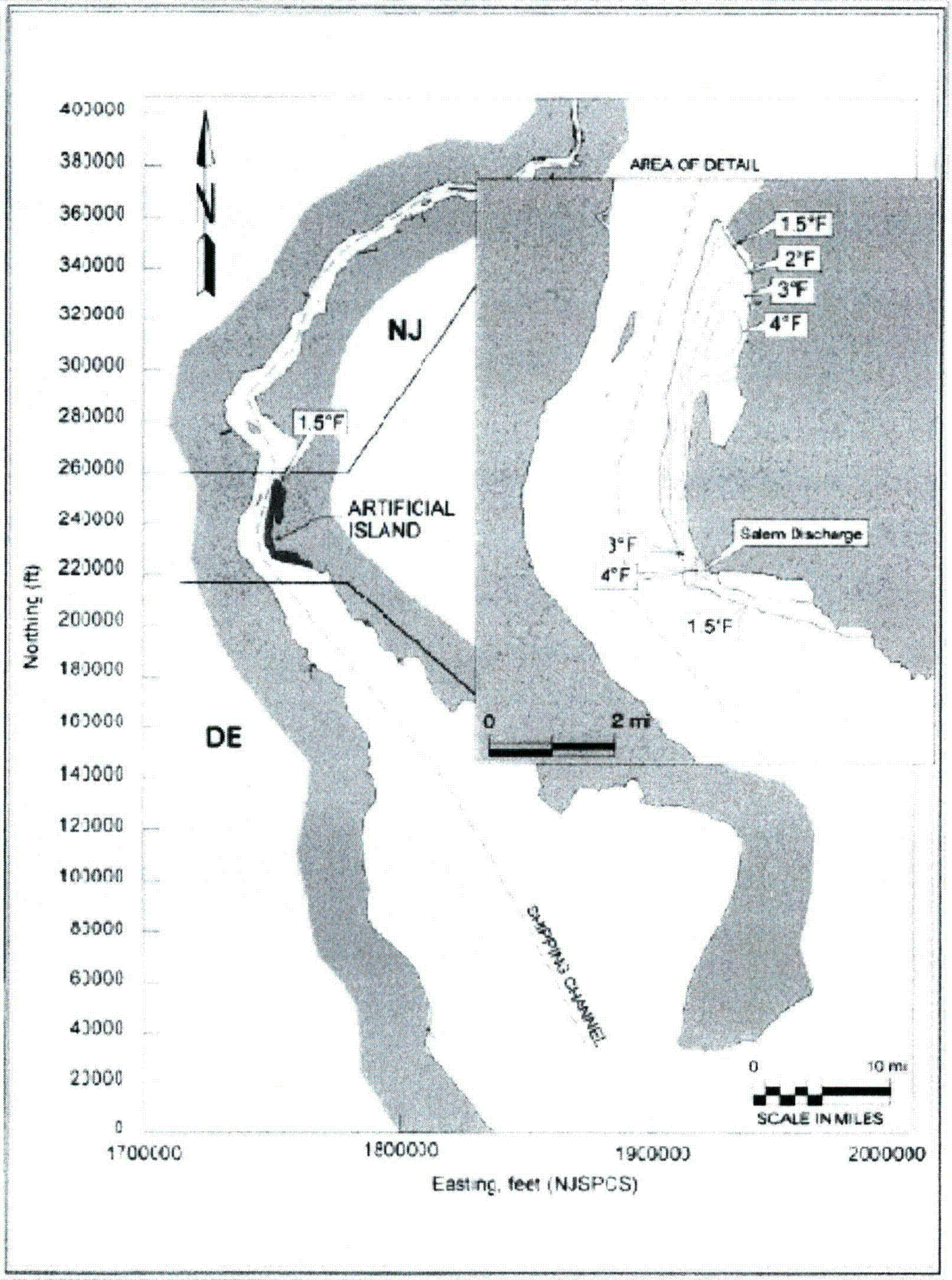


Figure 4-3. Surface ΔT isotherms for Salem's longest plume at the end of flood on May 31, 1998 (Source: PSEG, 1999c).

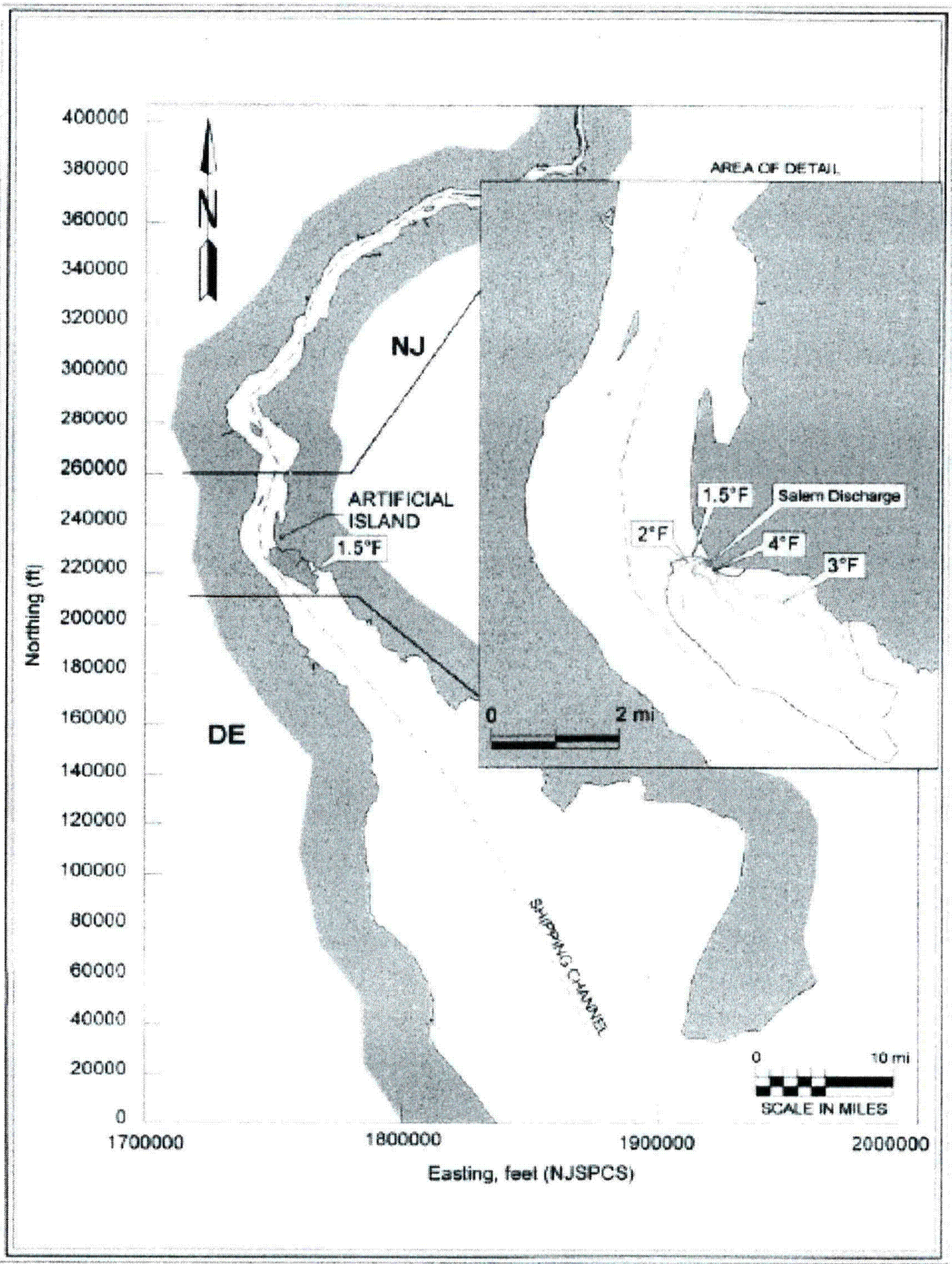


Figure 4-4. Surface ΔT isotherms for Salem at the end of ebb on June 2, 1998 (Source: PSEG, 1999c).

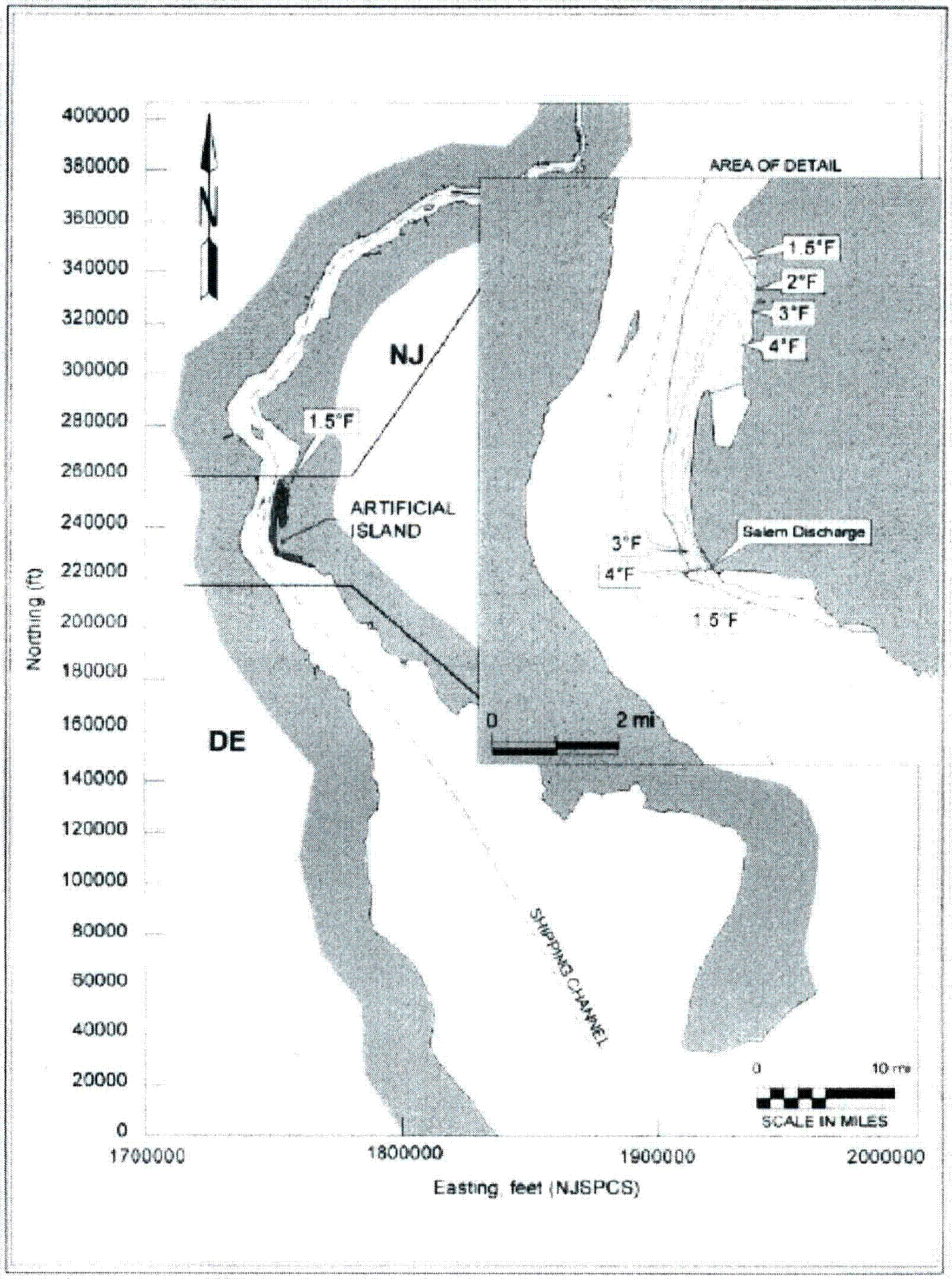


Figure 4-5. Bottom ΔT isotherms for Salem's longest plume at the end of the flood on May 31, 1998 (Source: PSEG, 1999c).

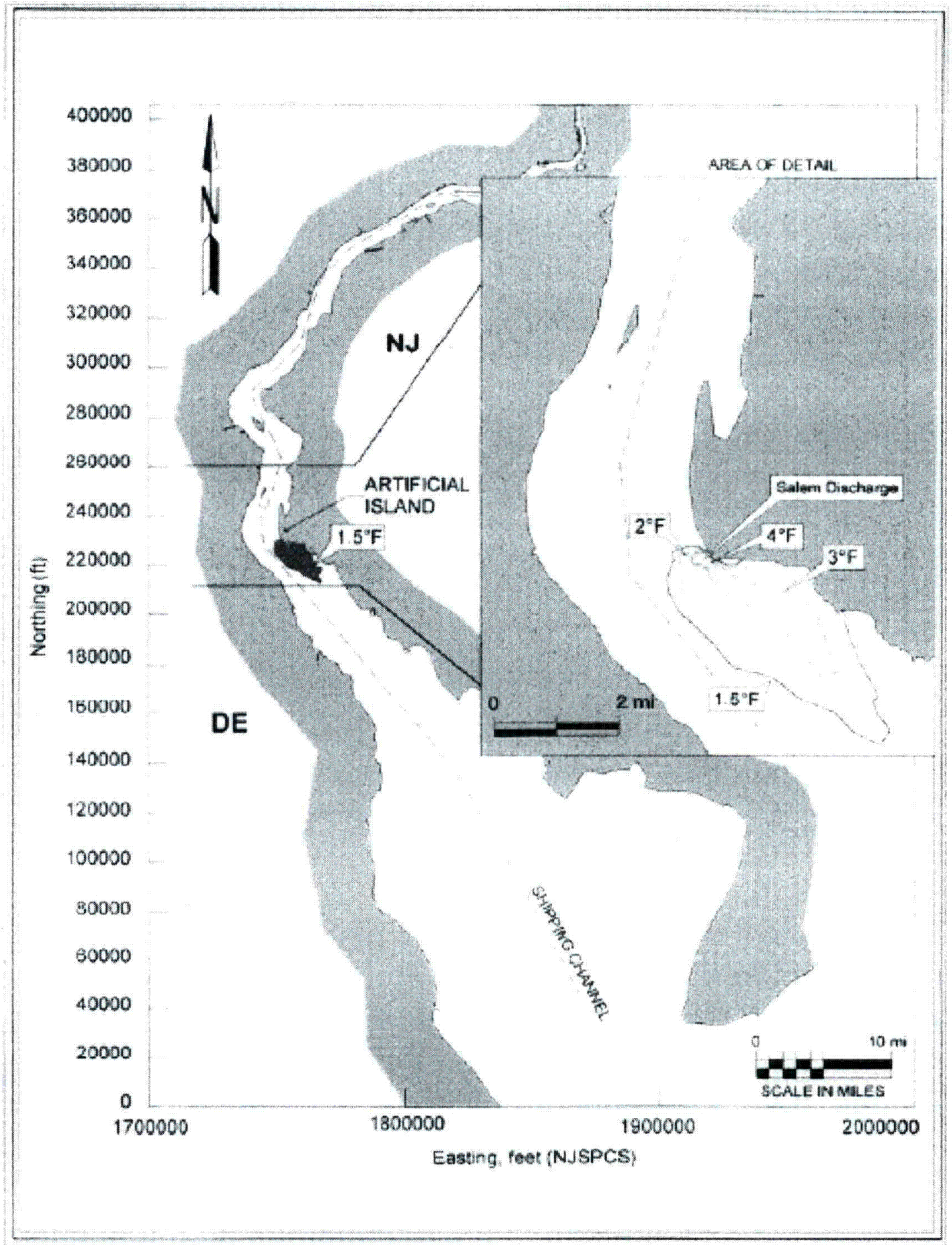


Figure 4-6. Bottom ΔT isotherms for Salem at the end of the ebb on June 2, 1998 (Source: PSEG, 1999c).

Thermal Discharge Studies

Extensive studies were conducted at Salem between 1968 and 1999 to determine the effects of the thermal plume on the biological community of the Delaware Estuary. Initial studies were conducted in 1968 to determine the location and design for the outfall that would best minimize the potential for adverse environmental effects. Several hydrothermal and biothermal studies subsequently have been conducted in support of requests for variance from thermal discharge limitations pursuant to Section 316(a). The Section 316(a) Demonstrations from 1974 through 1979 evaluated information on the life history, geographical distribution, and thermal tolerances of the RIS compared to the characteristics of the projected thermal plume. Supplements included information on the potential for Salem's thermal plume to promote the presence of undesirable organisms; use of the area in the vicinity of the Salem facility as spawning and nursery habitat; attraction of fish to the thermal plume and the potential for cold shock; effects of thermal plume entrainment on ichthyoplankton and zooplankton; effects of the plume on migration of anadromous fishes; and effects of the thermal plume on macroinvertebrates, such as blue crabs, oysters (*Crassostrea virginica*), and shipworms (Teredinidae), and other benthos (PSEG, 1975).

In 1995, PSEG applied to the DRBC for revision of the Salem Docket to provide seasonal HDAs to assure compliance with DRBC's water quality regulations. PSEG used mathematical modeling and statistical analyses to characterize the maximum size of the summer thermal plume (June through August) and non-summer thermal plume (September through May) in terms of the 24-hr average ΔT between the thermal plume and ambient water temperatures. PSEG also updated the information collected on the thermal tolerances, preferences, and avoidances of the RIS and conducted an evaluation of the potential for the thermal plume to have adverse effects on these species. The assessment indicated that Salem's thermal plume and the proposed HDAs would not have the potential to adversely affect aquatic life or recreational uses in the Delaware Estuary, and the DRBC granted the requested HDAs (PSEG, 1999c).

In 1999 PSEG submitted an application to renew the NJPDES permit for Salem, and the Section 316(a) Demonstration included provided another thermal plume characterization, biothermal assessment, and detailed analysis of the potential effects of Salem's thermal plume on the aquatic community. NJDEP reviewed this Section 316(a) Demonstration, determined that a "thermal discharge at the Station, which does not exceed a maximum of 115 °F, is expected to assure the protection and propagation of the balanced indigenous population," and included a Section 316(a) variance in Salem's 2001 NJPDES permit (NJDEP, 2001).

The 1999 Section 316(a) Demonstration includes the most detailed and most recent evaluation of the potential effects of the thermal discharge on the aquatic environment near Salem. This evaluation includes a four-part assessment of the potential for the discharge to negatively affect the balanced indigenous community of the Delaware Estuary, including consideration of the following factors: (1) the vulnerability of the aquatic community to thermal effects; (2) the potential for the survival, growth, and reproduction of the RIS to be affected; (3) the potential for effects of other pollutants to be increased by heat; and (4) evidence of prior appreciable harm from the thermal discharge (PSEG, 1999c).

Conclusions of the vulnerablity analysis indicate that the location and design of Salem's discharge minimize the potential for adverse environmental effects. The high exit velocity produces rapid dilution, which limits high temperatures to relatively small areas in the zone of initial mixing in the immediate vicinity of the discharge. Fish and other nektonic organisms are essentially excluded from these areas due to high velocities and turbulence. The offshore location and rapid dilution of the thermal discharge also places the highest temperature plumes in an area of the Estuary where productivity is lowest (PSEG, 1999c).

The RIS evaluation in the 1999 Section 316(a) Demonstration included an assessment of the potential for the thermal plume to adversely affect survival, growth, and reproduction of the selected RIS. The RIS included alewife (*Alosa pseudoharengus*), American shad (*Alosa sapidissima*), Atlantic croaker (*Micropogonias undulatus*), bay anchovy (*Anchoa mitchilli*), blueback herring (*Alosa aestivalis*), spot (*Leiostomus xanthurus*), striped bass (*Morone saxatilis*), weakfish (*Cynoscion regalis*), white perch (*Morone americana*), blue crab (*Callinectes sapidus*), opossum shrimp (*Neomysis americana*), and scud (*Gammarus daiberi, G. fasciatus, G. tigrinus*). For each of the RIS, temperature requirements and preferences as well as thermal limits were identified and compared to temperatures in the thermal plume to which these species may be exposed (PSEG, 1999c).

This biothermal assessment concluded that Salem's thermal plume would not have substantial effects on the survival, growth, or reproduction of the selected species from heat-induced mortality. Scud, blue crab, and juvenile and adult American shad, alewife, blueback herring, white perch, striped bass, Atlantic croaker, and spot have higher thermal tolerances than the temperature of the plume in areas where their swimming ability would allow them to be exposed. Juvenile and adult weakfish and bay anchovy could come into contact with plume waters that exceed their tolerances during the warmer months, but the mobility of these organisms is expected to allow them to avoid contact with these temperatures (PSEG, 1999c).

The biothermal assessment also concluded that less-mobile organisms, such as scud, juvenile blue crab, and fish eggs, would not be likely to experience mortality from being transported through the plume. American shad, alewife, blueback herring, white perch, striped bass, Atlantic croaker, spot, and weakfish are not likely to spawn in the vicinity of the discharge. Scud, juvenile blue crab, and eggs and larvae that do occur in the vicinity of the discharge have higher temperature tolerances than the maximum temperature of the centerline of the plume in average years. Opossum shrimp, weakfish, and bay anchovy may experience some mortality during peak summer water temperatures in warm years (approximately 1 to 3 percent of the time) (PSEG, 1999c).

Interactions of heat with other pollutants were also evaluated in the 1999 Section 316(a) Demonstration. The assessment concluded that the thermal plume has no observable effects on the dissolved oxygen level near the Salem discharge. In addition, the assessment indicates that there is no potential for plume interaction with other contaminants in the Estuary from other industrial, municipal, or agricultural sources such as polycarbonated biphenyols (PCBs), dichlorodiphenyltrichloroethane (DDT), dieldrin, polycyclic aromatic hydrocarbons (PAHs), tetrachloroethene (PCE), dichloroethene (DCE), and copper due to the low concentrations of such contaminants in the vicinity of Salem (PSEG, 1999c).

As part of the 1999 Section 316(a) Demonstration, an analysis of the biological community in the Delaware Estuary was conducted to determine whether there has been evidence of changes within the community that could be attributable to the thermal discharge at Salem. PSEG concluded that observed changes in the species composition or overall abundance in organisms in the estuary since Salem began operation are within the range expected to occur as a result of natural variation or changes in water quality. PSEG found no indications of increases in populations of nuisance species or stress-tolerant species, and it found statistically significant increases in the abundance of juveniles for almost all species of RIS evaluated. PSEG concluded that a declining trend for blueback herring was a coast-wide trend and not related to Salem's operation (PSEG, 1999c).

4.5.5 Total Impact on Aquatic Resources

The principal means by which the Salem facility may affect aquatic resources of the Delaware Estuary are the processes of entrainment and impingement of organisms at the cooling water intake and the discharge of thermal effluent. These processes simultaneously and cumulatively affect the aquatic community of the estuary, so assessment of their collective impacts is warranted. Because the Salem facility has been operating for more than 30 years, the total impacts of its operation are integrated and reflected in the condition of the ecosystem of the estuary. In addition, HCGS has been operating for over 23 years and, although its use of water from the estuary is substantially less than Salem, it contributes incrementally to the impacts discussed herein. By evaluating total impacts from the historical, long-term operation of these facilities and the beneficial effects of ongoing restoration activities, total impacts on the estuary from future operation during the relicensing period can be assessed.

Impact Assessment

PSEG prepared an assessment of Adverse Environmental Impact for the Salem facility as part of its 2006 NJPDES application (PSEG, 2006a). The assessment analyzed the composition of the fish community in the vicinity, trends in the relative abundance of the RS, and the long-term sustainability of fish stocks in the Delaware Estuary. The assessment demonstrated that the Salem cooling water intake has not caused and is unlikely to cause in the future substantial harm to the sustainability of populations of important aquatic species, including threatened or endangered species, or to the structure and function of the ecosystem in the Delaware Estuary (PSEG, 2006a).

PSEG (2006a) calculated estimates of production lost due to impingement and entrainment at Salem for the 13 RS, or target species, of PSEG's monitoring program (i.e., American shad, alewife, Atlantic croaker, Atlantic menhaden, Atlantic silverside, bay anchovy, blueback herring, bluefish, spot, striped bass, weakfish, white perch, and blue crab). These species make up more than 98 percent of the age-0 biomass lost to impingement and entrainment. Production lost was calculated using data on biomass lost to impingement and entrainment from 2002 through 2004 and adding projections of production foregone for those organisms through the first year of life. Production foregone was projected using literature estimates of growth rates. Biomass lost to impingement and entrainment was estimated to be 138,057 pounds (lbs) wet weight/year (yr; 62,623 kilograms [kg] wet weight/yr). Production forgone was estimated to be 4,664,837 lbs wet weight/yr (2,115,970 kg wet weight/yr). Production lost was therefore estimated to be 4,802,894 lbs wet weight/yr (2,178,593 kg wet weight/yr). Production lost was also calculated separately for river herring to facilitate direct comparisons of loss to production gained from restoration activities (fish ladders). The production of river herring foregone due to impingement and entrainment losses was estimated to be 6,093 lbs wet weight/yr (2,764 kg wet weight/yr) (PSEG, 2006a).

PSEG (2006a) analyzed data on the composition of the fish community in the Delaware Estuary over the period from 1970 through 2004 to estimate species richness and species density. Species richness is the number of species present in a community regardless of the area analyzed; species density is the number of species per unit of area or volume. Nearfield sampling using a 16-ft (4.9 m) bottom trawl was conducted in most years since 1970. Bottom trawl data from 1970 to 1977, the pre-operational period, were compared to data from 1986 to 2004, the operational period. Species richness and density in the vicinity of Salem generally were higher for the operational period than the pre-operational period, though no long-term trends in species richness or density were evident (PSEG, 2006a).

PSE&G (2006a) also evaluated abundance data for the RS at Salem to assess long-term population trends. Government agencies and PSEG have conducted several monitoring programs in the Delaware Estuary for many years. Data from four monitoring programs were used by PSEG (2006a) for the trends analysis: the DNREC Juvenile Trawl Survey, the NJDEP Beach Seine Survey, the PSEG Bay-wide Bottom Trawl Survey, and the PSEG Beach Seine Survey. Results of the PSEG trends analysis indicate that seven species (alewife, American shad, Atlantic croaker, blue crab, striped bass, weakfish, and white perch) have shown a trend of generally increasing abundance, one species (spot) has shown a trend of declining abundance, and the remaining five species (Atlantic menhaden, Atlantic silverside, bay anchovy, and blueback herring) show no clear trends in abundance over the long term in the Delaware Estuary (PSEG, 2006a).

Stock assessment data are lacking for spot, the only species to show a long-term decline in the trends analysis. Significant population fluctuations are expected because spot are short-lived and their numbers are directly affected by changing environmental conditions in spawning and nursery areas in a given year. Spot use brackish and saltwater habitats mainly from Chesapeake Bay to South Carolina, and those that spend the summer in the northern portion of their range move south in autumn. A coastwide assessment of the species has not been performed by the Atlantic States Marine Fisheries Commission (ASFMC), but National Marine Fisheries Service (NMFS) landings data and survey data from several States provide indications of spot abundance. Annual coastal landings data for spot beginning in 1950 fluctuate significantly but indicate a gradual declining trend in commercial landings through 2005. Juvenile abundance indices for spot have been highly variable, were below average in 2006 in the Delaware Estuary, and have generally declined in Chesapeake Bay since 1992. Commercial catch-per-unit effort for spot generally has increased in Maryland since 1994 (ASFMC, 2008). Given these indications of a general decline in spot abundance in the northern portion of its range, the decline in abundance in the Delaware Estuary does not appear to be related to the operation of the Salem facility.

PSE&G (2006a) performed a stock jeopardy analysis to determine whether Salem has an impact on the long-term sustainability of fish stocks. The models used in the analysis assess the effect of impingement and entrainment losses on spawning stock biomass (SSB) and spawning stock biomass per recruit (SSBPR). These metrics are commonly used by fisheries managers to establish maximum fishing rates for managed fish populations. The stock jeopardy analysis, utilizing methodology described in Barnthouse et al. (2002), compared the estimated impacts of Salem on these metrics with the impacts of fishing on the same metrics. PSEG (2006a) concluded that for those species analyzed the effects of impingement and entrainment are negligible compared to the effects of fishing and that reducing or eliminating impingement and entrainment at Salem would not measurably increase the reproductive potential or spawning stock biomass of any of these species.

Restoration

In addition to the changes in technology and operations of the Salem facility, PSEG has implemented restoration activities that enhance the fish and shellfish populations in the Delaware Estuary. In compliance with Salem's 1994 and 2001 NJPDES permits, PSEG implemented the Estuary Enhancement Program (EEP), which has preserved and/or restored more than 20,000 acres (ac; 8,000 hectares [ha]) of wetland and adjoining upland buffers (PSEG, 2009a).

In particular, the program restored 4,400 ac (1,800 ha) of formerly diked salt hay farms to reestablish conditions suitable for the growth of low marsh vegetation such as saltmarsh cord grass (*Spartina alterniflora*) and provide for tidal exchange with the estuary. These restored wetlands increase the production of fish and shellfish by increasing primary production in the detritus-based food web of the Delaware Estuary. Both primary and secondary consumers benefit from this increase in production, including many of the RS at Salem and federally managed species with essential fish habitat (EFH) in the estuary. PSEG (2006a) estimated the increase in production of secondary consumers due to this restoration to be at least 18.6 million lbs/yr (8.44 million kg/yr). These secondary consumers include species of fish and shellfish affected by impingement and entrainment at Salem, as well as other species.

The EEP also included the installation of 13 fish ladders at impoundments in New Jersey and Delaware (PSEG, 2009a). The fish ladders eliminate blockages to spawning areas for anadromous fish species such as alewife and blueback herring (both RS at Salem). Fish ladders were constructed in New Jersey at Sunset Lake, Stewart Lake (two ladders), Newton Lake and Cooper River Lake, and in Delaware at Noxontown Pond, Silver Lake (Dover), Silver Lake (Milford), McGinnis Pond, Coursey Pond, McColley Pond, Garrisons Lake, and Moore's Lake (PSEG, 2009a). Most anadromous fish exhibit spawning site fidelity, returning to the same areas where they hatched to spawn. Therefore, PSEG undertook a stocking program that transplanted gravid adults into the newly accessible impoundments to induce future spawning runs (PSEG, 2009a).

Along with the active restoration programs described above, PSEG has provided funding through the EEP for many other programs in the area, including some managed by NJDEP and the Delaware Department of Natural Resources and Environmental Control (DNREC). Examples of these funded programs are restoration of three areas in Delaware dominated by common reed (*Phragmites australis*), State-managed artificial reef programs, revitalization of 150 ac (61 ha) of State-managed oyster habitat, and restoration of 964 ac (390 ha) of degraded wetlands at the Augustine Creek impoundment (PSEG, 2009a).

A requirement of the 2001 NJPDES permit for Salem was for PSEG to evaluate and quantify the increased production associated with its restoration activities and compare it to the production lost due to entrainment and impingement at the facility. These restoration production estimates were provided in Section 7 of the 2006 NJPDES permit renewal application (PSEG, 2006a). The assessment included estimates of increased production associated with the restoration of the three salt hay farms and 12 fish ladder sites. It did not include production associated with the restoration of marshes dominated by common reed, upland buffer areas, and artificial reefs (PSEG, 2006a).

PSEG (2006a) used an Aggregated Food Chain Model (AFCM) to estimate the annual production (lbs wet weight/yr) of secondary consumers attributable to the restoration of the salt hay farm sites. This method used data for the biomass of above-ground vegetation collected during the annual monitoring from 2002 through 2004 to estimate primary production (production of above-ground marsh vegetation). This primary production was then converted to production of secondary consumers through three trophic transfers: vegetation to detrital complex (dissolved and particulate organic matter, bacteria, fungi, protozoa, nematodes, rotifers, copepods, and other microscopic organisms) to primary consumers (zooplankton and macroinvertebrates) to secondary consumers (age-0 fish). PSEG also used two independent methods, an ecosystem model and a fish abundance model, to corroborate the AFCM estimates.

PSEG (2006a) calculated the production of secondary consumers attributable to the restoration of the salt hay marsh sites to be 11,228,415 lbs wet weight/yr (5,093,209 kg wet weight/yr). PSEG (2006a) concluded that the methods used were likely to have underestimated total production attributable to the salt hay marsh restoration because they did not include production associated with below-ground plant parts (roots and rhizomes), benthic algae, or other primary producers such as photosynthetic bacteria. PSEG (2006a) estimated the increase in production attributable to restoration of the salt hay farms to be 2.3 times the annual production lost from impingement and entrainment at Salem.

PSEG (2006a) estimated the annual production of river herring (blueback herring and alewife) attributable to the installation of fish ladders at 12 impoundments in New Jersey and Delaware using results from surveys of juvenile fish in the impoundments, which were then converted to weight using an age-1 average weight. PSEG (2006a) calculated the production of river herring due to the fish ladders to be 944 lbs wet weight/yr (428 kg wet weight/yr), which it estimated was equivalent to about 1/6 of the production of river herring lost to impingement and entrainment at the facility.

<u>Conclusions</u>

Entrainment, impingement, and heat shock cumulatively affect the aquatic resources of the Delaware Estuary. PSEG has conducted extensive studies of the effects of entrainment (Section 4.5.2) and impingement (Section 4.5.3) at Salem over the more than 30-yr period during which it has been operating. PSEG also has conducted extensive studies of the thermal plume at Salem (Section 4.5.4) that have shown that the thermal discharge from operation of the Salem facility has not had a noticeable adverse effect on the balanced indigenous community of the Delaware Estuary in the vicinity of the outfall. Thus, PSEG was granted a thermal variance in accordance with Section 316(a) of the CWA in 1994, and this variance remains a part of the current NJPDES permit issued to PSEG in 2001 and was administratively continued in 2006. Multiple long-term, large-scale studies of the estuary by PSEG and State and Federal agencies have documented the ecological condition of the estuary through time and allowed the analysis of long-term trends in populations of RS. The results of the studies indicate that the processes of entrainment, impingement, and thermal discharge collectively have not had a noticeable adverse effect on the balanced indigenous community of the Delaware Estuary in the vicinity of Salem.

The Staff considered these results and reviewed the available information, including that provided by the applicant, the Staff's site visit, the States of New Jersey and Delaware, the

NJPDES permits and applications, and other public sources. The NJDEP, not the NRC, is responsible for issuing and enforcing NPDES permits. NRC assumes that NJDEP will continue to apply the best information available to the evaluation and approval of future NJPDES permits. The Staff concludes that impacts to fish and shellfish from the collective effects of entrainment, impingement, and heat shock at Salem during the renewal term would be SMALL.

The Staff identified a variety of measures that could mitigate potential impacts resulting from continued operation of the Salem cooling water system, although it should be noted that the NRC cannot impose mitigation requirements on the applicant. The Atomic Safety and Licensing Appeal Board in the "Yellow Creek" case determined that EPA has sole jurisdiction over the regulation of water quality with respect to the withdrawal and discharge of waters for nuclear power stations and that the NRC is prohibited from placing any restrictions or requirements upon the licensees of those facilities with regards to water quality (Tennessee Valley Authority [Yellow Creek Nuclear Plant, Units 1 and 2], ALAB-515, 8 NRC 702, 712-13 [1978]).

A few mitigation measures for the effects of the cooling water system on aquatic organisms include conversion to a closed cycle cooling water system, scheduling plant outages during historic peak impingement and entrainment periods, installing variable speed drive controllers on the pump motors to allow flow reductions during months of high biological activity, the use of dual-flow fine-mesh screens, and the use of a sound deterrent system for fish. These mitigation measures could reduce impacts by reducing the flow rate of water drawn into the facility, resulting in a commensurate decrease in impingement and entrainment, or by excluding organisms from the intake or deterring them from entering the area.

PSEG performed a cost-benefit analysis of these mitigation measures as part of its CDS for the 2006 NPDES permit renewal application (PSEG, 2006a). EPA's evaluation of the Salem NPDES permit renewal application would likely address any applicable site-specific mitigation measures that may reduce entrainment and impingement impacts. EPA's Phase II Rule has been suspended, and compliance with CWA Section 316(b) is based on EPA's best professional judgment.

4.6 Terrestrial Resources

The Category 1 issues related to terrestrial resources and applicable to Salem and HCGS are listed in Table 4-19. There are no Category 2 issues related to terrestrial resources. Section 2.2.6 provides a description of the terrestrial resources at the site of the Salem and HCGS facilities and in the surrounding area.

Table 4-19. Terrestrial Resources Issues Applicable to Salem and/or HCGS.

Issues	GEIS Section	Category
Cooling tower impacts on crops and ornamental vegetation[(a)]	4.3.4	1
Cooling tower impacts on native plants[(a)]	4.3.5.1	1
Bird collisions with cooling towers[(a)]	4.3.5.2	1
Power line right-of-way management (cutting and herbicide application)[(b)]	4.5.6.1	1
Bird collisions with power lines[(b)]	4.5.6.1	1
Impacts of electromagnetic fields on flora and fauna (plants, agricultural crops, honeybees, wildlife, livestock) [(b)]	4.5.6.3	1
Floodplains and wetland on power line right-of-way[(b)]	4.5.7	1

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

The Staff did not identify any new and significant information during the review of the Salem and HCGS ER documents (PSEG, 2009a; PSEG, 2009b), the Staff's site audit, the scoping process, or the evaluation of other available information (including bird mortality surveys conducted for the HCGS cooling tower from 1984 to 1986). Therefore, the NRC staff concludes that there would be no impacts related to these issues beyond those discussed in the GEIS (NRC, 1996). Regarding these issues, the GEIS concluded that the impacts are SMALL, and additional site-specific mitigation measures are not likely to be sufficiently beneficial to warrant implementation.

4.7 Threatened or Endangered Species

Potential impacts to threatened or endangered species are listed as a Category 2 issue in 10 CFR Part 51, Subpart A, Appendix B, Table B-1. The GEIS section and category for this issue are listed in Table 4-20.

Table 4-20. Category 2 Issues Applicable to Threatened or Endangered Species During the Renewal Term

Issue	GEIS Section	Category
Threatened or endangered species	4.1	2

This site-specific issue requires consultation with appropriate agencies to determine whether threatened or endangered species are present and whether they would be adversely affected by continued operation of the nuclear facility during the license renewal term. The presence of threatened or endangered species in the vicinity of the site of the Salem and HCGS facilities is discussed in Sections 2.2.7.1 and 2.2.7.2. In 2009, the Staff contacted NMFS and U.S. Fish and Wildlife Service (FWS) to request information on the occurrence of threatened or endangered species in the vicinity of the site and the potential for impacts on those species from license renewal. NMFS identified in its response a species federally listed as endangered, the shortnose sturgeon (*Acipenser brevirostrum*), and a candidate species, the Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), as having the potential to be affected by the proposed action (NMFS, 2010). Additionally, NMFS identified four Federally listed sea turtle species, the threatened loggerhead (*Caretta caretta*), and the endangered Kemp's ridley (*Lepidochelys kempi*), green (*Chelonia mydas*), and leatherback (*Dermochelys coriacea*), as having the potential to be adversely affected by the proposed action. These six species, their habitats, and their life histories, are described in Section 2.2.7.1.

In response to the NRC's request for information on Federally listed species potentially affected by the proposed action, FWS (2010) indicated that there were no Federally listed species under its jurisdiction present on the Salem and HCGS site. In letters to PSEG on September 9, 2009 (FWS, 2009a) and the NRC on June 29, 2010 (FWS, 2010), FWS stated that along Salem and HCGS transmission line Right-of-Ways (ROWs) in New Jersey are areas of potential habitat for the bog turtle (*Clemmys muhlenbergii*) and known occurrences and other areas of potential habitat for the swamp pink (*Helonias bullata*). Both of these species are Federally listed as threatened.

The Staff has prepared a Biological Assessment (BA) for NMFS that documents its review of the potential for the proposed action to affect the Federally listed species under the jurisdiction of NMFS. The BA is provided in Appendix D of this draft SEIS. During informal consultation with FWS regarding the potential for effects on terrestrial threatened or endangered species, the staff determined that a BA for FWS was not needed because there was no likelihood of adverse effects on Federally listed species under the jurisdiction of FWS at known occurrences along the transmission line corridors or potentially occurring within the vicinity of the power plant or within the transmission line ROWs. PSEG (2009a) committed to FWS that it will protect both Federally and State-listed threatened or endangered species along PSEG transmission line ROWs and adopted the conservation measures recommended by FWS for the swamp pink and bog turtle, which are described in Section 4.7.2.

4.7.1 Aquatic Threatened or Endangered Species of the Delaware Estuary

Pursuant to consultation requirements under Section 7 of the Endangered Species Act of 1973, the Staff sent a letter to NMFS dated December 23, 2009 (NRC, 2009b) requesting information on federally listed endangered or threatened species, as well as proposed or candidate species. In its response on February 11, 2010, NMFS stated that the shortnose sturgeon, the Atlantic sturgeon, and four sea turtle species are known to occur in the Delaware River and estuary in the vicinity of Salem and HCGS, and that no critical habitat is currently designated by NMFS near these facilities (NMFS, 2010).

At Salem, NMFS considers takes to include mortalities as well as turtles that are impinged but removed alive and released. In 1991, NMFS issued a Biological Opinion that found that continued operation of Salem and HCGS would affect threatened or endangered sea turtles but was not likely to jeopardize any populations, and it issued an Incidental Take Statement (ITS) for Kemp's ridley, green, and loggerhead turtles and shortnose sturgeon. The number of turtles impinged in 1991 was unexpectedly high, exceeding the incidental take allowed and resulting in additional consultation. An opinion issued in 1992 revised the ITS. The impingement of sea turtles exceeded the allowable take in 1992 as well, prompting additional consultation between NRC and NMFS (NMFS, 1999). A 1993 Biological Opinion (NMFS 1993) required that PSEG track all loggerhead sea turtles taken alive at the cooling water intake structure (CWIS) and released. Also in 1993, PSEG implemented a policy of removing the ice barriers from the trash racks on the intake structure during the period between May 1 and October 24, which resulted in substantially lower turtle impingement rates at Salem.

In 1999, NRC requested that the studies of released turtles be eliminated due to the reduction in the number of turtles impinged after the 1993 change in procedure regarding the removal of ice barriers. NMFS responded in 1999 with a letter and an incidental take statement stating that these studies could be discontinued because it appeared that the reason for the relatively high impingement numbers previously was the ice barriers that had been left on the intake structure during the warmer months (NMFS, 1999). This letter allowed an annual incidental take of 5 shortnose sturgeon, 30 loggerhead sea turtles, 5 green sea turtles, and 5 Kemp's ridley sea turtles. In addition, the statement required ice barrier removal by May 1 and replacement after October 24, and it required that in the warmer months the trash racks must be cleaned weekly and inspected every other hour, and in the winter they should be cleaned every other week. The statement requires that if a turtle is killed, the racks must be inspected every hour for the rest of the warm season. Dead shortnose sturgeon are required to be inspected for tags, and live sturgeon are to be tagged and released (NMFS, 1999). No sea turtles have been captured at Salem since 2001 (NMFS, 2009).

No shortnose sturgeon or sea turtles have been impinged at the HCGS intake structure (NMFS, 2009), and NMFS has not required monitoring at HCGS beyond normal cleaning of the intake structure (NMFS, 1993).

The Staff discusses the potential effects of entrainment, impingement, and thermal discharges on these and other important species in Sections 4.5.2, 4.5.3, and 4.5.4. Based on evaluation by the Staff of entrainment data provided by PSEG, there is no evidence that the eggs or larvae of either sturgeon species are commonly entrained at Salem and HCGS. Neither of the sturgeon species is on the list of species that has been collected in annual entrainment monitoring during the 1978 – 2008 period (Table 4.21). The life histories of these sturgeon, described in Section 2.2.7.1, suggest that entrainment of their eggs or larvae is unlikely. Shortnose sturgeon spawn upstream in freshwater reaches of the Delaware River and are most abundant between Philadelphia and Trenton. Their eggs are demersal and adhere to the substrate, and juvenile stages tend to remain in freshwater or fresher areas of the estuary for 3 to 5 years before moving to more saline areas such as the nearshore ocean. Thus, shortnose sturgeon eggs or larvae are unlikely to be present in the water column at the Salem or HCGS intakes well downstream of the spawning areas. Similarly, the life history of the Atlantic sturgeon makes entrainment of its eggs or larvae very unlikely.

Table 4-21. Impingement data for shortnose sturgeon and three sea turtle species with recorded impingements at Salem intakes, 1978-2008.

Year	Number Impinged[(1)]			
	Shortnose sturgeon	**Kemp's ridley sea turtle**	**Green sea turtle**	**Loggerhead sea turtle**
1978	2 (2)	0	0	0
1979	0	0	0	0
1980	0	1	1	2 (2)
1981	1 (1)	1 (1)	0	3 (2)
1982	0	0	0	1 (1)
1983	0	1 (1)	0	2 (2)
1984	0	1	0	2 (2)
1985	0	2 (1)	0	6 (5)
1986	0	1 (1)	0	0
1987	0	3 (1)	0	3
1988	0	2 (1)	0	8 (6)
1989	0	6 (2)	0	2
1990	0	0	0	0
1991	3 (3)	1	1	23 (1)
1992	2 (2)	4 (2)	1 (1)	10
1993	0	1	0	0
1994	2 (2)	0	0	1
1995	0	0	0	1 (1)
1996	0	0	0	0
1997	0	0	0	0
1998	3 (1)	0	0	1 (1)
1999	1	0	0	0
2000	1 (1)	0	0	2 (1)
2001	0	0	0	1 (1)
2002	0	0	0	0
2003	1 (1)	0	0	0
2004	2 (1)	0	0	1
2005	0	0	0	0
2006	0	0	0	0
2007	1 (1)	0	0	0
2008	1 (1)	0	0	0
2009	0	0	0	0
Total	20 (16)	24 (10)	3 (1)	69 (25)

[(1)] Numbers in parentheses indicate the number of individuals out of the yearly total shown that were either dead when found at the intakes or died afterward. Impingements of Atlantic sturgeon or leatherback sea turtles were not reported in the data on which this table was based.

Source: PSEG, 2010a.

Both sturgeon species and three of the four turtle species have been impinged at Salem. Atlantic sturgeon were collected in impingement studies in a single year, 2006 (PSEG biological monitoring reports 1995-2006). From 1978 through 2009, 20 shortnose sturgeon were impinged at the Salem intakes, of which 16 died. Between 1978 and 2008, 24 Kemp's ridley sea turtles were impinged, of which ten died. Three green turtles (one died) and 69 loggerhead turtles (25 died) also were impinged. Impingement of the turtles was greatest in 1991 and 1992 (Table 4.21). After PSEG modified its use of the ice barriers in 1993, turtle impingement numbers returned to levels much lower than in 1991. From 1994 through 2009, Salem impinged seven sea turtles (all loggerheads), and four of these died. Also during this 16-yr period, 12 shortnose sturgeon were impinged, of which eight died. Sea turtles have not been impinged at Salem since 2004 (NMFS, 2009).

Section 4.5.4 discusses potential impacts of thermal discharges on the aquatic biota of the Delaware Estuary, and the Staff expect impacts on fish and invertebrates, including those preyed upon by sturgeon and sea turtles, to be minimal. The high exit velocity of the discharge produces rapid dilution, which limits high temperatures to relatively small areas in the zone of initial mixing in the immediate vicinity of the discharge. Fish and many other organisms are largely excluded from these areas due to high velocities and turbulence. Shortnose and Atlantic sturgeon and the four sea turtle species have little potential to experience adverse effects from exposure to the temperatures at the discharge because of their life history characteristics and their mobility. Sturgeon spawning and nursery areas do not occur in the area of the discharge in the estuary, and adult sturgeon forage on the bottom while the buoyant thermal plume rises toward the surface. Sea turtles prefer warmer water temperatures, occur in the region only during warm months, and are unlikely to be sensitive to the localized area of elevated temperatures at the discharge. NMFS (1993) considered the possibility that the warm water near the discharge could cause sea turtles to remain in the area until surrounding waters are too cold for their safe departure in the fall, but it concluded that this scenario was not supported by any existing data.

The Staff reviewed information from the site audit, the applicant's ERs for Salem and HCGS, biological monitoring reports, other reports, and coordination with NMFS, FWS, and State regulatory agencies in New Jersey and Delaware regarding listed species. The Staff concludes that the impacts on Federally listed threatened or endangered aquatic species of the Delaware Estuary during an additional 20 years of operation of the Salem and HCGS facilities would be SMALL. NRC provides a Biological Assessment of the potential effects from the proposed license renewal for the Salem and HCGS facilities on Federally listed endangered or threatened species under NMFS jurisdiction in Appendix D.

4.7.2 Terrestrial and Freshwater Aquatic Threatened or Endangered Species

Two Federally listed terrestrial or freshwater aquatic species that might occur near the Salem and HCGS facilities and their associated transmission line ROWs are the bog turtle and swamp pink. Section 2.2.7.2 discusses characteristics, habitat requirements, and likelihood of occurrence of these species. Coordination correspondence between FWS and NRC (FWS, 2010) indicates that no Federally listed species occur on the site of the Salem and HCGS facilities, but that there are areas of potential habitat for the bog turtle and known occurrences and other areas of potential habitat for the swamp pink along the New Freedom North and New Freedom South transmission line ROWs.

FWS coordinated with PSEG to review all of its transmission line spans in New Jersey, including the lines from Salem and HCGS, and transmitted to PSEG the known locations of the presence or potential presence of Federally listed species along each span. FWS (2009a) also recommended to PSEG conservation measures for each Federally listed species that potentially could occur along its transmission line spans. In October 2009, PSEG (2009d) confirmed to FWS its commitment to protecting both Federally and State-listed threatened or endangered species along PSEG transmission line ROWs and adopted the conservation measures recommended by FWS for each species, including the swamp pink and bog turtle. Based on PSEG's adoption of these conservation measures, in November 2009 FWS concurred that "continued vegetation maintenance activities within the transmission system are not likely to adversely affect Federally listed or candidate species" (FWS, 2009b). Thus, the Federally listed species potentially occurring in the transmission line ROWs for Salem and HCGS in New Jersey would not be adversely affected by future vegetation maintenance activities. The FWS New Jersey Field Office also coordinated with the FWS Chesapeake Bay Field Office regarding the transmission line ROW from HCGS that crosses the river and traverses New Castle County in Delaware. FWS (2009b) concluded that "no proposed or federally listed endangered or threatened species are known to exist" within that ROW area.

The ROW maintenance procedures agreed upon for protection of the bog turtle include: use of a certified bog turtle surveyor to examine spans containing known or potential habitat, to flag areas of potential habitat plus a 150-ft (46 m) buffer, and to be on site during maintenance activities in flagged areas; performance of maintenance activities by hand in flagged areas, including selective use of specific herbicides; no use of herbicides in known nesting areas, which include all flagged areas around extant occurrences; timing restrictions to avoid disturbance during nesting season; and provision of the surveyor's reports to FWS (PSEG, 2009d). The ROW maintenance procedures agreed upon for protection of the swamp pink include: use of a qualified botanist to survey suitable forested wetland habitat on and adjacent to the ROW for the plant; flagging of a 200-ft (61 m) radius area around any identified populations of swamp pink; avoidance of any maintenance activities within the flagged areas without FWS approval; limitation of herbicide use within 500 ft (152 m) of a population to manual applications to woody stumps only; and provision of the surveyor's reports to FWS (PSEG, 2009d).

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

4.8 Human Health

The human health issues applicable to Salem and HCGS are discussed below and listed in Table 4-22 for Category 1, Category 2, and uncategorized issues.

Table 4-22. Human Health Issues. *Table B-1 of Appendix B to Subpart A of 10 CFR Part 51 contains more information on these issues.*

Issues	GEIS Section	Category
Radiation exposures to the public during refurbishment	NA[a]	1
Occupational radiation exposures during refurbishment	NA[a]	1
Microbiological organisms (occupational health)	4.3.6	1
Microbiological organisms (public health, for plants using lakes or canals or discharging small rivers)	4.3.6[b]	2
Noise	4.3.7	1
Radiation exposures to public (license renewal term)	4.6.2	1
Occupation radiation exposures (license renewal term)	4.6.3	1
Electromagnetic fields – acute effects (electric shock)	4.5.4.1	2
Electromagnetic fields – chronic effects	4.5.4.2	Uncategorized

[a] - Issues apply to refurbishment, an activity that neither Salem nor HCGS plan to undertake.
[b] - Issue applies to plant features such as cooling lakes or cooling towers that discharge to small rivers. Neither Salem nor HCGS have applicable features.

4.8.1 Generic Human Health Issues

The Staff did not identify any new and significant information related to human health issues or radiation exposures during its review of the PSEG environmental reports, the site audit, or the scoping process. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS. For these issues, the GEIS concluded that the impacts are SMALL, and additional site-specific mitigation measures are not likely to be sufficiently beneficial to be warranted (Category 1 issues). These impacts will remain SMALL through the license renewal term.

4.8.2 Radiological Impacts of Normal Operations

Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, applicable to Salem and HCGS in regard to radiological impacts are listed in Table 4-22. PSEG stated in its ER that it was not aware of any new radiological issues associated with the renewal of the Salem and HCGS operating licenses. The Staff has not identified any new and significant information, during its independent review of PSEG's ER, the site audit, the scoping process, or its evaluation of other available information. Therefore, the Staff concludes that there would be no impact from radiation exposures to the public or to workers during the renewal term beyond those discussed in the GEIS.

According to the GEIS, the impacts to human health are SMALL, and additional plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted

- Radiation exposures to public (license renewal term). Based on information in the GEIS, the Commission found the following:

  Radiation doses to the public will continue at current levels associated with normal operations.

- Occupational exposures (license renewal term). Based on information in the GEIS, the Commission found the following:

  Projected maximum occupational doses during the license renewal term are within the range of doses experienced during normal operations and normal maintenance outages, and would be well below regulatory limits.

Therefore, the Staff expects that there would be no impacts during the renewal term beyond those discussed in the GEIS.

There are no Category 2 issues related to radiological impacts of routine operations.

The information presented below is a discussion of selected radiological programs conducted at Salem and HCGS.

Radiological Environmental Monitoring Program

PSEG conducts a radiological environmental monitoring program (REMP) to assess the radiological impact, if any, to its employees, the public, and the environment around the plant site. The REMP provides measurements of radiation and of radioactive materials for the exposure pathways and the radionuclides which lead to the highest potential radiation exposures to the public. The REMP supplements the radioactive effluent monitoring program by verifying that any measurable concentrations of radioactive materials and levels of radiation in the environment are not higher than those calculated using the radioactive effluent release measurements and transport models.

The objectives of the REMP are as follows:

- To fulfill the requirements of the radiological surveillance sections of the Plants' Technical Specifications and the Offsite Dose Calculation Manual.
- To determine whether any significant increase occurred in the concentration of radionuclides in critical pathways for the transfer of radionuclides through the environment to man.
- To determine if operation of the plants caused an increase in the radioactive inventory of long-lived radionuclides in the environment.
- To detect any change in ambient gamma radiation levels.
- To verify that operation of the plants have no detrimental effects on the health and safety of the public or on the environment.

An annual radiological environmental operating report is issued, which contains a discussion of the results of the monitoring program. The report contains data on the monitoring performed for the most recent year as well as graphs containing historical information. The REMP collects samples of environmental media in order to measure the radioactivity levels that may be present. The media samples are representative of the radiation exposure pathways that may impact the public. The REMP measures the aquatic, terrestrial, and atmospheric environment for radioactivity, as well as the ambient radiation. Ambient radiation pathways include radiation from radioactive material inside buildings and plant structures and airborne material that may be released from the plant. In addition, the REMP measures background radiation (i.e., cosmic sources, global fallout, and naturally occurring radioactive material, including radon). Thermoluminescent dosimeters (TLDs) are used to measure ambient radiation. The atmospheric environmental monitoring consists of sampling and analyzing the air for particulates and radioiodine. Terrestrial environmental monitoring consists of analyzing samples of locally grown vegetables and fodder crops, drinking water, groundwater, meat, and milk. The aquatic environmental monitoring consists of analyzing samples of surface water, fish, crabs, and sediment. An annual land use census is conducted to determine if the REMP needs to be revised to reflect changes in the environment or population that might alter the radiation exposure pathways. Salem and HCGS has an onsite groundwater protection program designed to monitor the onsite plant environment for early detection of leaks from plant systems and pipes containing radioactive liquid (PSEG, 2009a; PSEG, 2009b; PSEG, 2010b). Additional information on the groundwater protection program is contained later in this section and in the Ground Water Quality section in Chapter 2 of this document.

The Staff reviewed the Salem and HCGS annual radiological environmental operating reports for 2005 through 2009 to look for any significant impacts to the environment or any unusual trends in the data (PSEG, 2006c; PSEG, 2007b; PSEG, 2008b; PSEG, 2009e; PSEG, 2010b). A five year period provides a representative data set that covers a broad range of activities that occur at a nuclear power plant such as refueling outages, non-refueling outage years, routine operation, and years where there may be significant maintenance activities. Based on the Staff's review, no unusual trends were observed and the data showed that there was no significant radiological impact to the environment from operations at Salem and HCGS. Small amounts of radioactive material (i.e., tritium, cesium-137, and manganese-54) were detected below NRC's reporting values for radionuclides in environmental samples. Overall, the results, with the exception of the on-site groundwater contaminated with tritium, were comparable to the results obtained during the preoperational phase of the REMP and with historical results obtained since commercial operation.

The NJDEP's Bureau of Nuclear Engineering performs an independent Environmental Surveillance and Monitoring Program (ESMP) in the environment around the Salem and Hope Creek Nuclear Generating Stations. The ESMP provides a comprehensive monitoring strategy that ensures that New Jersey citizens are aware of and, if necessary, protected from harmful exposure to radioactive effluent discharges from New Jersey's nuclear power plants during normal or accident operations.

The specific objectives of the ESMP are to monitor pathways for entry of radioactivity into the environment in order to identify potential exposures to the population from routine and accidental releases of radioactive effluent, and to provide a summary and interpretation of this information to members of the public and government agencies.

The Staff reviewed the NJDEP's 2008 report (the most recent report available to the Staff at the time this draft SEIS was prepared) which contains information on the environmental sampling conducted during the time period of January 1, 2008 through December 31, 2008. The State reported the following: "Overall, the data collected by the NJDEP's ESMP throughout 2008 indicate that residents living in the area around Oyster Creek and Salem/Hope Creek nuclear power plants have not received measurable exposures of radiation above normal background" (NJDEP, 2009a).

Radiological Groundwater Protection Program

In response to an identified radioactive liquid release from the Salem Unit 1 spent fuel pool in 2002, PSEG implemented a Remedial Action Work Plan (RAWP) and developed a voluntary Radiological Groundwater Protection Program (RGPP) in 2006 that added additional groundwater sampling locations, outside the scope of the REMP. The RAWP, which was reviewed by the NRC and approved by the NJDEP, is a program designed to remediate the site's groundwater to remove the tritiated groundwater and control the tritium plume from reaching the site boundary and impacting the off-site environment. The results of the RGPP groundwater monitoring program have been reported in the annual radiological environmental operating report since 2006.

The radiological monitoring data for 2009 showed a wide range of tritium concentrations in the on-site groundwater. For HCGS, the results show that tritium was detected at concentrations that ranged from the lower limit of detection value of 200 pico Curies per liter (pCi/L) to a maximum of 7,778 pCi/L. As a result of the positive indications of tritium, the applicant increased the sampling frequency for the monitoring wells. Subsequent sampling did not reproduce the highest levels observed; however, variations in the levels were observed throughout 2009. As a result, the applicant continues to track the concentrations of tritium in the groundwater to determine if a trend can be observed. For the Salem units, the results show that tritium was detected in on-site groundwater in concentrations that ranged from the lower limit of detection value of 200 pCi/L to a maximum of 2,259 pCi/L. The applicant is tracking the tritium concentration levels to determine if a trend can be observed (PSEG, 2010b). The Staff notes that no groundwater samples reached the NRC's reporting level of 20,000 pCi/L for tritium in environmental samples.

As part of the applicant's investigation for new and significant information that is relevant to its license renewal application, the issue of tritium in the groundwater was evaluated. The applicant's evaluation concludes that changes in tritium-related groundwater quality are not significant at Salem and would not preclude current or future uses of the groundwater for the following reasons:

- Although tritium concentrations are elevated in the shallow aquifer beneath Salem, PSEG has been performing remedial actions since 2004, and concentrations continue to decrease.
- Tritium concentrations in groundwater are due to an historic incident; the source (spend fuel pool water leak) has been eliminated.
- No tritium concentrations above either the EPA Drinking Water Standard or the NJDEP

  Ground Water Quality Criterion have migrated to the property boundary or into geologic formations deeper than the shallow aquifer. Offsite tritium concentrations are below regulatory limits.
- There is no human exposure pathway and, therefore, no threat to public or employee health or safety.

<u>Radioactive Effluent Release Program</u>

All nuclear plants were licensed with the expectation that they would release radioactive material to both the air and water during normal operation. However, NRC regulations require that radioactive gaseous and liquid releases from nuclear power plants must meet radiation dose-based limits specified in 10 CFR Part 20, and as low as is reasonably achievable (ALARA) criteria in Appendix I to 10 CFR Part 50. The regulatory limits protect plant workers and members of the public from radioactive material released by a nuclear power plant. In addition, nuclear power plants are required to file an annual report to the NRC which lists the types and quantities of radioactive effluents released into the environment. The radioactive effluent release and radiological environmental monitoring reports are available for review by the public through the NRC's ADAMS electronic reading room on the NRC website.

The Staff reviewed the annual radioactive effluent release reports for 2005 through 2009 (PSEG, 2006d; PSEG, 2007c; PSEG, 2008c; PSEG, 2009f; PSEG, 2010c). The review focused on the calculated doses to a member of the public from radioactive effluents released from Salem and HCGS. The doses were compared to the radiation protection standards in 10 CFR 20.1301 and the ALARA dose design objectives in Appendix I to 10 CFR Part 50.

Dose estimates for members of the public are calculated based on radioactive gaseous and liquid effluent release data and atmospheric and aquatic transport models. The 2009 annual radioactive material release report (PSEG 2010c) contains a detailed presentation of the radioactive discharges and the resultant calculated doses. The following summarizes the calculated dose to a member of the public located outside the Salem and HCGS site boundary from radioactive gaseous and liquid effluents released during 2009:

<u>Salem Units 1 and 2</u>

- The total-body dose to an offsite member of the public from radioactive liquid effluents from Salem Unit 1 was 3.22 E-05 millirem (mrem; 3.22 E-07 millisieverts [mSv]) and 2.72 E-05 mrem (2.72 E-07 mSv) for Unit 2, which is well below the 3 mrem (0.03 mSv) dose criterion for an individual reactor unit in Appendix I to 10 CFR Part 50.
- The maximum dose to any organ (i.e., skin, thyroid, liver, G.I. tract, etc.) of an offsite member of the public from radioactive liquid effluents from Salem Unit 1 was 8.60 E-05 mrem (8.60 E-07 mSv) and 8.89 E-05 (8.89 E-07 mSv) for Unit 2, which is well below the 10 mrem (0.1 mSv) dose criterion for an individual reactor unit in Appendix I to 10 CFR Part 50.
- The air dose at the site boundary from gamma radiation in gaseous effluents from Salem Unit 1 was 1.28 E-04 millirad (mrad; 1.28 E-06 megagray [mGy]), and 2.74 E-05 mrad (2.74 E-07 mGy) for Unit 2, which is well below the 10 mrad (0.1 mGy) dose criterion for an individual reactor unit in Appendix I to 10 CFR Part 50.
- The air dose at the site boundary from beta radiation in gaseous effluents from Salem Unit 1 was 3.14 E-04 mrad (3.14 E-06 mGy) and 1.46 E-05 mrad (1.46 E-07 mGy) for Unit 2, which is well below the 20 mrad (0.2 mGy) dose criterion for an individual reactor unit in Appendix I to 10 CFR Part 50.
- The maximum dose to any organ (i.e., skin, thyroid, liver, G.I. tract, etc.) of a member of the public at the site boundary from radioactive iodine, tritium, and radioactive particulate

matter from Unit 1 was 2.70 E-03 mrem (2.70 E-05 mSv) and 1.65 E-03 mrem (1.65 E-05 mSv) for Unit 2, which is well below the 15 mrem (0.15 mSv) dose criterion for an individual reactor unit in Appendix I to 10 CFR Part 50.

Hope Creek Generating Station

- The total-body dose to an offsite member of the public from radioactive liquid effluents from HCGS was 8.32 E-05 mrem (8.32 E-07 mSv), which is well below the 3 mrem (0.03 mSv) dose criterion for an individual reactor unit in Appendix I to 10 CFR Part 50.
- The maximum dose to any organ (i.e., skin, thyroid, liver, G.I. tract, etc.) of an offsite member of the public from radioactive liquid effluents from HCGS was 3.05 E-04 mrem (3.05 E-06 mSv), which is well below the 10 mrem (0.1 mSv) dose criterion for an individual reactor unit in Appendix I to 10 CFR Part 50.
- The air dose at the site boundary from gamma radiation in gaseous effluents from HCGS was 7.29 E-04 mrad (7.29 E-06 mGy), which is well below the 10 mrad (0.1 mGy) dose criterion for an individual reactor unit in Appendix I to 10 CFR Part 50.
- The air dose at the site boundary from beta radiation in gaseous effluents from HCGS was 7.34 E-04 mrad (7.34 E-06 mGy), which is well below the 20 mrad (0.2 mGy) dose criterion for an individual reactor unit in Appendix I to 10 CFR Part 50.
- The maximum dose to any organ (i.e., skin, thyroid, liver, G.I. tract, etc.) of a member of the public at the site boundary from radioactive iodine, tritium, and radioactive particulate matter from HCGS was 1.97 E-02 mrem (1.97 E-04 mSv), which is well below the 15 mrem (0.15 mSv) dose criterion for an individual reactor unit in Appendix I to 10 CFR Part 50.

Salem – Hope Creek Site Total

- The total-body dose to an offsite member of the public from the combined radioactive effluents from all three reactor units was 7.26 E-03 mrem (7.26 E-05 mSv), which is well below the 25 mrem (0.25 mSv) dose criterion in 40 CFR Part 190.
- The dose to any organ (i.e., skin, thyroid, liver, G.I. tract, etc.) of an offsite member of the public from the combined radioactive effluents from all three reactor units was 2.54 E-02 mrem (2.54 E-04 mSv), which is well below the 25 mrem (0.25 mSv) dose criterion in 40 CFR Part 190.
- The thyroid dose to an offsite member of the public from the combined radioactive effluents from all three reactor units was 2.41 E-02 mrem (2.41 E-04 mSv), which is well below the 75 mrem (0.75 mSv) dose criterion in 40 CFR Part 190.

Based on the Staff's review of the Salem and HCGS radioactive waste system's performance in controlling radioactive effluents and the resultant doses to members of the public in conformance with the ALARA criteria in Appendix I to 10 CFR Part 50, the Staff found that the 2009 radiological effluent data for Salem and HCGS are consistent, within reasonable variation attributable to operating conditions and outages, with the historical data. The results demonstrate that Salem and HCGS are operating in compliance with Federal radiation protection standards contained in Appendix I to 10 CFR Part 50, 10 CFR Part 20, and 40 CFR Part 190.

Routine plant operational and maintenance activities currently performed will continue during the license renewal term. Based on the past performance of the radioactive waste system to maintain the dose from radioactive effluents to be ALARA, similar performance is expected during the license renewal term.

The radiological impacts from the current operation of Salem and HCGS are not expected to change significantly. Continued compliance with regulatory requirements is expected during the license renewal term; therefore, the impacts from radioactive effluents would be SMALL.

4.8.3 Microbiological Organisms – Public Health

Both Salem and HCGS have thermal discharges to the Delaware Estuary, a large brackish, tidally-influenced water body that allows their thermal plumes to disperse quickly. There are no other facilities that release thermal discharges to the Estuary in the vicinity of Salem and HCGS.

Table B-1 of Appendix B to Subpart A of 10 CFR Part 51 and Table 4-22 list the effects of thermophilic microbiological organisms on human health as a Category 2 issue and requires the conduct of a plant-specific evaluation before license renewal. This issue applies to plant features such as cooling lakes or cooling towers that discharge to small rivers. NRC has determined that Salem and HCGS discharge to an estuary (NRC, 1996). Neither Salem nor HCGS use cooling ponds, cooling lakes, cooling canals, or discharge to a small river. Therefore, this issue does not apply and the effects of plant discharges on microbiological organisms do not need to be addressed for license renewal.

4.8.4 Electromagnetic Fields – Acute Effects

Based on the GEIS, the Commission found that electric shock resulting from direct access to energized conductors or from induced charges in metallic structures has not been found to be a problem at most operating plants and generally is not expected to be a problem during the license renewal term. However, site-specific review is required to determine the significance of the electric shock potential along the portions of the transmission lines that are within the scope of this SEIS.

In the GEIS (NRC, 1996), the Staff found that without a review of the conformance of each nuclear plant transmission line with National Electrical Safety Code (NESC) criteria, it was not possible to determine the significance of the electric shock potential (IEEE, 2002). Evaluation of individual plant transmission lines is necessary because the issue of electric shock safety was not addressed in the licensing process for some plants. For other plants, land use in the vicinity of transmission lines may have changed, or power distribution companies may have chosen to upgrade line voltage. To comply with 10 CFR 51.53(c)(3)(ii)(H), the applicant must provide an assessment of the impact of the proposed action on the potential shock hazard from the transmission lines if the transmission lines that were constructed for the specific purpose of connecting the plant to the transmission system do not meet the recommendations of the NESC for preventing electric shock from induced currents.

As described in Section 2.1.1.6, four 500-kilovolt (kV) transmission lines were specifically constructed to distribute power to the electrical grid from the Salem and HCGS. One 500-kV line, the HCGS-New Freedom line, was originally constructed to connect HCGS to the transmission system. Two additional lines, Salem-New Freedom North and Salem-Keeney (via

Red Lion substation), were originally built for Salem but have since been connected to HCGS. The fourth line, Salem-New Freedom South, originates at Salem (PSEG, 2009a; PSEG, 2009b).

PSEG conducted an analysis of the Salem HCGS transmission lines using a computer model of induced current under the line and the results were field verified. PSEG calculated electric field strength and induced current using a computer code called ACDCLINE, produced by the Electric Power Research Institute. The analysis determined that there are no locations under the transmission lines that have the capacity to induce more than 5 milliamperes (mA) in a vehicle parked beneath the line. Therefore, the lines meet the NESC 5 mA criterion. The maximum induced current calculated for the power lines was 4.2 mA for the Salem-New Freedom South line (PSEG, 2009a; PSEG, 2009b).

PSEG also conducts regular aerial and ground surveillance and maintenance to ensure that design ground clearances do not change. The aerial patrols of all corridors include checks for encroachments, broken conductors, broken or leaning structures, and signs of burnt trees, any of which would be evidence of clearance problems. Ground inspections include examination for clearance at questionable locations, examination for integrity of structures, and surveillance for dead or diseased trees that might fall on the transmission line. Problems noted during any inspection are brought to the attention of the appropriate organizations for corrective action (PSEG, 2009a; PSEG, 2009b).

The Staff has reviewed the available information, including the applicant's evaluation and computational results for the potential impacts of electric shock resulting from operation of Salem and HCGS and their associated transmission lines. The staff concludes that the potential impacts of electric shock during the renewal term would be SMALL.

4.8.5 Electromagnetic Fields – Chronic Effects

In the GEIS, the chronic effects of 60-hertz (Hz) electromagnetic fields from power lines were not designated as Category 1 or 2, and will not be until a scientific consensus is reached on the health implications of these fields.

The potential for chronic effects from these fields continues to be studied and is not known at this time. The National Institute of Environmental Health Sciences (NIEHS) directs related research through the U.S. Department of Energy (DOE).

The report by NIEHS (NIEHS, 1999) contains the following conclusion:

> The NIEHS concludes that ELF-EMF (extremely low frequency-electromagnetic field) exposure cannot be recognized as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard. In our opinion, this finding is insufficient to warrant aggressive regulatory concern. However, because virtually everyone in the United States uses electricity and therefore is routinely exposed to ELF-EMF, passive regulatory action is warranted such as continued emphasis on educating both the public and the regulated community on means aimed at reducing exposures. The NIEHS does not believe that other cancers or non-cancer health outcomes provide sufficient evidence of a risk to currently warrant concern.

This statement is not sufficient to cause the Staff to change its position with respect to the chronic effects of electromagnetic fields. The NRC staff considers the GEIS finding of "not applicable" still appropriate and will continue to follow developments on this issue.

4.9 Socioeconomics

The socioeconomic issues applicable to Salem and HCGS during the license renewal term are listed in Table 4-23, including applicable GEIS section and category (Category 1, Category 2, or uncategorized).

Table 4-23. Socioeconomic Issues. *Section 2.2.8 of this report describes the socioeconomic conditions near Salem and HCGS.*

Issue	GEIS Section	Category
Housing impacts	4.7.1	2
Public services: public safety, social services, and tourism and recreation	4.7.3; 4.7.3.3; 4.7.3.4; 4.7.3.6	1
Public services: public utilities	4.7.3.5	2
Public services: education (license renewal term)	4.7.3.1	1
Offsite land use (license renewal term)	4.7.4	2
Public services: transportation	4.7.3.2	2
Historic and archaeological resources	4.7.7	2
Aesthetic impacts (license renewal term)	4.7.6	1
Aesthetic impacts of transmission lines (license renewal term)	4.5.8	1
Environmental justice	Not addressed (a)	Uncategorized (a)

(a) Guidance related to environmental justice was not in place at the time the GEIS and the associated revisions to 10 CFR Part 51 were prepared. Therefore, environmental justice must be addressed in plant-specific reviews.

4.9.1 Generic Socioeconomic Issues

The NRC reviewed and evaluated the Salem and HCGS ERs (PSEG, 2009a; PSEG, 2009b), scoping comments, and other available information, and visited the Salem and HCGS sites and did not identify any new and significant information that would change the conclusions presented in the GEIS. Therefore, there would be no impacts related to the Category 1 issues during the period of extended operation beyond those discussed in the GEIS. For Salem and HCGS, the GEIS conclusions for category 1 issues are incorporated by reference. Impacts for Category 2 and uncategorized issues are discussed in the following.

4.9.2 Housing Impacts

According to the 2000 Census, approximately 501,820 people lived within 20 mi (32 km) of Salem and HCGS, which equates to a population density of 450 persons per square mile (PSEG, 2009a; PSEG, 2009b). This density translates to GEIS Category 4 – least sparse (greater than or equal to 120 persons per square mile within 20 mi [32km]). Approximately 5,201,842 people live within 50 mi (80 km) of Salem and HCGS (PSEG, 2009a; PSEG, 2009b). This equates to a population density of 771 persons per square mile. Applying the GEIS proximity measures, this value translates to a Category 4 – in close proximity (greater than or equal to 190 persons per square mile within 50 mi [80 km]). Therefore, according to the sparseness and proximity matrix presented in the GEIS, the sparseness Category 4 and proximity Category 4 indicate that Salem and HCGS are located in a high population area.

Table B-1 of Appendix B to Subpart A of 10 CFR Part 51 states that impacts on housing availability are expected to be of small significance in high-density population areas where growth control measures are not in effect. Since Salem and HCGS are located in a high population area, and Cumberland, Gloucester, Salem, and New Castle Counties are not subject to growth control measures that would limit housing development, any changes in employment at Salem and HCGS would have little noticeable effect on housing availability in these counties. Since PSEG has no plans to add non-outage employees during the license renewal period, employment levels at Salem and HCGS would remain relatively constant with no additional demand for permanent housing during the license renewal term. In addition, the number of available housing units has kept pace with or exceeded the growth in the area population. Based on this information, there would be no additional impact on housing during the license renewal term beyond what has already been experienced.

4.9.3 Public Services: Public Utilities

As discussed in Section 4.7.4 of the GEIS, impacts on public utility services (e.g., water, sewer) are considered SMALL if the public utility has the ability to respond to changes in demand and would have no need to add or modify facilities. Impacts are considered MODERATE if service capabilities are overtaxed during periods of peak demand. Impacts are considered LARGE if additional system capacity is needed to meet ongoing demand.

Analysis of impacts on the public water and sewer systems considered both facility demand and facility-related population growth. As previously discussed in Section 2.1.7, Salem and HCGS obtain their potable water supply directly from groundwater sources. The facility does not purchase water from a public water system. Water usage by Salem and HCGS has not stressed the supply source capacity (usage is approximately 41 percent of the permitted withdrawal [DRBC 2000; NJDEP 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.

Since PSEG has no plans to add non-outage employees during the license renewal period, employment levels at Salem and HCGS would remain relatively unchanged with no additional demand for public water services. Public water systems in the region are adequate to meet the demand of residential and industrial customers in the area. Therefore, there would be no additional impact to public water services during the license renewal term beyond what is currently being experienced.

4.9.4 Offsite Land Use – License Renewal Period

Off-site land use during the license renewal term is a Category 2 issue. Table B-1 of Appendix B to Subpart A of 10 CFR Part 51 notes that "significant changes in land use may be associated with population and tax revenue changes resulting from license renewal." In Section 4.7.4 of the GEIS, the magnitude of land-use changes as a result of plant operation during the period of extended operation is defined as follows:

SMALL - Little new development and minimal changes to an area's land-use pattern.

MODERATE - Considerable new development and some changes to the land-use pattern.

LARGE - Large-scale new development and major changes in the land-use pattern.

Tax revenue can affect land use because it enables local jurisdictions to provide the public services (e.g., transportation and utilities) necessary to support development. Section 4.7.4.1 of the GEIS states that the assessment of tax-driven land-use impacts during the license renewal term should consider (1) the size of the plant's payments relative to the community's total revenues, (2) the nature of the community's existing land-use pattern, and (3) the extent to which the community already has public services in place to support and guide development. If the plant's tax payments are projected to be small relative to the community's total revenue, tax-driven land-use changes during the plant's license renewal term would be SMALL, especially where the community has pre-established patterns of development and has provided adequate public services to support and guide development. Section 4.7.2.1 of the GEIS states that if tax payments by the plant owner are less than 10 percent of the taxing jurisdiction's revenue, the significance level would be SMALL. If the plant's tax payments are projected to be medium to large relative to the community's total revenue, new tax-driven land-use changes would be MODERATE. If the plant's tax payments are projected to be a dominant source of the community's total revenue, new tax-driven land-use changes would be LARGE. This would be especially true where the community has no pre-established pattern of development or has not provided adequate public services to support and guide development.

Population-Related Impacts

Since PSEG has no plans to add non-outage employees during the license renewal period, there would be no noticeable change in land use conditions in the vicinity of the Salem and HCGS. Therefore, there would be no population-related land use impacts during the license renewal term beyond those already being experienced.

Tax Revenue-Related Impacts

As previously discussed in Section 2.2.8.6, PSEG and the Salem site's minority owner Exelon pay annual real estate taxes to Lower Alloways Creek Township. From 2003 through 2009, the owners paid between $1.2 and $1.5 million annually in property taxes to Lower Alloways Creek Township. This represented between 54 and 59 percent of the township's total annual property tax revenue. Each year, Lower Alloways Creek Township forwards this tax money to Salem County, which provides most services to township residents. The property taxes paid annually for Salem and HCGS during 2003 through 2009 represent approximately 2.5 to 3.5 percent of

Salem County's total annual property tax revenues during that time period. PSEG pays annual property taxes to the City of Salem for the Energy and Environmental Resource Center, located in Salem. However, the tax payments for the Center would continue even if the licenses for Salem and HCGS were not renewed; therefore, these tax payments are not considered in the evaluation of tax revenue-related impacts during the license renewal term.

Since PSEG started making payments to the local jurisdiction, population levels and land use conditions in Lower Alloways Creek Township and Salem County have not changed significantly, which might indicate that these tax revenues have had little or no effect on land use activities within the township or county.

Since PSEG has no plans to add non-outage employees during the license renewal period, employment levels at Salem and HCGS would remain relatively unchanged. There would be no increase in the assessed value of Salem and HCGS, and annual property tax payments to Lower Alloways Creek Township would be expected to remain relatively constant throughout the license renewal period. Based on this information, there would be no tax revenue-related land-use impacts during the license renewal term beyond those already being experienced.

4.9.5 Public Services: Transportation Impacts

Table B-1, 10 CFR Part 51 states: "Transportation impacts (level of service) of highway traffic generated... during the term of the renewed license are generally expected to be of small significance. However, the increase in traffic associated with additional workers and the local road and traffic control conditions may lead to impacts of moderate or large significance at some sites." All applicants are required to assess the impacts of highway traffic generated by the proposed project on the level of service of local highways during the term of the renewed license (see 10 CFR 51.53(c)(3)(ii)(J)).

Since PSEG has no plans to add non-outage employees during the license renewal period, traffic volume and levels of service on roadways in the vicinity of Salem and HCGS would not change. Therefore, there would be no transportation impacts during the license renewal term beyond those already being experienced.

4.9.6 Historic and Archaeological Resources

The National Historic Preservation Act (NHPA) requires that Federal agencies take in to account the effects of their undertakings on historic properties. The historic preservation review process mandated by Section 106 of the NHPA is outlined in regulations issued by the Advisory Council on Historic Preservation at 36 CFR Part 800. Renewal of an operating license is an undertaking that could potentially affect historic properties. Therefore, according to the NHPA, the NRC is to make a reasonable effort to identify historic properties in areas of potential effects. If no historic properties are present or affected, the NRC is required to notify the State Historic Preservation Officer before proceeding. If it is determined that historic properties are present the NRC is required to assess and resolve possible adverse effects of the undertaking.

A review of the New Jersey State Museum (NJSM) files shows that there are no previously recorded archaeological or above ground historic architectural resources identified on the Salem/Hope Creek property. As noted in Section 2.2.9.1, literature review and background research of the plant property was conducted as part of the applicant's ER; however, no systematic pedestrian or subsurface archaeological surveys have been conducted at the Salem/Hope Creek site to date. Background research identified 23 National Register of Historic Places listed resources within a 10 mi (16 km) radius of the facility; however, none are located within the boundaries of the Salem/Hope Creek property.

There is little potential for historic and archaeological resources to be present on most of the Salem/Hope Creek property. As noted in Section 2.2.9.2, due to the fact that the Salem and Hope Creek generating stations are located on a manmade island, there is little potential for prehistoric archaeological resources to be present. However, because the creation of the island dates to the historic period, there is potential for historic-period archaeological resources to be present in areas not previously disturbed by construction activities.

No new facilities, service roads, or transmission lines are proposed for the Salem/Hope Creek site as a part of this operating license renewal, nor are refurbishment activities proposed. Therefore, the potential for National Register eligible historic or archaeological resources to be impacted by renewal of this operating license is SMALL. Based on this conclusion there would be no need to review mitigation measures.

4.9.7 Environmental Justice

Under Executive Order (EO) 12898 (59 FR 7629), Federal agencies are responsible for identifying and addressing, as appropriate, potential disproportionately high and adverse human health and environmental impacts on minority and low-income populations. In 2004, the Commission issued a *Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions* (69 FR 52040), which states, "The Commission is committed to the general goals set forth in EO 12898, and strives to meet those goals as part of its NEPA review process."

The Council of Environmental Quality (CEQ) provides the following information in *Environmental Justice: Guidance Under the National Environmental Policy Act* (CEQ, 1997):

> **Disproportionately High and Adverse Human Health Effects.**
>
> Adverse health effects are measured in risks and rates that could result in latent cancer fatalities, as well as other fatal or nonfatal adverse impacts on human health. Adverse health effects may include bodily impairment, infirmity, illness, or death. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant (as employed by NEPA) and appreciably exceeds the risk or exposure rate for the general population or for another appropriate comparison group (CEQ, 1997).
>
> **Disproportionately High and Adverse Environmental Effects.**
>
> A disproportionately high environmental impact that is significant (as defined by NEPA) refers to an impact or risk of an impact on the natural or physical environment in a low-income or minority community that appreciably exceeds the environmental impact on the larger community. Such effects may include ecological, cultural, human health, economic, or social impacts. An adverse environmental impact is an impact that is determined to be both harmful and significant (as employed by NEPA). In assessing cultural and aesthetic environmental impacts, impacts that uniquely affect geographically

dislocated or dispersed minority or low-income populations or American Indian tribes are considered (CEQ, 1997).

The environmental justice analysis assesses the potential for disproportionately high and adverse human health or environmental effects on minority and low-income populations that could result from the operation of Salem and HCGS during the renewal term. In assessing the impacts, the following definitions of minority individuals and populations and low-income population were used (CEQ, 1997):

Minority individuals

Individuals who identify themselves as members of the following population groups: Hispanic or Latino, American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, or two or more races, meaning individuals who identified themselves on a Census form as being a member of two or more races, for example, Hispanic and Asian.

Minority populations

Minority populations are identified when (1) the minority population of an affected area exceeds 50 percent or (2) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.

Low-income population

Low-income populations in an affected area are identified with the annual statistical poverty thresholds from the Census Bureau's Current Population Reports, Series P60, on Income and Poverty.

<u>Minority Population in 2000</u>

There are a total of 23 counties in the 50-mi (80-km) radius surrounding Salem and HCGS. Of these, seven are in New Jersey (Salem, Cumberland, Cape May, Atlantic, Gloucester, Camden and Burlington), three are in Delaware (New Castle, Kent and Sussex), six are in Pennsylvania (Philadelphia, Montgomery, Delaware, Chester, Lancaster, and York) and seven are in Maryland (Harford, Cecil, Baltimore, Kent, Queen Anne's, Caroline and Talbot).

According to 2000 Census data, 35.1 percent of the population (1,872,783 persons) residing within a 80-km (50-mi) radius of Salem and HCGS identified themselves as minority individuals. The largest minority group was Black or African American (1,213,122 persons or 19.5 percent), followed by Asian (190,983 persons or 3.1 percent). A total of 341,886 persons (5.5 percent) identified themselves as Hispanic or Latino ethnicity (USCB, 2003).

Of the 4,579 census block groups located wholly or partly within the 50-mi radius of Salem and HCGS, 1,860 block groups were determined to have minority population percentages that exceeded the 50-mi (80-km) radius percentage (USCB, 2000a). The largest minority group was Black or African American, with 1,284 block groups that exceed the 50-mi (80-km) radius percentage. These block groups are primarily located in Philadelphia County, Pennsylvania. There were 24 block groups with Asian, 94 block groups with Some Other Race, and 1 block group with Two or More Races minority classifications that exceeded the 50-mi (80-km) radius percentage. A total of 202 block groups exceeded the 80-km (50-mi) radius percentage for

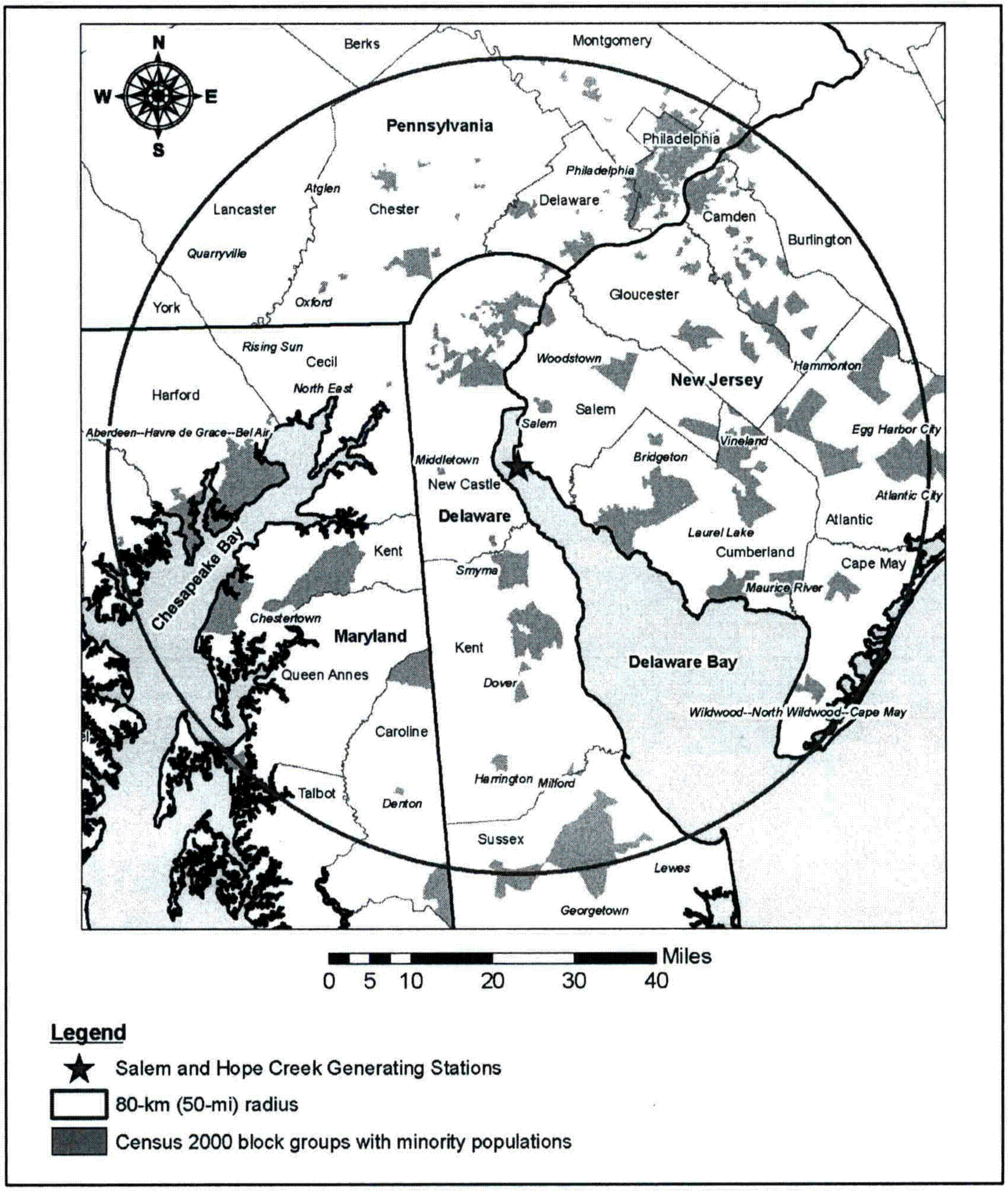
Hispanic or Latino ethnicity. The minority population nearest to Salem and HCGS is located in the City of Salem, New Jersey.

Based on 2000 Census data, Figure 4-7 shows minority block groups within an 50-mi (80-km) radius of Salem and HCGS.

Low-Income Population in 2000

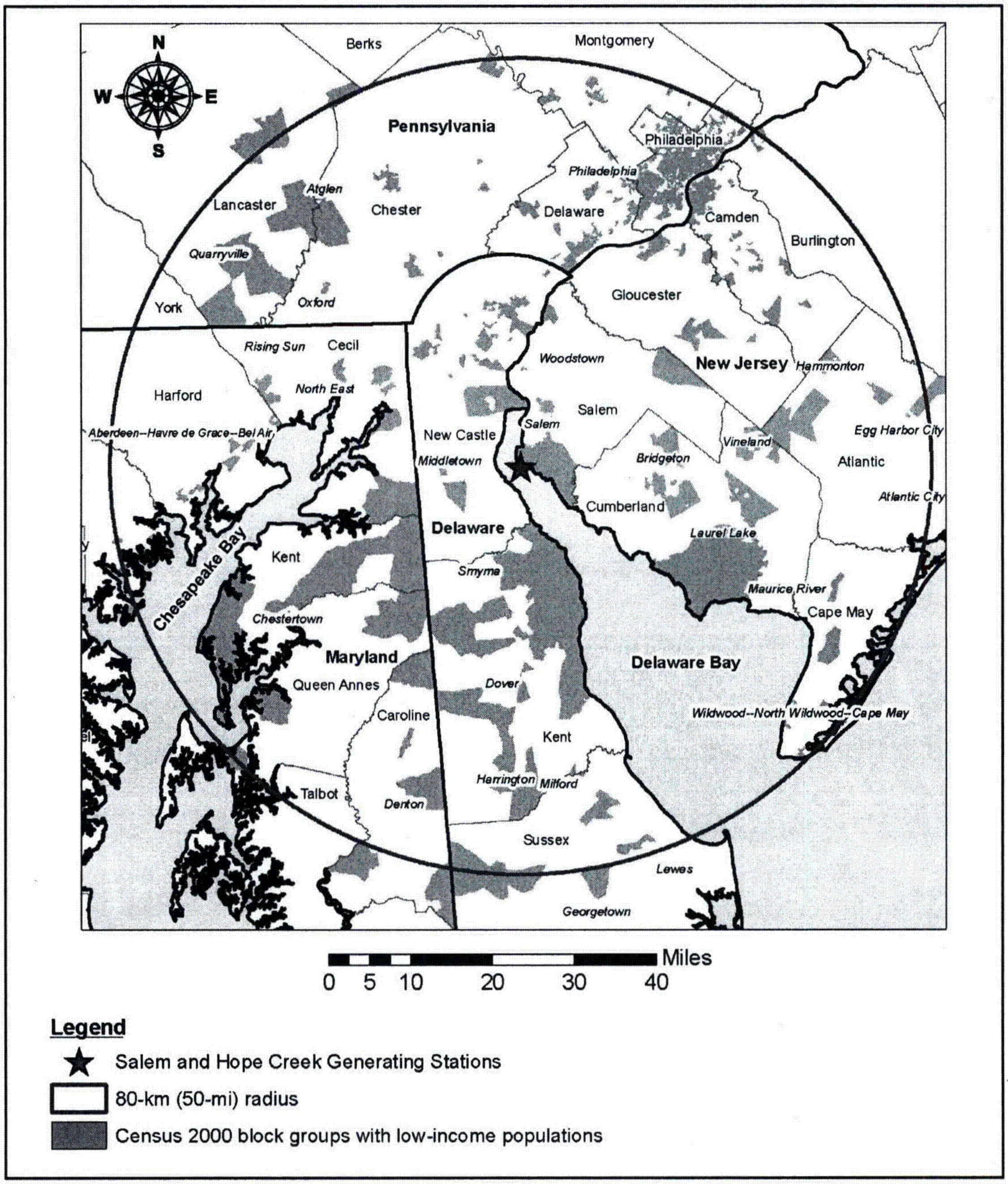
According to 2000 Census data, 119,283 families (2.2 percent) and 620,903 individuals (11.6 percent) residing within a 50-mi (80 km) radius of Salem and HCGS were identified as living below the Federal poverty threshold in 1999 (USCB, 2003). (The 1999 Federal poverty threshold was $17,029 for a family of four). The USCB reported 6.3 percent of families and 8.5 percent of individuals in New Jersey, 6.5 percent of families and 9.2 percent of individuals in Delaware, 7.8 percent of families and 11.0 percent of individuals in Pennsylvania, and 6.1 percent of families and 8.5 percent of individuals in Maryland living below the Federal poverty threshold in 1999 (USCB, 2000a; USCB, 2000b).

Census block groups were considered low-income block groups if the percentage of families and individuals living below the Federal poverty threshold exceeded the 50-mi (80 km) radius percentage. Based on 2000 Census data, there were 1,778 block groups within a 50-mi (80 km) radius of Salem and HCGS that could be considered low-income block groups. The majority of low-income population census block groups were located in Philadelphia County, Pennsylvania. The low-income population nearest to Salem and HCGS is located in Lower Alloways Creek Township in Salem County, New Jersey. Figure 4-8 shows low-income census block groups within a 50-mi (80 km) radius of Salem and HCGS.



Source: USCB, 2003

Figure 4-7. Census 2000 minority block groups within a 50-mi radius of Salem and HCGS



Source: USCB, 2003

Figure 4-8. Census 2000 low-income block groups within a 50-mi radius of Salem and HCGS

Radiological Exposure

As part of addressing environmental justice associated with license renewal, the Staff also analyzed the risk of radiological exposure through the consumption patterns of special pathway receptors, including subsistence consumption of fish and wildlife, native vegetation, surface waters, sediments, and local produce; absorption of contaminants in sediments through the skin; and inhalation of plant materials. The special pathway receptors analysis, discussed below, is important to the environmental justice analysis because consumption patterns may reflect the traditional or cultural practices of minority and low-income populations in the area.

Section 4-4 of EO 12898 (59 FR 7629) directs Federal agencies, whenever practical and appropriate, to collect and analyze information on the consumption patterns of populations that rely principally on fish and/or wildlife for subsistence and to communicate the risks of these consumption patterns to the public. In this draft SEIS, the Staff considered whether there were any means for minority or low-income populations to be disproportionately affected by examining impacts to American Indian, Hispanic, and other traditional lifestyle special pathway receptors. Special pathways that took into account the levels of contaminants in native vegetation, crops, soils and sediments, surface water, fish, and game animals on or near Salem and HCGS were considered.

PSEG has an ongoing comprehensive 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 (14 to 29 km) 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, 2010c).

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, 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, 2010c).

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, 2010c).

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, 2010c).

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 contained 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, 2010c).

Surface water samples collected monthly at four indicator stations and one control station contained trace amounts of tritium (slightly above the minimum detectable concentration range) at the indicator stations; no tritium was detected 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 contained gross alpha activity below per-operational levels; all samples contained 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 contained only 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, 2010c).

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; detected Potassium 40 concentrations were 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 those detected during 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; these samples were 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 occurring 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, 2010c).

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, 2010c).

Previously, PSEG had also tested muskrat populations in the area. Muskrats are trapped and consumed by the local population (PSEG, 2006c). As of 2006, no muskrat samples have been available for testing as the trappers who were supplying PSEG with samples were no longer operating (PSEG, 2007c). The last muskrat data was collected in 2005; only one sample detectable levels of potassium-40; no other radionuclides were detected (PSEG, 2006c).

The results of the 2009 REMP sampling and previous REMP reports (including the consideration of 2005 REMP muskrat data) demonstrate that the routine operation at Salem and HCGS has had no significant or measurable radiological impact on the environment. No elevated radiation levels have been detected in the offsite environment as a result of plant operations and the storage of radioactive waste.

The NJDEP 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 contained only potassium-40, a naturally-occurring radionuclide. Trace amounts of strontium-90 were detected in all milk samples, at levels consistent with what is expected as a result of nuclear weapons testing in the 1950s and 1960s (NJDEP, 2009b).

Based on these 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.

Analysis of Impacts

The NRC addresses environmental justice matters for license renewal through (1) identification of minority and low-income populations that may be affected by the proposed license renewal, and (2) examining any potential human health or environmental effects on these populations to determine if these effects may be disproportionately high and adverse.

The discussion and figures above indentifies the location of minority and low-income populations residing within a 50-mi (80 km) radius of Salem and HCGS. This area of impact is consistent with the impact analysis for public and occupational health and safety, which also considers the radiological effects on populations located within a 50-mi (80 km) radius of the plant. As previously discussed for the other resource areas in Chapter 4, the analyses of impacts for all resource areas indicated that the impact from license renewal would be SMALL.

Chapter 5 discusses the environmental impacts from postulated accidents that might occur during the license renewal term, which include both design basis and severe accidents. In both cases, the Commission has generically determined that impacts associated with such accidents are SMALL because nuclear plants are designed to successfully withstand design basis accidents, and that any risk associated with severe accidents were also SMALL.

Therefore the Staff concludes that there would be no disproportionately high and adverse impacts to minority and low-income populations from the continued operation of Salem and HCGS during the license renewal term.

4.10 Evaluation of Potential New and Significant Information

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

The Staff has a process for identifying new and significant information. That process is described in detail in NUREG-1555, Supplement 1, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal* (NRC, 1999b). The search for new information includes: (1) review of an applicant's ER and the process for discovering and evaluating the significance of new information; (2) review of records of public comments; (3) review of environmental quality standards and regulations; (4) coordination with Federal, State, and local environmental protection and resource agencies, and (5) review of the technical literature. New information discovered by the Staff is evaluated for significance using the criteria set forth in the GEIS. For Category 1 issues where new and significant information is identified, reconsideration of the conclusions for those issues is limited in scope to the assessment of the relevant new and significant information; the scope of the assessment does not include other facets of an issue that are not affected by the new information.

The Staff has not identified any new and significant information on environmental issues listed in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, related to the operation of Salem and HCGS during the period of license renewal. The Staff also determined that information provided during the public comment period did not identify any new issues that require site-specific assessment.

The Staff reviewed the discussion of environmental impacts in the GEIS (NRC, 1996) and conducted its own independent review (including two public scoping meetings held in November 2009) to identify new and significant information.

4.11 Cumulative Impacts

The Staff considered potential cumulative impacts in the environmental analysis of continued operation of Salem and HCGS. For the purposes of this analysis, past actions are those related to the resources at the time of the power plants licensing and construction; present actions are those related to the resources at the time of current operation of the power plants; and future actions are considered to be those that are reasonably foreseeable through the end of plant operations including the period of extended operation. Therefore, the analysis considers potential impacts through the end of the current license terms as well as the 20-year renewal license renewal terms. The geographic area over which past, present, and future actions would occur depend on the type of action considered and is described below for each impact area.

4.11.1 Cumulative Impact on Water Resources

For the purposes of this cumulative impact assessment, the spatial boundary of the groundwater system is the Potomac-Raritan-Magothy aquifer, which is a large aquifer of regional importance for municipal and domestic water supply. Although other aquifers (the shallow water-bearing zone, Vincentown Aquifer, and Mt. Laurel-Wenonah Aquifer) underlie the Salem and HCGS facilities, almost all groundwater use by the facilities is from the Potomac-Raritan-Magothy aquifer. The spatial boundary for potential cumulative surface water impacts is the Delaware River Basin.

Actions that can impact groundwater and surface water resources in the region include overuse of groundwater resources, unregulated use of water resources, drought impacts, and the need for flow compensation in the Delaware River for consumptive water use.

Within the Salem and HCGS local area, groundwater is not accessed for public or domestic water supply within 1 mi (1.6 km) of the Salem and HCGS facilities (PSEG, 2009a; PSEG, 2009b). However, groundwater is the primary source of municipal water supply within Salem and the surrounding counties, and 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 had a cumulative adverse impact on the availability of groundwater within the aquifer (USGS, 1983). In reaction to this impact, NJDEP implemented water management measures, including limitations on pumping. As of 1998, NJDEP-mandated decreases in water withdrawals had resulted in general recovery of water level elevations in both the Upper and Middle Potomac-Raritan-Magothy aquifers in the Salem County area (USGS, 2009). Therefore, the use of groundwater by the facilities is not contributing to a cumulative effect on local groundwater users or larger regional users. Based on these observations, the Staff concludes that, when added to the groundwater usage from other past, present, and reasonably foreseeable future actions, the cumulative impact on groundwater use is SMALL.

Although the Salem and HCGS facilities use surface water from the Delaware River for cooling purposes, the Delaware River is a tidal estuary at the facility location. Therefore, there is no potential for cumulative surface water use conflicts, and the cumulative impact on surface water use is SMALL.

4.11.2 Cumulative Impacts on Estuarine Aquatic Resources

This section addresses past, present, and future actions that have created or could result in cumulative adverse impacts on the aquatic resources of the Delaware Estuary, the geographic area of interest for this analysis. Cumulative impacts on freshwater aquatic resources other than the Delaware River are discussed with terrestrial resources in Section 4.11.3.

A wide variety of historical events have cumulatively affected the Delaware Estuary and its resources. Europeans began settling the estuary region early in the 17th century. By 1660 the English had established multiple small settlements, and major changes in the environment began. Philadelphia had 5,000 inhabitants by 1700 and became the predominant city and port in America. Agriculture grew throughout the region, and the clearing of forest led to erosion. Dredging, diking, and filling gradually altered extensive areas of shoreline and tidal marsh. By the late 1800s, industrialization had altered much of the watershed of the upper estuary, and fisheries were declining due to overfishing as well as pollution from ships, sewers, and industry. By the 1940s, anadromous fish were blocked from migrating upstream to spawn due to a barrier of low oxygen levels in the Philadelphia area. This barrier combined with small dams on tributaries nearly destroyed the herring and shad fisheries. A large increase in industrial pollution during and after World War II resulted in the Delaware River near Philadelphia becoming one of the most polluted river reaches in the world. Major improvements in water quality began in the 1960s through the 1980s as a result of State, multi-State, and Federal action, including the Clean Water Act and the activities of the Delaware River Basin Commission (Delaware Estuary Program, 1995).

In addition to past events, a variety of current and likely future activities and processes also have cumulative impacts on the aquatic resources of the Delaware Estuary to which the proposed action may contribute. Stressors associated with the proposed action and other activities or processes that may contribute to cumulative impacts on the aquatic resources of the estuary include the following:

- continued operation of the once-through cooling system for Salem Units 1 and 2
- continued operation of the closed-cycle cooling system for HCGS
- construction and operation of proposed additional unit at Salem/HCGS site
- continued withdrawal and discharge of water to support power generation, industry, and municipal water suppliers
- fishing pressure
- habitat loss and restoration
- changes in water quality
- climate change.

Each of these stressors may influence the structure and function of estuarine food webs and result in observable changes to the aquatic resources in the Delaware Estuary. In most cases, it is not possible to determine quantitatively the impact of individual stressors or groups of stressors on aquatic resources. The stressors affect the estuary simultaneously, and their effects are cumulative. A discussion follows of how the stressors listed above may contribute to cumulative impacts on aquatic resources of the Delaware Estuary.

<u>Continued Operation of the Salem Once-Through Cooling System</u>

Based on the assessment presented in Section 4.5 of this draft SEIS, the Staff concluded that entrainment, impingement, and thermal discharge impacts on aquatic resources from the operation of Salem Units 1 and 2 collectively have not had a noticeable adverse effect on the balanced indigenous community of the Delaware Estuary in the vicinity of Salem. The continued operation of Salem during the renewal term would continue to contribute to cumulative impacts on the estuarine community of fish and shellfish. As discussed in Sections 4.5.2 through 4.5.5, there has been extensive, long-term monitoring of fish and invertebrate populations of the Delaware Estuary. The data collected by these studies reflect the cumulative effects of multiple stressors acting on the estuarine community. For example, data from 1970 through 2004 were analyzed using commonly accepted techniques for assessing species richness (the average number of species in the community) and species density (the average number of species per unit volume or area). This analysis found that in the vicinity of Salem and HCGS since 1978, when Salem began operation, finfish species richness has not changed, and species density has increased (PSEG, 2006a). Operation of Salem during the relicensing period likely would continue to contribute substantially to cumulative impacts on aquatic resources in conjunction with HCGS and other facilities that withdraw water from or discharge to the Delaware Estuary. However, given the long-term improvements in the estuarine community during recent decades while these facilities were operating, their cumulative impacts are expected to be limited, with effects on individual species populations potentially ranging from negligible to noticeable.

Continued Operation of the HCGS Closed-Cycle Cooling System

As discussed in Section 4.5.1, the closed-cycle cooling system used by HCGS substantially reduces the volume of water withdrawn by the facility and substantially reduces entrainment, impingement, and thermal discharge effects compared to the Salem once-through cooling system. Accordingly, the impacts of these effects from operation of the HCGS cooling system during the relicensing period would be limited, and the incremental contribution of HCGS to cumulative impacts on the estuarine community would be minimal. HCGS has operated in conjunction with Salem since 1986 and the community has been simultaneously affected by both facilities. Therefore, the analysis of Salem's effects on the aquatic community discussed above incorporates the cumulative effects of both HCGS and Salem. Operation of HCGS during the relicensing period would continue to contribute to cumulative impacts in conjunction with Salem and other facilities that withdraw water from or discharge to the Delaware Estuary. As described above for Salem, these cumulative impacts are expected to be limited, with effects on individual species populations potentially ranging from negligible to noticeable.

Construction and Operation of Proposed Additional Unit at Salem/HCGS Site

On May 25, 2010, PSEG submitted to NRC an application for an Early Site Permit for the possible construction and operation of a new nuclear facility with one or two reactor units on Artificial Island adjacent to Salem and HCGS (PSEG, 2010e). The projected start of construction would be in 2016 (NRC, 2010). If PSEG decides to proceed and construct a new nuclear power facililty at the Salem/HCGS site, it would contribute to cumulative impacts on aquatic resources during construction and operation. The impacts of this action on aquatic resources during the construction period may be substantial in the immediate vicinity of the construction activities, but would be limited in extent and unlikely to significantly contribute to cumulative impacts on the estuarine community in conjunction with the ongoing operation of Salem and HCGS. Given the planned use of a closed-cycle cooling system for the new facility, the impacts on aquatic resources from its operation likely would be similar to those of HCGS and substantially smaller than those of Salem. Nevertheless, the long-term operation of the new facility would add to the cumulative impacts on the estuarine community from Salem and HCGS during the period in which their operations overlap.

NRC concluded in the GEIS that impacts on aquatic ecology are Category 1 issues at power plants with closed-cycle cooling systems, such as the system at HCGS and the system planned for the new facility. The Staff concludes in this SEIS (see Section 4.5.5) that impacts on aquatic ecology from the collective effects of entrainment, impingement, and heat shock at Salem during the renewal term would be SMALL. Thus, the incremental contributions of each of the three facilities to impacts on aquatic resources would be minor. However, it is possible that, depending on the characteristics of the new facility, their cumulative impacts could alter an important attribute of the Delaware Estuary, such as certain fish populations, to a noticeable degree.

The specific impacts of this action ultimately would depend on the actual design, operating characteristics, and construction practices proposed by the applicant. Such details are not available at this time. However, if a combined license application is submitted to NRC, the detailed impacts of this additional unit adjacent to the site of the existing Salem and HCGS units then would be analyzed and addressed in a separate NEPA document prepared by NRC.

Continued Water Withdrawals and Discharges

No large industrial facilities lie downstream of Artificial Island on either side of the estuary south to the mouth of Delaware Bay. An oil refinery lies upstream of Artificial Island in Delaware approximately 8 mi (13 km) to the north, and many industrial facilities are upstream from there (PSEG, 2009a). Many of these facilities are permitted to withdraw water from the river and to discharge effluents to the river. In addition, water is withdrawn from the nontidal, freshwater reaches of the river to supply municipal water throughout New Jersey, Pennsylvania, and New York (DRBC, 2010). In the tidal portion of the river, water is used for power plant cooling systems as well as industrial operations. DRBC-approved water users in this reach include 22 industrial facilities and 14 power plants in Delaware, New Jersey, and Pennsylvania (DRBC, 2005). Of these facilities, Salem uses by far the largest volume of water, with a reported water withdrawal volume in 2005 of 1,067,892 million gallons (4,042 million m^3) (DRBC, 2005). This volume exceeds the combined total withdrawal for all other industrial, power, and public water supply purposes in the tidal portion of the river. The volume of water withdrawn by HCGS in 2005 was much lower, at 19,561 million gallons (74 million m^3) (DRBC, 2005).

These activities are expected to continue in the future, and water supply withdrawals likely will increase in the future in conjunction with population growth. Because water withdrawals from the Delaware River will continue, and are likely to increase, during the relicensing term, this activity will continue to contribute to cumulative effects in the estuary. Similarly, ongoing discharges of effluents to the river and estuary will continue to have cumulative effects. Withdrawals and discharges are regulated by Federal and State agencies as well as by the DRBC, limiting the magnitude of their effects. Permit requirements are expected to limit adverse effects from withdrawals and discharges, and cumulative impacts from these activities on the aquatic resources of the Delaware Estuary are expected to be minimal.

Fishing Pressure

The majority of the RS and EFH species at Salem are commercially or recreationally important and, thus, are subject to effects from the harvesting of fish stocks. Losses from fish populations due to fishing pressure are cumulative in conjunction with losses due to entrainment and impingement at Salem and HCGS as well as other water intakes. In most cases, the commercial or recreational catches of RS are regulated by Federal or State agencies, but losses of some RS continue to occur as bycatch caught unintentionally when fishing for other species. The extent and magnitude of fishing pressure and its relationship to cumulative impacts on fish populations and the overall aquatic community of the Delaware Estuary are difficult to determine because of the large geographic scale of the fisheries and the natural variability that occurs in fish populations and the ecosystem. Fishing pressure (and protection of fisheries through catch restrictions) has the potential to influence the food web of the Delaware Estuary by affecting fish and invertebrate populations in areas extending from the Atlantic Ocean and Delaware Bay through the estuary and upriver.

Habitat Loss and Restoration

As described above, alterations to terrestrial, wetland, shoreline, and aquatic habitats have occurred in the Delaware Estuary since colonial times. Development, agriculture, and other upland habitat alterations in the watershed have affected water quality. The creation of dams and the filling or isolation of wetlands to support industrial and agricultural activities has dramatically changed patterns of nutrient and sediment loading to the estuary. Such activities also have reduced productive marsh habitats and limited access of anadromous fish to upstream spawning habitats. In addition, historic dredging and deposition activities have altered estuarine environments and affected flow patterns, and future activities, such as dredging to deepen the shipping channel through the estuary, may continue to influence estuarine habitats. Development along the shores of the estuary in some places also has resulted in the loss of shoreline habitat.

Although habitat loss in the vicinity of the Delaware Estuary continues to occur currently and is likely in the future, habitat restoration activities have had a beneficial effect on the estuary and are expected to continue as a requirement of the Salem NJPDES permit during the license renewal term (see Section 4.5.5). In addition, NRC expects wetland permitting regulations to limit future losses of wetland habitat from development in the watershed. Thus, the net cumulative impacts on aquatic habitats associated with the estuary are likely to be minimal in the future, and restoration activities are expected to provide ongoing habitat improvements.

Water Quality

In general, there is evidence that water quality in the Delaware River Basin, including the estuary, is improving. Upgrades to wastewater treatment facilities and improved agricultural practices during the past 25 years have reduced the amount of untreated sewage, manure, and fertilizer entering the river and contributed to reductions in nutrients and an apparent increase in dissolved oxygen. Chemical contaminants persist in sediments and the tissues of fish and invertebrates, and nonpoint discharges of chemicals still occur (Kauffmann, Belden, and Homsey, 2008). Water quality in the Delaware Estuary likely will continue to be adversely affected by human activities; however, improvement may continue in many water quality parameters, and the incremental contribution of Salem and HCGS to adverse effects on water quality is expected to be minimal.

Climate Change

The potential cumulative effects of climate change on the Delaware Estuary, whether from natural cycles or related to anthropogenic activities, could result in a variety of environmental alterations that would affect aquatic resources. The environmental changes that could affect estuarine systems include sea level rise, temperature increases, salinity changes, and wind and water circulation changes. Changes in sea level could result in dramatic effects on tidal wetlands and other shoreline communities. Water temperature increases could affect spawning patterns or success, or influence species distributions when cold-water species move northward while warm-water species become established in new habitats. Changes in estuarine salinity patterns could influence the spawning and distribution of RS and the ranges of exotic or nuisance species. Changes in precipitation patterns could have major effects on water circulation and alter the nature of sediment and nutrient inputs to the system. This could result in changes to primary production and influence the estuarine food web on many levels. Thus, the extent and magnitude of climate change impacts may make this process an important contributor to cumulative impacts on the aquatic resources of the Delaware Estuary, and these impacts could be substantial over the long term. However, the operation of Salem and HCGS during the renewal term would not emit greenhouse gases that may promote climate change and would not contribute to the cumulative effects of climate change on the Delaware Estuary or the region.

Final Assessment of Cumulative Impacts on Aquatic Resources

Aquatic resources of the Delaware Estuary are cumulatively affected to varying degrees by multiple activities and processes that have occurred in the past, are occurring currently, and are likely to occur in the future. The food web and the abundance of RS and other species have been substantially affected by these stressors historically. The impacts of some of these stressors associated with human activities have been and can be addressed by management actions (e.g., cooling system operation, fishing pressure, water quality, and habitat restoration). Other stressors, such as climate change and increased human population and associated development in the Delaware River Basin, cannot be directly managed and their effects are more difficult to quantify and predict. It is likely, however, that future anthropogenic and natural environmental stressors would cumulatively affect the aquatic community of the Delaware Estuary sufficiently that they would noticeably alter important attributes, such as species ranges, populations, diversity, habitats, and ecosystem processes. Based on this assessment, the Staff concludes that cumulative impacts during the relicensing period from past, present, and future stressors affecting aquatic resources in the Delaware Estuary would range from SMALL to MODERATE. The incremental contributions specifically from the continued operation of Salem and HCGS to impacts on aquatic resources of the estuary would be SMALL for most impacts.

4.11.3 Cumulative Impacts on Terrestrial and Freshwater Resources

This section addresses past, present, and future actions that could result in adverse cumulative impacts on terrestrial resources, including resources associated with uplands, wetlands, and bodies of freshwater other than the Delaware River (discussed in Section 4.11.2). For the purpose of this analysis, the geographic area of interest includes the Salem and HCGS site on Artificial Island and the associated transmission line ROWs identified in Section 2.1.5.

Impacts on terrestrial and freshwater resources in the area began with historical settlement and development by Europeans, which involved clearing of forests and filling and draining of wetlands for agriculture. Colonial settlement of the Delaware River area of southern New Jersey began in 1638. During the 1640s, a fortification, Fort Elfsborg, was built in an area that previously was mostly swampland between Salem and Alloway Creek. As settlement progressed, forested regions in this part of southern New Jersey were further cleared for towns, farming, and lumber (Morris Land Conservancy, 2006). Tidal marshes along the margins of the Delaware Estuary were managed for salt hay farms and other agricultural uses, the hydrology of marshes was altered for mosquito control, and marshes were filled for disposal of dredged material and for development (Philipp, 2005). Industrial development in the area began with the glassmaking industry in the early 1700s and continued through the 1800s (Morris Land Conservancy, 2006). The Industrial Revolution and other historical trends continued the changes in land use and the loss of terrestrial communities of native vegetation and wildlife.

The Salem and HCGS facilities are located within 740 ac (300 ha) of PSEG property on 1,500-ac (600 ha) Artificial Island. Construction of Salem and HCGS converted 373 ac (151 ha) in the southwest corner of Artificial Island to facilities and industrial uses. Artificial Island was originally created by deposition of hydraulic dredge material in the early 20th century, and all terrestrial resources on the island have become established since then. Before development of the land on the Salem and HCGS sites, the vegetative communities of the island consisted mainly of typical coastal tidal marsh species, including salt-tolerant grasses such as cordgrass (*Spartina* spp.) and common reed (*Phragmites australis)*, which could survive in the brackish habitats. There was no known previous development or use of Artificial Island prior to the construction of Salem and HCGS. Currently, the Salem and HCGS sites are developed and maintained for operation of the facilites. The remainder of Artificial Island consists mainly of undeveloped areas of tidal marsh with poor quality soils and very few trees. Non-wetland areas are vegetated mainly with grasses, small shrubs, and planted trees in developed areas (PSEG, 2009a; PSEG, 2009b).

Construction of the transmission line ROWs maintained by PSEG for Salem and HCGS resulted in subsequent changes to the wildlife and plant species present within the vicinity of Artificial Island and along the length of the transmission line ROWs. The transmission lines ROWs have a total length of approximately 149 mi (240 km) and occupy approximately 4,376 ac (1,771 ha). The three ROWs for the Salem and HCGS power transmission system pass through a variety of habitat types, including marshes and other wetlands, agricultural or forested land, and some urban and residential areas (PSEG, 2009a; PSEG, 2009b). Fragmentation of the previously contiguous forested, agricultural, and swamp areas that the transmission ROWs traverse likely resulted in edge effects such as changes in light, wind, and temperature; changes in abundance and distribution of interior species; reduced habitat ranges for certain species; and an increased susceptibility to invasive species, such as multiflora rose (*Rosa multiflora*) in uplands, purple loosestrife (*Lythrum salicaria*) in wetlands, and Japanese stiltgrass (*Microstegium vimineum*) in both habitat types (Snyder and Kaufman, 2004). ROW maintenance is likely to continue to have future impacts on terrestrial habitat, such as prevention of natural succession stages within the ROWs, increases in edge species, and decreases in interior species.

Land use data provide an indication of the impacts on terrestrial resources that have resulted from historical and ongoing development. Current land uses in the region are discussed by county in Section 2.2.8.3 of this draft SEIS. In Salem County, based on 2008 data, farmland under active cultivation is the predominant type of land cover (42 percent), followed by tidal and freshwater wetlands (30 percent), forests (12 percent), residential/commercial/industrial uses (13 percent), and other undeveloped natural areas (3 percent) (Morris Land Conservancy, 2006). In the two adjacent counties in New Jersey (Cumberland and Gloucester), agriculture accounts for 19 and 26 percent of the land cover, and urban land use in the two counties was 12 percent and 26 percent, respectively (Delaware Valley Regional Planning Commission [DVRPC], 2009; Gloucester County, 2009). Thus, commercial and industrial facilities, including the Salem and HCGS site and ROWs, have had a smaller impact on the loss of native terrestrial forest and wetland habitats in the region compared to agricultural development.

Although development of PSEG property on Artificial Island has contributed minimally to impacts on terrestrial resources from historical and ongoing development in the region, portions of both PSEG land and the island have been protected from development. Approximately 25 percent (100 ac [40 ha]) of PSEG property and approximately 80 percent (1,200 ac [485 ha]) of Artificial Island remain undeveloped. These areas consist predominantly of estuarine marsh and freshwater emergent marsh, wetlands, and ponds. The U.S. government owns the portions of the island adjacent to Salem and HCGS (to the north and east), while the State of New Jersey owns the rest of the island as well as much nearby inland property (Lower Alloways Creek Township [LACT],1988a; LACT, 1988b; PSEG 2009a; PSEG, 2009b). In conjunction with the Artificial Island wetlands, public lands in the region also preserve forest and wetland habitat and have a beneficial cumulative impact on terrestrial resources. In compliance with Salem's 1994 and 2001 NJPDES permits, PSEG implemented the EEP, which has preserved and/or restored more than 20,000 ac (8,000 ha) of wetland and adjoining upland buffers around the Delaware Estuary. In particular, the program restored 4,400 ac (1,780 ha) of formerly diked salt hay farms to reestablish conditions suitable for the growth of low marsh vegetation such as saltmarsh cord grass (*Spartina alterniflora*) and provide for tidal exchange with the estuary (PSEG, 2009a).

PSEG has indicated the possibility of constructing a new reactor unit at the Salem and HCGS site on Artificial Island (PSEG, 2010c). It would be primarily located on previously disturbed land adjacent to the existing Salem and HCGS units. It is not know at this time whether new transmission lines would be constructed. If additional ROW needs to be cleared, terrestrial habitats and the wildlife they support could potentially be affected in the areas it would traverse.

The Staff concludes that the minimal terrestrial impacts expected from the continued operation of Salem and HCGS, including the operation and maintenance of the transmission line ROWs, would not contribute to the overall decline in the condition of terrestrial resources. However, while the level of impact due to direct and indirect impacts of Salem and HCGS on terrestrial communities is SMALL, the cumulative impact when combined with all other sources, even if Salem and HCGS were excluded, would be MODERATE.

4.11.4 Cumulative Human Health Impacts

The radiological dose limits for protection of the public and workers have been developed by the NRC and EPA to address the cumulative impact of acute and long-term exposure to radiation and radioactive material. These dose limits are codified in 10 CFR Part 20 and 40 CFR Part 190. For the purpose of this analysis, the area within a 50-mi (80.4-km) radius of the Salem and HCGS site was included. The radiological environmental monitoring program conducted by

PSEG in the vicinity of the Salem and HCGS site measures radiation and radioactive materials from all sources (i.e., hospitals and other licensed users of radioactive material); therefore, the monitoring program measures cumulative radiological impacts. Within the 50-mi (80-km) radius of the Salem and HCGS site, there are no other nuclear power reactors or uranium fuel cycle facilities.

On May 25, 2010 PSEG submitted an application for an Early Site Permit (ESP) for the possible construction of a fourth reactor at the Salem and HCGS site (PSEG 2010e). A specific reactor design has not been selected; therefore, the application uses a plant parameter envelope approach to evaluate the suitability of the site based on the potential environmental impacts from a blend of reactor types. This approach uses surrogate values as upper and lower bounds for issues such as power level, radioactive effluents, public dose estimates, thermal discharges, air quality, and accident consequences, for each of the potential reactor designs being considered. This is a conservative approach allowed by the NRC for the analysis of the environmental impacts from an unspecified reactor design at a specific location. A final decision by the applicant on the reactor design will be deferred until the submission of an application for either a construction permit or a combined construction permit and operating license.

The NRC will evaluate the ESP application in accordance with its regulations to ensure the application meets the NRC requirements for adequate protection and safety of the public and the environment. As discussed above, any new potential source of radioactive emissions from a uranium fuel cycle facility will be evaluated during the licensing process to address the cumulative impact of acute and long-term exposure to radiation and radioactive material.

The applicant constructed an independent spent fuel storage installation (ISFSI) on the Salem and HCGS site in 2007 for the storage of its spent fuel. Currently, only spent fuel from HCGS is being stored in the ISFSI. The installation and monitoring of this facility is governed by NRC requirements in 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste." Radiation from this facility as well as from the operation of Salem and HCGS are required to be within the radiation dose limits in 10 CFR Part 20, 40 CFR Part 190, and 10 CFR Part 72. The NRC performs periodic inspections of the ISFSI and Salem and HCGS to verify their compliance with licensing and regulatory requirements.

Radioactive effluent and environmental monitoring data for the five-year period from 2005 to 2009 were reviewed as part of the cumulative impacts assessment. These reports show that past and current annual radiological doses to a maximally exposed member of the public at the site boundary are well below regulatory dose limits. In Section 4.8 the Staff concluded that impacts of radiation exposure to the public and workers from operation of Salem and HCGS during the renewal term are SMALL. The possible addition of a fourth reactor to the three-reactor site is not expected to result in any substantial increases in doses that would cause the cumulative dose impact to approach regulatory limits. This is because the reactor would be required to maintain its radiological release within NRC's dose limits for individual reactor units and the cumulative dose from all reactor units and the ISFSI on the site. Also, the NRC and the State of New Jersey would regulate any future actions in the vicinity of the Salem and HCGS site that could contribute to cumulative radiological impacts. Therefore, the staff concludes that the cumulative radiological impact to the public and workers from continued operation of Salem and HCGS, its associated ISFSI, and a possible fourth power reactor would be SMALL.

The Staff has determined that the electric-field-induced currents from the Salem and HCGS transmission lines are below the NESC criteria for preventing electric shock from induced currents. Therefore, the Salem and HCGS transmission lines do not significantly affect the overall potential for electric shock from induced currents within the analysis area; the impact is SMALL. The potential effect from the chronic exposure to these electric fields continues to be studied and is not known at this time. The Staff considers the GEIS finding of "Uncertain" still appropriate and will continue to follow developments on this issue.

4.11.5 Cumulative Air Quality Impacts

The Salem and HCGS facilities are located in Salem County, which is included with the Metropolitan Philadelphia Interstate Air Quality Control Region (AQCR), which encompasses the area geographically located in five counties of New Jersey, including Salem and Gloucester Counties, New Castle County Delaware, and five counties of Pennsylvania (40 CFR 81.15). Salem County is designated as in attainment/unclassified area with respect to the National Ambient Air Quality Standards (NAAQSs) for Particulate Matter less than 2.5 microns in diameter ($PM_{2.5}$), sulfur dioxide (SO_2), nitrogen oxides (NOx), carbon monoxide (CO), and lead. The county, along with all of southern New Jersey, is a nonattainment area with respect to the 1-hour primary ozone standard and the 8-hour ozone standard. For the 1-hour ozone standard, Salem County is located within the multi-state Philadelphia-Wilmington-Trenton non-attainment area, and for the 8-hour ozone standard, it is located in the Philadelphia-Wilmington-Atlantic City (PA-NJ-DE-MD) 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 2010b). New Castle County, Delaware is considered to be in moderate non-attainment for the ozone standards, and non-attainment for $PM_{2.5}$ (40 CFR 81.315).

The State of New Jersey has implemented several measures to address greenhouse gas (GHG) emissions within the state. In February 2007, the governor signed EO 54 calling for a reduction in GG emissions to 1990 levels by 2020, and to 80 percent below 2006 levels by 2050. These objectives became mandatory in July 2007, with passage of the Global Warming Response Act. New Jersey also joined with nine other northeastern and mid-Atlantic states in the Regional Greenhouse Gas Initiative (RGGI) through Assembly Bill 4559 in January 2008. The RGGI caps carbon dioxide (CO_2) emissions from power plants, and requires utilities to purchase emissions credits, with the funds used to finance energy efficiency and renewable energy programs.

Potential cumulative effects of climate change on the State of New Jersey, whether or not from natural cycles of anthropogenic (man-induced) activities, could result in a variety of changes to the air quality of the area. As projected in the "Global Climate Change Impacts in the United States" report by the United States Global Change Research Program (USGCRP, 2009), the temperatures in the mid-Atlantic have already risen up to 1°F (0.6°C) since the 1961-1979 baseline, and are projected to increase by 3 to 6°F (1.7 to 3.3 °C) more by 2090. Increases in average annual temperatures, higher probability of extreme heat events, higher occurrences of extreme rainfall (intense rainfall or drought) and changes in the wind patterns could affect concentrations of the air pollutants and their long-range transport, because their formation partially depends on the temperature and humidity and is a result of the interactions between hourly changes in the physical and dynamic properties of the atmosphere, atmospheric circulation features, wind, topography, and energy use (Integrated Panel on Climate Change [IPCC], 2010).

Consistent with the findings in the GEIS, the Staff concludes that the impacts from continued operation of the Salem and HCGS facilities on air quality are SMALL. As no refurbishment is planned at the facilities during the license renewal period, no additional air emissions would result from refurbishment activities (PSEG, 2009a; PSEG, 2009b). In comparison with construction and operation of a comparable fossil-fueled power plant, license renewal would result in a new cumulative deferral of GHG emissions, which would otherwise be produced if a new gas or coal-fired plant were instead constructed. When compared with the alternative of a new fossil-fuel power plant, the option of license renewal also results in a substantial new cumulative deferral in toxic air emissions.

For the purpose of this cumulative air impact assessment, the spatial bounds include the Metropolitan Philadelphia Interstate AQCR, which encompasses the area geographically located in five counties of New Jersey, including Salem and Gloucester Counties, New Castle County Delaware, and five counties of Pennsylvania. The Staff concludes that, combined with the emissions from other past, present, and reasonably foreseeable future actions, cumulative hazardous and criteria air pollutant emission impacts on air quality from Salem and HCGS-related actions would be SMALL. When considered with respect to an alternative of building a fossil-fuel powered plant, continuing the operation of the Salem and HCGS facilities would constitute a net cumulative beneficial environmental impact in terms of emissions offsets (i.e., reducing hazardous, criteria, and GHG air emissions) that would otherwise be generated by a fossil-fuel plant.

4.11.6 Cumulative Socioeconomic Impacts

As discussed in Section 4.9 of this draft SEIS, continued operation of Salem and HCGS during the license renewal term would have no impact on socioeconomic conditions in the region beyond those already being experienced. Since PSEG has indicated that there would be no major plant refurbishment, overall expenditures and employment levels at Salem and HCGS would remain relatively constant with no additional demand for housing, public utilities, and public services. In addition, since employment levels and the value of Salem and HCGS would not change, there would be no population and tax revenue-related land use impacts. There would also be no disproportionately high and adverse health or environmental impacts on minority and low-income populations in the region. Based on this and other information presented in this draft SEIS, there would be no cumulative socioeconomic impacts from Salem and HCGS operations during the license renewal term.

If PSEG decides to proceed and construct a new nuclear power plant unit at the Salem and HCGS site, the cumulative short-term construction-related socioeconomic impacts of this action could be MODERATE to LARGE in counties located in the immediate vicinity of Salem and HCGS. These impacts would be caused by the short-term increased demand for rental housing and other commercial and public services used by construction workers during the years of power plant construction. During peak construction periods there would be a noticeable increase in the number and volume of construction vehicles on roads in the immediate vicinity of the Salem and HCGS site.

The cumulative long-term operations-related socioeconomic impacts of this action during the operation of the new power plant unit would be SMALL to MODERATE. These impacts would be caused by the increased demand for permanent housing and other commercial and public services, such as schools, police and fire, and public water and electric services, from the addition of operations workers at the Salem and HCGS site during the years of new plant operations. During shift changes there would be a noticeable increase in the number of commuter vehicles on roads in the immediate vicinity of the Salem and HCGS site.

Since Salem County has less housing and public services available to handle the influx of construction workers in comparison to New Castle, Gloucester, and Cumberland Counties, the cumulative short-term construction-related socioeconomic impacts on Salem County would likely be MODERATE to LARGE. Over the long-term, cumulative operations impacts on Salem County would likely be SMALL to MODERATE since new operations workers would likely reside in the same counties and in the same pattern as the current Salem and HCGS workforce. Many of the operations workers would be expected to settle in Salem County where nearly 40 percent of the current workforce reside.

Because New Castle, Gloucester, and Cumberland Counties each has a larger available housing supply than Salem County, and the current number of Salem and HCGS workers residing in these three counties combined (43 percent) is the same as those residing in Salem County (40 percent), the cumulative construction- and operations-related socioeconomic impacts are likely to be SMALL in these three counties. If PSEG decides to construct a new nuclear power plant unit at the Salem and HCGS site, the cumulative impacts of this action would likely be SMALL on the four-county socioeconomic region of influence.

The specific impact of this action would ultimately depend on the actual design, characteristics, and construction practices proposed by the applicant. Such details are not available at this time, but if the combined license application is submitted to NRC, the detailed socioeconomic impacts of this action at the Salem and HCGS site would be analyzed and addressed in a separate NEPA document that would be prepared by NRC.

4.11.7 Summary of Cumulative Impacts

The Staff considered the potential impacts resulting from operation of Salem and HCGS during the period of extended operation and other past, present, and reasonably foreseeable future actions in the vicinity of Salem and HCGS. The preliminary determination is that the potential cumulative impacts resulting from Salem and HCGS operation during the period of extended operation would range from SMALL to LARGE. Table 4-24 summarizes the cumulative impact by resource area.

Table 4-24. Summary of Cumulative Impacts on Resource Areas

Resource Area	Impact	Summary
Land Use	SMALL	With respect to the Salem and HCGS facilities, no measureable changes in land use would occur over the proposed license renewal term. When combined with other past, present, and reasonable foreseeable future activities, impacts from continued operation of Salem and HCGS would constitute a SMALL cumulative impact on land use.
Air Quality	SMALL	Impacts of air emissions over the proposed license renewal term would be SMALL. When combined with other past, present, and reasonably foreseeable future activities, impacts to air resources from the Salem and HCGS facilities would constitute a SMALL cumulative impact on air quality. In comparison with the alternative of constructing and operating a comparable gas or coal-fired power plant, license renewal would result in a new cumulative deferral in both GHG and other toxic air emissions, which would otherwise be produced by a fossil-fueled plant.
Ground Water	SMALL	Groundwater consumption constitutes a SMALL cumulative impact on the resource. When this consumption is added to other past, present, and reasonably foreseeable future withdrawals, cumulative impact on groundwater resources is SMALL.
Surface Water	SMALL	Impacts on surface water over the proposed license term would be SMALL. When combined with other past, present, and reasonably foreseeable future activities, impacts to surface water from the Salem and HCGS facilities would constitute a SMALL cumulative impact.
Aquatic Resources	SMALL to MODERATE	Past and present operations have impacted aquatic resources in the vicinity of Salem and HCGS and would likely continue to in the future. Such impacts would continue to be SMALL. When combined with other past, present, and reasonable foreseeable future activities, impacts from continued operation of Salem and HCGS would constitute a SMALL to MODERATE cumulative impact on aquatic resources.
Terrestrial Resources	MODERATE	Past and present operations have impacted terrestrial habitat and species in the vicinity of Salem and HCGS. Continued impacts associated with the proposed license renewal term would be SMALL. When combined with other past, present, and reasonable foreseeable future activities, impacts from continued operation of Salem and HCGS would constitute a MODERATE cumulative impact on terrestrial resources.

Resource Area	Impact	Summary
Threatened or Endangered Species	SMALL	Past and present operations have impacted threatened or endangered species in the vicinity of Salem and HCGS and would likely continue to in the future. Such impacts would continue to be SMALL. When combined with other past, present, and reasonable foreseeable future activities, impacts from continued operation of Salem and HCGS would constitute a SMALL cumulative impact on threatened or endangered species.
Human Health	SMALL	When combined with the other past, present, and reasonably foreseeable future activities, the cumulative human health impacts of continued operation of Salem and HCGS from radiation exposure to the public, microbiological organisms from thermal discharges to the Delaware Estuary, and electric-field-induced currents from the Salem and HCGS transmission lines would all be negligible to SMALL.
Socioeconomics	SMALL to LARGE	Impacts on socioeconomics over the proposed license term would be SMALL depending on the alternative selected. When combined with other past, present, and reasonably foreseeable future activities, impacts to socioeconomics from the Salem and HCGS facilities would constitute a SMALL to LARGE cumulative impact.

4.12 References

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

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

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

10 CFR 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 than Class C Waste."

33 USC 1326. United States Code. Thermal Discharges

36 CFR 800. *Code of Federal Regulations.* Title 36, *Parks, Forests, and Public Property*, Part 800, "Protection of Historic Properties" Federal Register. August 5, 2004.

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

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