King, Ikeda

From: Bacuta, George
Sent: Friday, June 18, 2010 2:49 PM
To: Eccleston, Charles
Cc: McCoppin, Michael; Rosenberg, Stacey; Jolicoeur, John; Bacuta, George; Imboden, Andy
Subject: RE: Section S/HC Air impacts Chapter 2 & 4.1
Attachments: 18June2010_Charle's Draft_Chapter 2 V 2 (Tech Edited version) (2).doc

Charles: Attach my comments. Just e-mail or call me if you need additional assistance. Thanks, ... George

From: Bacuta, George
Sent: Thursday, June 17, 2010 2:20 PM
To: Eccleston, Charles
Cc: McCoppin, Michael; Rosenberg, Stacey
Subject: RE: Section S/HC Air impacts Chapter 2 & 4.1

Charles buddy,

Been reviewing Air, Solid, Hazardous Waste Sections (C 2 & 4), I got several comments and will send input by COB tomorrow (6/18, Friday).

Best,
George

From: Bacuta, George
Sent: Monday, June 14, 2010 3:40 PM
To: Eccleston, Charles
Subject: RE: Section S/HC Air impacts Chapter 2 & 4.1

Thanks. I'll take a look. Will do before 6/21. George

From: Eccleston, Charles
Sent: Monday, June 14, 2010 3:39 PM
To: Bacuta, George
Cc: Eccleston, Charles
Subject: Section S/HC Air impacts Chapter 2 & 4.1

George buddy,

Here is Chapter 2 and Section 4.1 of the Salem/Hope Creek SEIS. Please review the air impacts and make any changes in redline/strike out mode. Can you return this by next Monday 6/21?

Cheers,

Charles H. Eccleston

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

D-100

2.0 AFFECTED ENVIRONMENT

Salem Nuclear Generating Station (Salem) and Hope Creek Generating Station (HCGS) are located at the southern end of Artificial Island in Lower Alloways Creek Township, Salem County, New Jersey. The facilities are located at River Mile 50 and River Mile 51, respectively, approximately 17 miles (mi) south of the Delaware Memorial Bridge. Philadelphia is about 40 mi northeast and the city of Salem, New Jersey, is 8 mi northeast of the site (AEC, 1973). Figure 2-1 shows the location of Salem and HCGS within a 6-mi radius, and Figure 2-2 is an aerial photograph of the site.

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

2.1 FACILITY AND SITE DESCRIPTION AND PROPOSED PLANT OPERATION DURING THE RENEWAL TERM

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

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

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

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

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

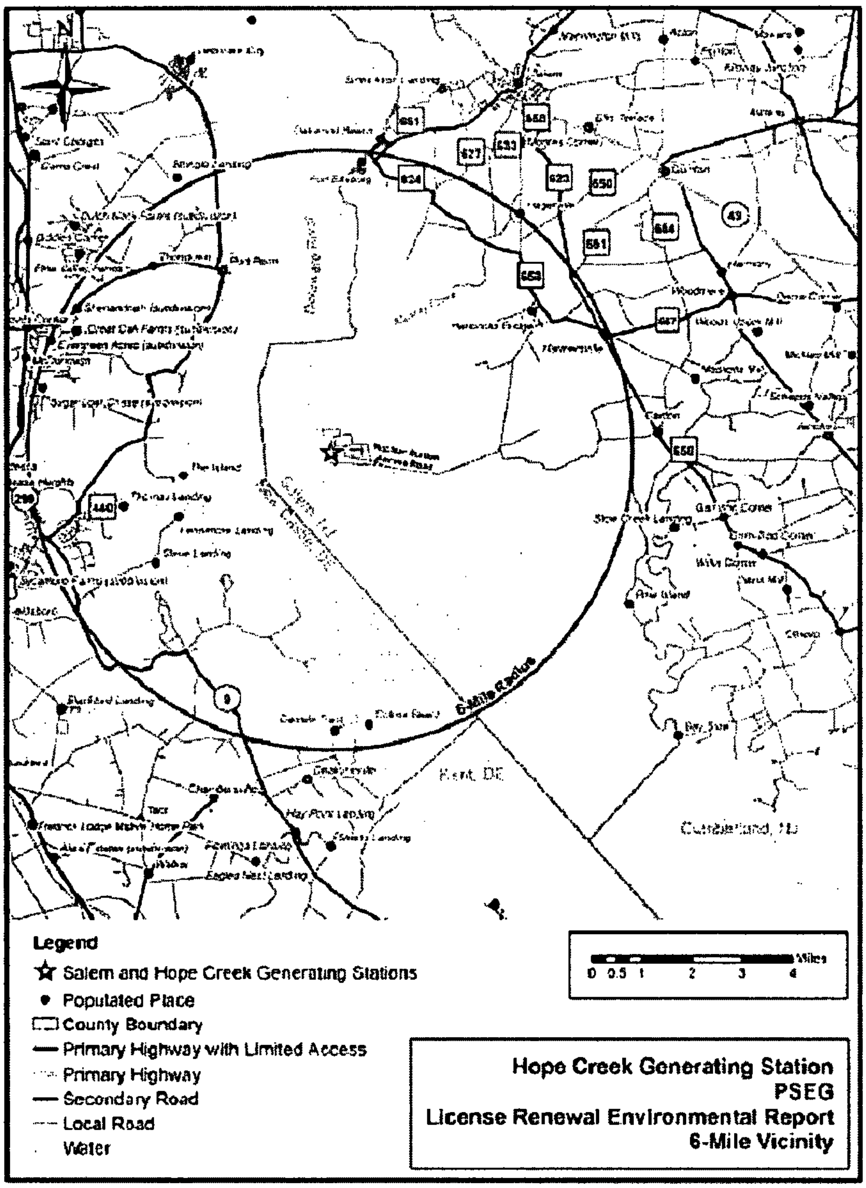


Figure 2-1. Location of the Salem Nuclear Generating Station and Hope Creek Generating Station Site, within a 6-Mile Radius (Source: PSEG, 2009a; PSEG, 2009b)

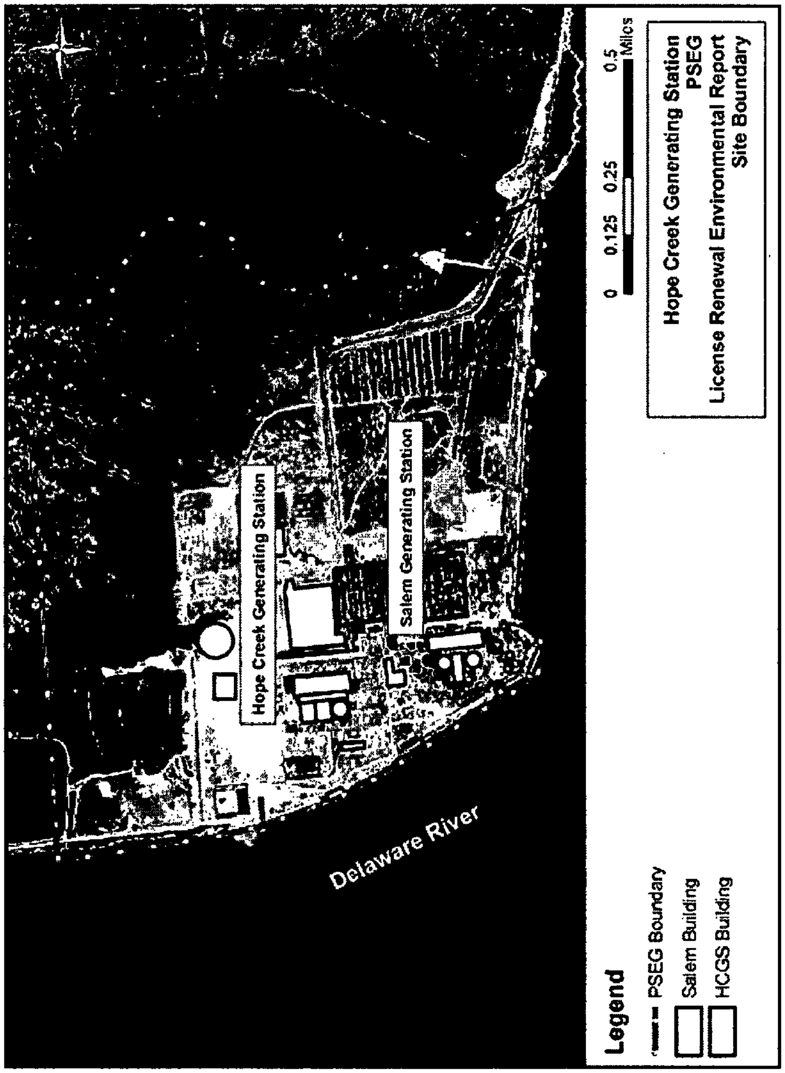


Figure 2-2. Aerial Photo (Source: PSEG, 2009a; PSEG, 2009b)

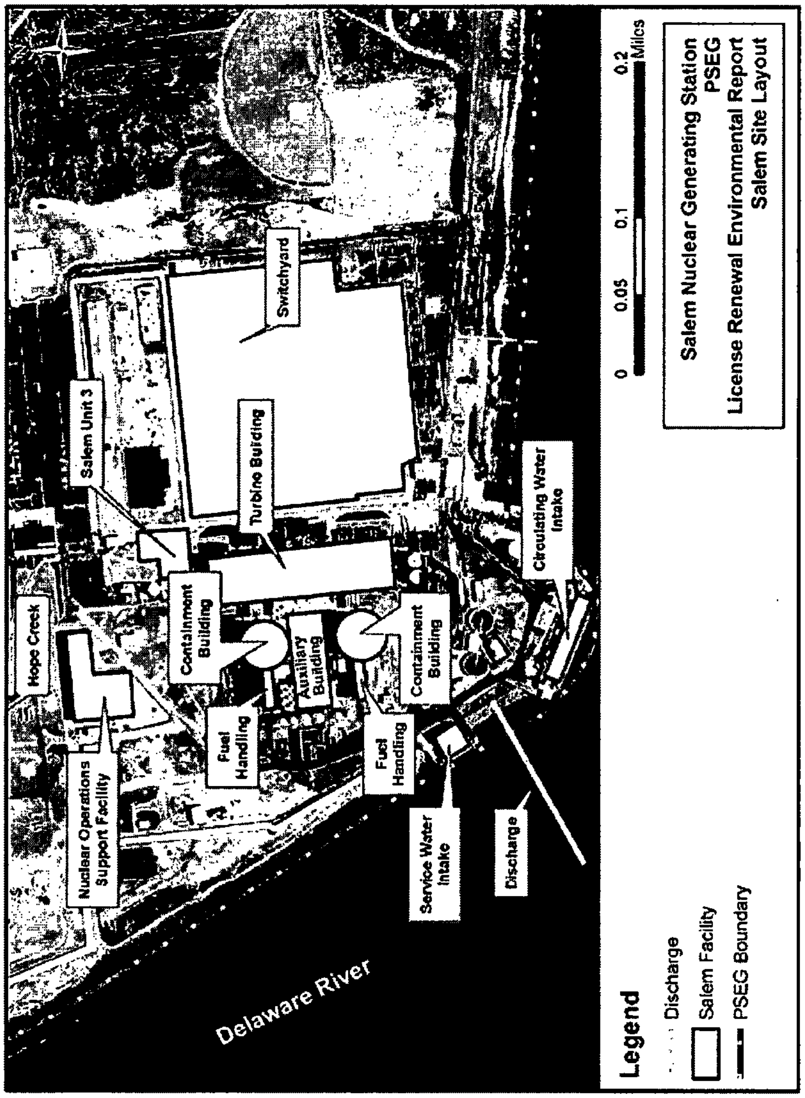


Figure 2-3. Salem Nuclear Generating Station Facility Layout (Source: PSEG, 2009a)

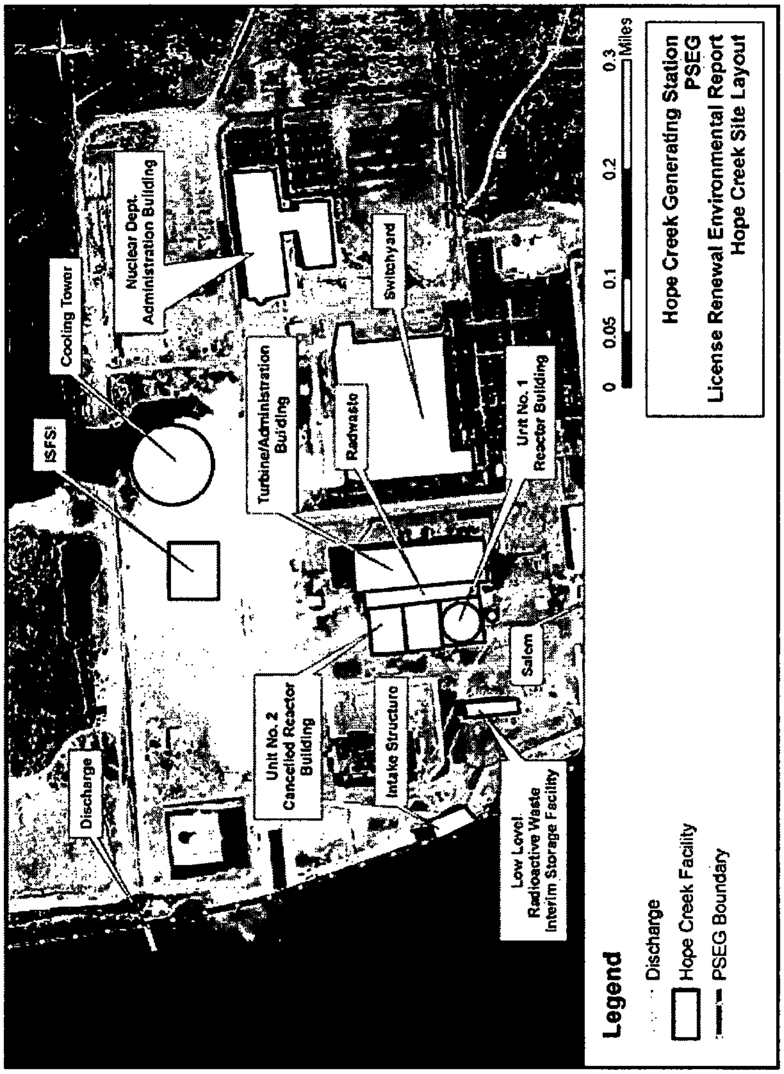
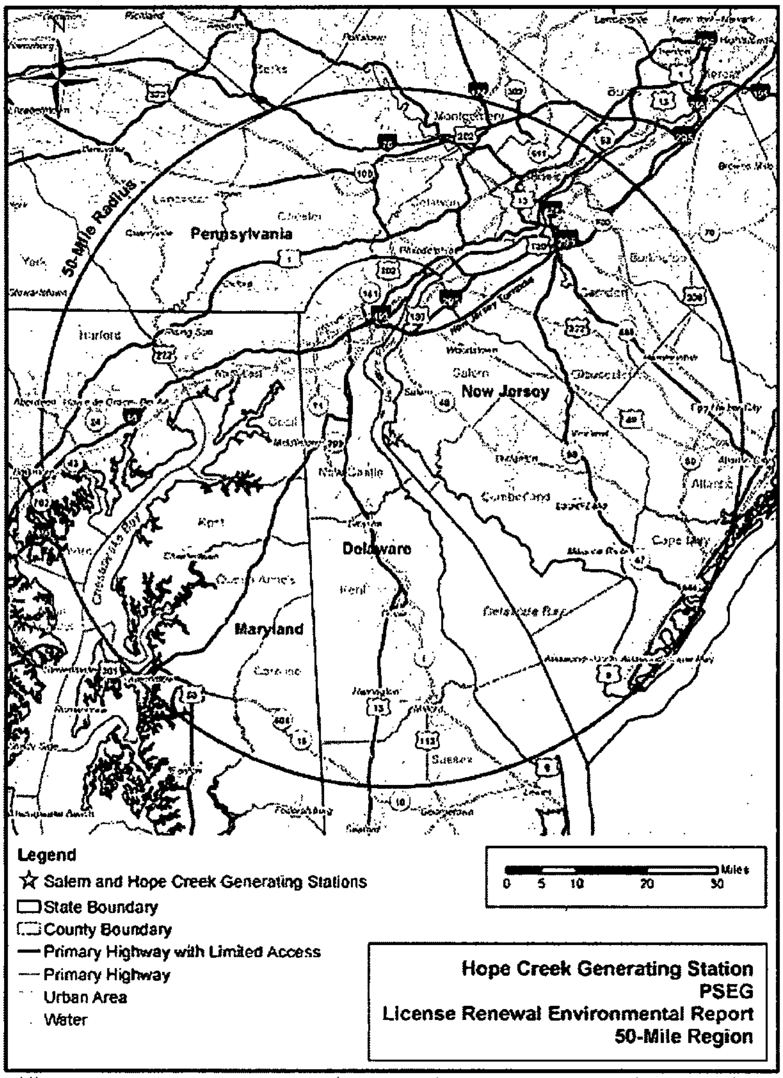


Figure 2-4. Hope Creek Generating Station Facility Layout (Source: PSEG, 2009b)

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



Comment [GCB11]: Please check your geographic locations of Philadelphia, Delaware and Baltimore with the north direction on the map, and make necessary changes. According to Figure 2.5, Baltimore is **southwest** of the Salem/HC facility.

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

Industrial activities within 10 mi of the site are confined principally to the west bank of the Delaware River, north of Artificial Island, in the cities of Delaware City, New Castle, and Wilmington. There is no significant industrial activity near the site. With little industry in the region, construction and retail trade account for nearly 40 percent of the revenues generated in the Salem County economy (USCB, 2006). Smaller communities in the vicinity of the site

(Haddock's Bridge, NJ; Salem, NJ; Quinton, NJ; and Shenandoah, DE) consist primarily of small retail businesses.

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

Salem currently employs a workforce of approximately 665 regular, full-time employees and HCGS currently employs a workforce of approximately 513 regular, full-time employees. The facilities share up to an additional 270 PSEG corporate and 86 matrixed employees for a total of about 1,500 site employees (PSEG, 2009a), (PSEG, 2009b).

2.1.1 Reactor and Containment Systems

2.1.1.1 *Salem Nuclear Generating Station*

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

In the PWR power generation system (Figure 2-6), reactor heat is transferred from the primary coolant to a lower pressure secondary coolant loop, allowing steam to be generated in the steam supply system. The primary coolant loops each contain one steam generator, two centrifugal coolant pumps, and the interconnected piping. Within the reactor coolant system (RCS), the reactor coolant is pumped from the reactor through the steam generators and back to the reactor inlet by two centrifugal coolant pumps located at the outlet of each steam generator. Each steam generator is a vertical, straight tube-and-shell heat exchanger that

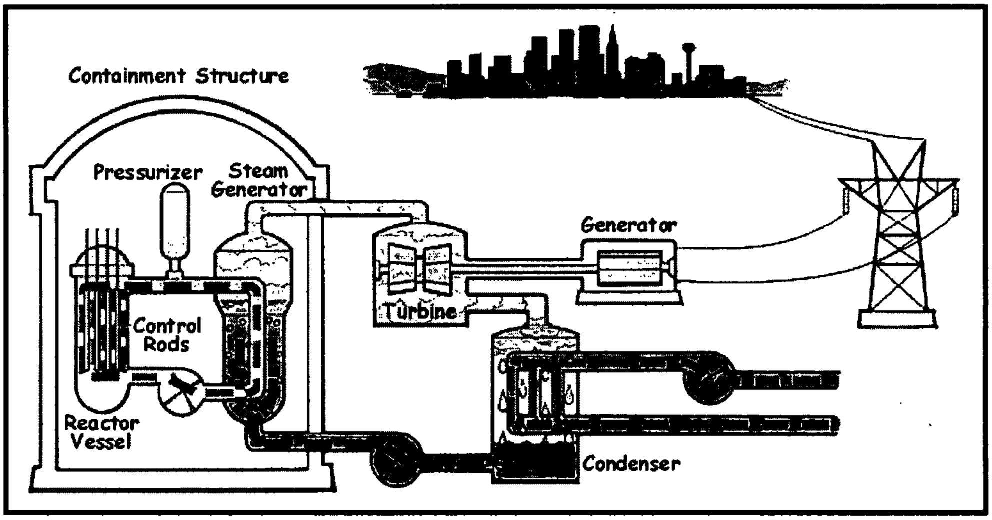


Figure 2-6. Simplified Design of a Pressurized Water Reactor (NRC, 2010a)

produces superheated steam at a constant pressure over the reactor operating power range. The steam is directed to a turbine, causing it to spin. The spinning turbine is connected to a generator, which generates electricity. The steam is directed to a condenser, where it cools and converts back to liquid water. This cool water is then cycled back to the steam generator, completing the loop (NRC, 2010a).

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

The cores of the Salem reactors are moderated and cooled by light water ($^{1}H_2O$ as compared to heavy water, $^{2}H_2O$) at a pressure of 2,250 pounds per square inch absolute (psia). Boron is present in the light water coolant as a neutron absorber. A moderator, or neutron absorber, is a substance that slows the speed of neutrons, increasing the likelihood of fission of a uranium-235 atom in the fuel. The cooling water is circulated by the reactor coolant pumps. These pumps are vertical, single-stage centrifugal pumps equipped with controlled-leakage shaft seals (PSEG, 2007a).

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

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

2.1.1.2 *Hope Creek Generating Station*

HCGS is a one-unit station, which uses a boiling water reactor (BWR) designed by General Electric. The power plant has a current licensed thermal power at 100 percent power of 3,840 MWt with an electrical output estimated to be approximately 1,083 MWe (73 FR 13032), (Nuclear News, 2009). HCGS has a closed-cycle circulating water system for condenser cooling that consists of a natural draft cooling tower and associated withdrawal, circulation, and discharge facilities. HCGS withdraws brackish water with the service water system (SWS) from the Delaware Estuary (PSEG, 2009b).

In the BWR power generation system (Figure 2-7), heat from the reactor causes the cooling water which passes vertically through the reactor core to boil, producing steam. The steam is directed to a turbine, causing it to spin. The spinning turbine is connected to a generator, which generates electricity. The steam is directed to a condenser, where it cools and converts back to liquid water. This cool water is then cycled back to the reactor core, completing the loop (NRC, 2010b).

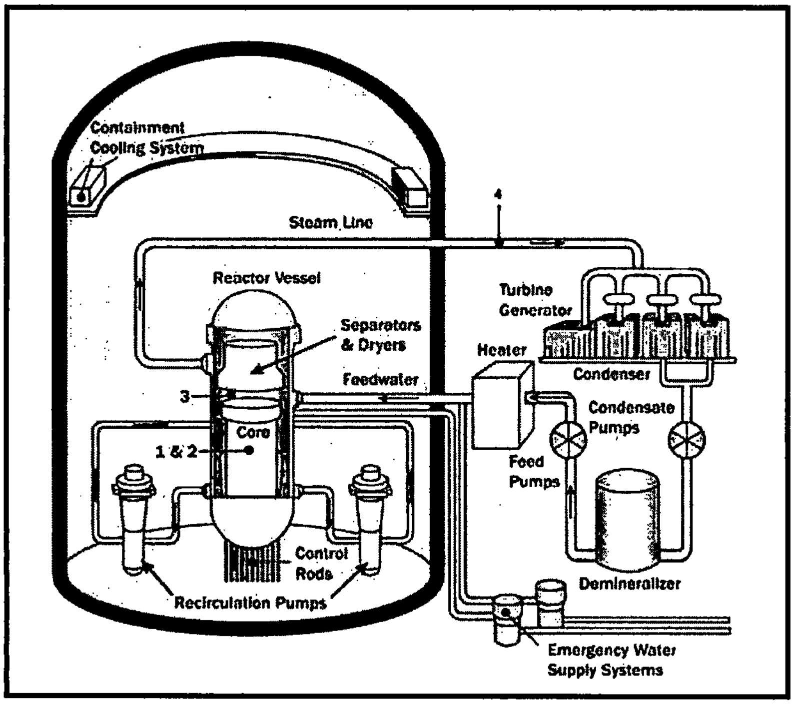


Figure 2-7. Simplified Design of a Boiling Water Reactor (Source: NRC, 2010b)

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

The HCGS reactor uses slightly enriched UO_2 ceramic fuel pellets in zircaloy cladding (PSEG, 2007a). Fuel pellets form fuel rods and fuel rods are joined together in fuel assemblies. HCGS uses fuel that is nominal enriched to 5.0 percent (percent uranium-235 by weight) and the combined fuel characteristics and power loading result in a fuel burn-up of about 60,000 megawatt-days per metric ton uranium (73 FR 13032).

2.1.2 Radioactive Waste Management

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

The Salem and HCGS facilities include radioactive waste systems, which collect, treat, and provide for the disposal of radioactive and potentially radioactive wastes that are byproducts of plant operations. Radioactive wastes include activation products resulting from the irradiation of reactor water and impurities therein (principally metallic corrosion products) and fission products resulting from defective fuel cladding or uranium contamination within the RCS. Radioactive waste system operating procedures ensure that radioactive wastes are safely processed and discharged from the plant within the limits set forth in Title 10 of the *Code of Federal Regulations* (CFR) Part 20, "Standards for Protection against Radiation," and 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities."

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

In 2005, the NRC issued a general license to PSEG authorizing that spent nuclear fuel could be stored at an independent spent fuel storage installation (ISFSI) at the PSEG site. The general license allows PSEG, as a reactor licensee under 10 CFR 50, to store spent fuel from both HCGS and Salem at the ISFSI, provided that such storage occurs in pre-approved casks in accordance with the requirements of 10 CFR 72, subpart K (General License for Storage of Spent Fuel at Power Reactor Sites) (NRC, 2005). At this time, only HCGS spent fuel is stored at the ISFSI. However, transfers of spent fuel from the Salem SFP to the ISFSI are expected to begin approximately 1 year before the remaining capacity of the pool is less than the capacity needed for a complete offload to spent fuel (PSEG, 2009b).

2.1.2.1 *Radioactive Liquid Waste*

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

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

Comment [GCB12]: Provide brief description of process for reader to understand how radioactivity is "remove" (or decrease) from (in) tank liquids before discharge.

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

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

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

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

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

2.1.2.2 *Radioactive Gaseous Waste*

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

At both facilities, radioactive gases are collected so that the short-lived gaseous isotopes (principally air with traces of krypton and xenon) are allowed to decay. At Salem, these gases are collected in tanks in the auxiliary building and released intermittently in a controlled manner. At HCGS, gases are held up in holdup pipes prior to entering a treatment section where adsorption of gases on charcoal provides additional time for decay. At HCGS, gases are then filtered using high-efficiency particulate air (HEPA) filters before being released to the atmosphere from the north plant vent.

Radioactive effluent release reports from 2004 through 2009 for gaseous effluents were reviewed by the NRC staff (PSEG, 2005a), (PSEG, 2006a), (PSEG, 2007a), (PSEG, 2008a), (PSEG, 2009c), (PSEG, 2010a). While variations in total effluents and effluent concentrations can vary from year to year due to outages and plant performance, based on the gaseous waste processing system's performance from 2004 through 2008, the gaseous discharges for 2009 are consistent with prior year effluents. The NRC staff identified no unusual trends.

2.1.2.3 *Radioactive Solid Waste*

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

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

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

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

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

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

2.1.2.4 *Mixed Waste*

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

2.1.3 Nonradioactive Waste Management

Comment [GCB13]: Write –up in this Section 2.1.3 does not necessarily follow current RERB's SEIS template or format, unless the template or format has been revised since March 2008. Template is available at G:\ADRO\DLR\RERB\REB Common\License Renewal Templates\EIS Templates\SEIS TEMPLATE 2008 REVISION\Post OGC Review Mar 2008\Word Pieces. Modify / rewrite as appropriate.

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

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

Comment [GCB14]: Cite MOA letter between State and EPA or applicable State regulation.

2.1.3.1 *Hazardous Waste*

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

PSEG is currently a small-quantity hazardous waste generator (PSEG, 2010b), generating less than 220 pounds/month (lb/month) (100 kilograms/month [kg/month]). Hazardous waste storage (180-day) areas include the hazardous waste storage facility (Location Nos. SH3 and SH30), the combo shop (Location No. SH5), and two laydown areas east of the combo shop (Location Nos. SH6 and SH7). Provide

Comment [GCB15]: Provide historical amounts generated in the last five years and provide brief description where most of the waste come from.

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

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

Proper facility identification numbers for hazardous waste operations include:

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

Under the Emergency Planning and Community Right-to-Know Act (EPCRA), applicable facilities are required to provide information on hazardous and toxic chemicals to local emergency planning authorities and the EPA (Title 42, Section 11001, of the United States Code [U.S.C.] [42 U.S.C. 11001]). On October 17, 2008, the EPA finalized several changes to the Emergency Planning (Section 302), Emergency Release Notification (Section 304), and Hazardous Chemical Reporting (Sections 311 and 312) regulations that were proposed on June 8, 1998 (63 Federal Register [FR] 31268). PSEG is subject to Federal EPCRA reporting requirements, and thus submits an annual Section 312 (TIER II) report on hazardous substances to local emergency agencies. List

Comment [GCB16]: List main chemicals or category of chemicals.

2.1.3.2 *Solid Waste*

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

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

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

2.1.3.3 *Universal Waste*

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

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

Comment [GCB17]: List historical amounts of materials disposed, describing collection and disposal process.

Comment [GCB18]: Insert sub-item for Toxic (or TSCA) Waste discussion (e.g. asbestos, lead-based paint, radon, PCBs, dioxins/furans, etc.). See RERB template at: G:\ADRO\DLR\RERB\REB Common\License Renewal Templates\EIS Templates\SEIS TEMPLATE 2008 REVISION\Post OGC Review Mar 2008\Word Pieces.

2.1.3.4 *Permitted Discharges*

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

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

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

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

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

2.1.3.5 *Pollution Prevention and Waste Minimization*

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

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

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

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

2.1.3.6 *Release of Plant-Related Radionuclides*

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

- HCGS, April 5, 1995: Approximately 88 millicuries (mCi) released from the decontamination solution evaporator steam from HCGS's south plant vent due to inadequate rigor during the design review process.

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

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

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

2.1.4 Facility Operation and Maintenance

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

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

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

2.1.5 Power Transmission System

Comment [GCB19]: RERB's SEIS template or format, unless the template or format has been revised since March 2008. Template is available at G:\ADRO\DLR\RERB\REB Common\License Renewal Templates\EIS Templates\SEIS TEMPLATE 2008 REVISION\Post OGC Review Mar 2008\Word Pieces. Modify / rewrite as appropriate.

Three right-of-way (ROW) corridors and five 500-kilovolt (kV) transmission lines connect Salem and HCGS to the regional electric grid, all of which are owned and maintained by Public Service Electric and Gas Company (PSE&G) and Pepco Holdings Inc. (PHI). Each corridor is 350 ft

(107 m) wide, with the exception of two-thirds of both the HCGS-Red Lion and Red Lion-Keeney lines, which narrow to 200 ft. Unless otherwise noted, the discussion of the power transmission system is adapted from the applicant's environmental reports (ER) (PSEG, 2009a), (PSEG, 2009b) or information gathered at the NRC's environmental site audit.

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

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

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

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

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

2.1.5.1 *New Freedom North Right-of-Way*

- Salem-New Freedom North – This 500-kV line, which is operated by PSE&G, runs northeast from HCGS for 39 mi (63 kilometers [km]) within a 350-ft (107-m) wide corridor to the New Freedom switching station north of Williamstown, NJ. This line shares the corridor with the 500-kV HCGS-New Freedom line.

- HCGS-New Freedom – This 500-kV line, which is operated by PSE&G, extends northeast from Salem for 43 mi (69 km) within a 350-ft (107-m) wide corridor to the New Freedom switching station north of Williamstown, NJ. This line shares the corridor with the 500-kV Salem-New Freedom North line. During 2008, a new substation (Orchard) was installed along this line, dividing it into two segments.

2.1.5.2 *New Freedom South Right-of-Way*

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

2.1.5.3 *Keeney Right-of-Way*

- Salem-Red Lion – This 500-kV line extends north from HCGS for 13 mi (21 km) and then crosses over the New Jersey-Delaware State line. It continues west over the Delaware River about 4 mi (6 km) to the Red Lion substation. In New Jersey, the line is operated by PSE&G, and in Delaware it is operated by PHI. Two thirds of the 17-mi (27-km) corridor is 200 ft (61 m) wide, and the remainder is 350-ft (107-m) wide.

- Red Lion-Keeney – This 500-kV line, which is operated by PHI, extends from the Red Lion substation 8 mi (13 km) northwest to the Keeney switch station. Two thirds of the corridor is 200 ft (70 m) wide, and the remainder is 350-ft (107-m) wide.

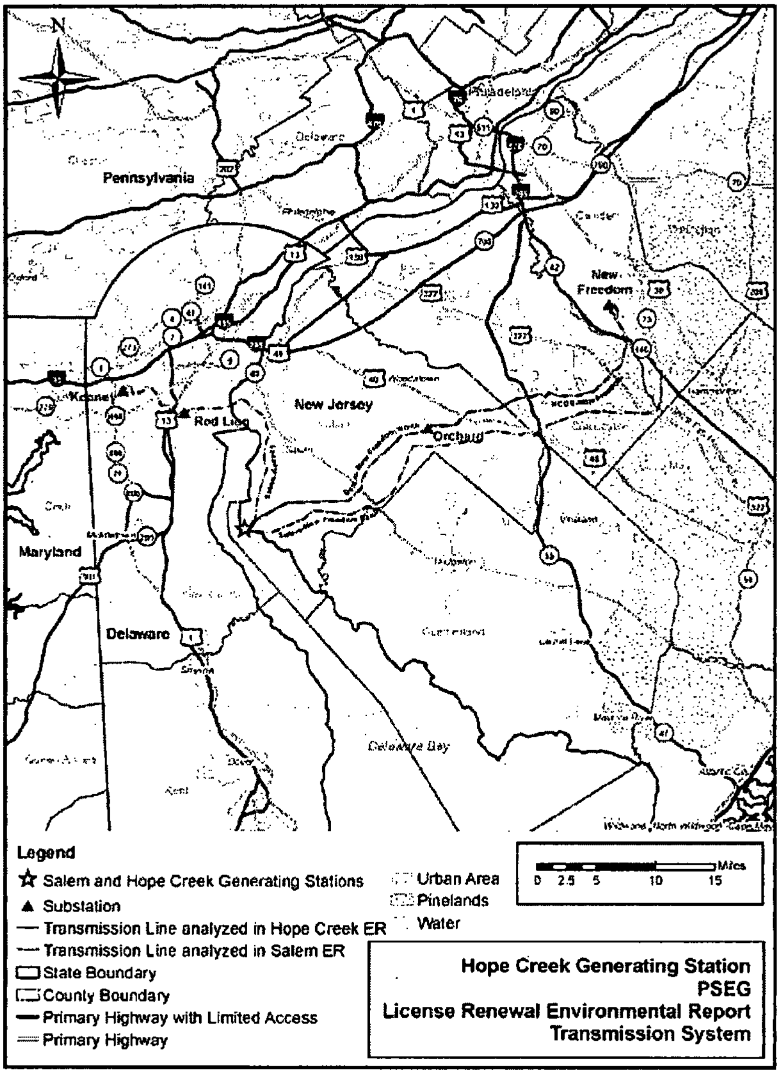


Figure 2-8. Salem Nuclear Generating Station and Hope Creek Generating Station Transmission Line System (Source: PSEG, 2009b)

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

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

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

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

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

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

2.1.6 Cooling and Auxiliary Water Systems

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

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

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

2.1.6.1 *Salem Nuclear Generating Station*

The Salem facility includes two intake structures, each equipped with equipment used to remove debris and biota from the intake water stream (i.e., removable ice barriers, trash racks, traveling screens, and a fish return system). The CWS withdraws brackish water from the Delaware Estuary using 12 circulating water pumps through a 12-bay intake structure located on the shoreline at the south end of the site, and discharges water north on the CWS intake structure via a discharge pipe that extends 500 ft (152 m) from the shoreline. Heavy duty trash racks protect the circulating water pumps and traveling screens from damage by large debris. The trash racks are constructed of 0.5-inch (1.27-cm) wide steel bars with slot openings that are 3 inch (7.6 cm) wide. No biocides are required in the CWS.

The CWS provides approximately 1,050,000 gallons per minute (gpm) (3,974,670 liters per minute [lpm]) to each of Salem's two reactor units. The total design flow is 1,110,000 gpm (4,201,794 lpm) through each unit. The intake velocity is approximately 1 per second (fps) (0.3 meters per second [mps]) at mean low tide (a rate that is compatible with the protection of aquatic wildlife) (EPA, 2001). The CWS provides water to the main condenser to condense steam from the turbine and the heated water is returned back to the estuary (the flow path is shown in the lower right of Figure 2-3).

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

To prevent organic buildup and biofouling in the heat exchangers and piping of the SWS, sodium hypochlorite is injected into the system. SWS water is discharged via the discharge pipe shared with the CWS. Residual chlorine levels are maintained in accordance with the site's NJPDES permit.

2.1.6.2 *Hope Creek Generating Station*

HCGS uses a single intake structure to supply water from the Delaware Estuary to the SWS. The intake structure consists of four active bays that are equipped with pumps and associated equipment (trash racks, traveling screens, and a fish-return system) and four empty bays that were originally intended to service a second reactor which was never built. Water is drawn into the SWS at a rate of 0.3 fps (0.09 mps) passing through trash racks and traveling screens. After passing through the traveling screens, the estuary water enters the service water pumps. Depending on the temperature of the Delaware Estuary water, two or three pumps are normally needed to supply service water. Each pump is rated at 16,500 gpm (62,459 lpm). To prevent organic buildup and biofouling in the heat exchangers and piping of the SWS, sodium hypochlorite is continuously injected into the system.

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

The SWS also provides makeup water for the CWS by supplying water to the cooling tower basin. The cooling tower basin contains approximately 9 million gallons (34 million liters) of water and provides approximately 612,000 gpm (2.317 million lpm) of water to the CWS via four pumps. The CWS provides water to the main condenser to condense steam from the turbine and the heated water is returned back to the estuary (the flow path is shown in the lower right of Figure 2-4).

The HCGS cooling tower is a 512-ft (156-m) high, single counterflow, hyperbolic, natural draft cooling tower (PSEG, 2008c). While the CWS is a closed-cycle system, water is lost due to evaporation. Monthly losses average from 9,600 gpm (36,340 lpm) in January to 13,000 gpm (49,210 lpm) in July. Makeup water is provided by the SWS.

2.1.7 Facility Water Use and Quality

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

2.1.7.1 *Groundwater Use*

The Salem and HCGS facilities access groundwater through production wells to supply fresh water for potable, industrial process makeup, fire protection, and sanitary purposes (PSEG, 2009a), (PSEG, 2009b). Facility groundwater withdrawal is authorized by the NJDEP and the DRBC. The total authorized withdrawal volume is 43.2 million gallons (163 million liters) per month for both the Salem and HCGS sites combined (NJDEP, 2004a), (DRBC, 2000). Although each facility has its own wells and individual pumping limits, the systems are interconnected so that water can be transferred between the facilities, if necessary (PSEG, 2009a), (PSEG, 2009b). The NJDEP permit is a single permit which establishes a combined permitted limit for both facilities of 43.2 million gallons (163 million liters) per month (NJDEP, 2004a).

The groundwater for Salem is produced primarily from two wells, PW-5 and PW-6. PW-5 is installed at a depth of 840 ft (256 m) below ground surface (bgs) in the Upper Raritan Formation, and PW-6 is installed at a depth of 1,140 ft (347 m) in the Middle Raritan Formation. PW-5 has a capacity of 800 gpm (3,016 lpm), and PW-6 has a capacity of 600 gpm (2,262 lpm) (DRBC, 2000). The average water withdrawal from these two wells between 2002 and 2008 was 114 million gallons (430 million liters) per year (TetraTech, 2009). These wells are used to maintain water volume within two 350,000 gallon (1.3 million liter) storage tanks, of which 600,000 gallons (2.26 million liters) is reserved for fire protection (PSEG, 2009a). In addition to these two primary wells, two additional wells, PW-2 and PW-3, exist at Salem. These wells are installed within the Mount Laurel-Wenonah aquifer at depths of about 290 ft (88 m) bgs (DRBC, 2000). These wells are classified as standby wells by NJDEP (NJDEP, 2004a), and had only minor usage in the period from 2002 to 2008 (TetraTech, 2009).

The groundwater for HCGS is produced from two production wells, HC-1 and HC-2, which are installed at depths of 816 ft (249 m) bgs in the Upper Potomac-Raritan-Magothy aquifer

(DRBC, 2000). Each well has a pumping capacity of 750 gpm (2,827 lpm), and the average water withdrawal from the two wells between 2002 and 2008 was 96 million gallons (362 million liters) per year (TetraTech, 2009). The wells are used to maintain water supply within two 350,000 gallon (1.3 million liter) storage tanks. The bulk of the water in the storage tanks (656,000 gallons [2.47 million liters]) is reserved for fire protection, and the remainder is used for potable, sanitary, and industrial uses (PSEG, 2009b).

Overall, the combined water usage for the two facilities has averaged 210 million gallons (792 million liters) per year, or 17.5 million gallons (66 million liters) per month (TetraTech, 2009). This usage is approximately 41 percent of the withdrawal permitted under the DRBC authorization and NJDEP permit (DRBC, 2000), (NJDEP, 2004a).

2.1.7.2 *Surface Water Use*

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

The Salem units are both once-through circulating water systems that withdraw brackish water from the Delaware River through a single CWS intake located at the shoreline on the southern end of Artificial Island. The CWS intake structure consists of 12 bays, each outfitted with removable ice barriers, trash racks, traveling screens, circulating water pumps, and a fish return system. The pump capacity of the Salem CWS is 1,110,000 gpm (4,201,794 lpm) for each unit, or a total of 2,220,000 gpm (8,403,588 lpm) for both units combined. Although the initial design included use of sodium hypochlorite biocides, these were eliminated once enough operational experience was gained to indicate that they were not needed. Therefore, the CWS water is used without treatment (PSEG, 2009a).

In addition to the CWS intake, the Salem units withdraw water from the Delaware River for the SWS, to provide cooling for auxiliary and reactor safeguard systems. The Salem SWS is supplied through a single intake structure located approximately 400 ft (122 m) north of the CWS intake. The Salem SWS intake is also fitted with trash racks, traveling screens, and fish-return troughs. The pump capacity of the Salem SWS is 65,250 gpm (246,996 lpm) for each unit, or a total of 130,500 gpm (493,992 lpm) for both units combined. The Salem SWS water is treated with sodium hypochlorite biocides to prevent biofouling (PSEG, 2009a).

The withdrawal of Delaware River water for the Salem CWS and SWS systems is regulated under the terms of Salem NJPDES Permit No. NJ005622 and is also authorized by the DRBC. The NJPDES permit limits the total withdrawal of Delaware River water to 3,024 million gallons per day (mgd) (11,447 million liters per day), for a monthly maximum of 90,720 million gallons (342,014 million liters) (NJDEP, 2001). The DRBC authorization allows withdrawals not to exceed 97,000 million gallons (365,690 million liters) in a single 30-day period (DRBC, 1977), (DRBC, 2001). The withdrawal volumes are reported to NJDEP through monthly discharge monitoring reports (DMRs), and copies of the DMRs are submitted to DRBC.

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

The HCGS facility uses a closed-cycle circulating water system, with a natural draft cooling tower, for condenser cooling. Like Salem, HCGS withdraws water from the Delaware River to supply a SWS, which cools auxiliary and other heat exchange systems. The outflow from the HCGS SWS is directed to the cooling tower basin, and serves as makeup water to replace water lost through evaporation and blowdown from the cooling tower. The HCGS SWS intake is located on the shore of the river and consists of four separate bays with service water pumps, trash racks, traveling screens, and fish-return systems. The structure includes an additional four bays that were originally intended to serve a second HCGS unit, which was never constructed. The pump capacity of the HCGS SWS is 16,500 gpm (62,459 lpm) for each pump, or a total of 66,000 gpm (249,836 lpm) when all four pumps are operating. Under normal conditions, only two or three of the pumps are typically operated. The HCGS SWS water is treated with sodium hypochlorite to prevent biofouling (PSEG, 2009b).

The discharge from the HCGS SWS is directed to the cooling tower basin, where it acts as makeup water for the HCGS CWS. The natural draft cooling tower has a total capacity of 9 million gallons (34 million liters) of water, and circulates water through the CWS at a rate of 612,000 gpm (2.317 million lpm). Water is removed from the HCGS CWS through both evaporative loss from the cooling tower and from blowdown to control deposition of solids within the system. Evaporative losses result in consumptive loss of water from the Delaware River. The volume of evaporative losses vary throughout the year depending on the climate, but range from approximately 9,600 gpm (36,340 lpm) in January to 13,000 gpm (49,210 lpm) in July. Blowdown water is returned to the Delaware River (NJDEP, 2002b).

The withdrawal of Delaware River water for the HCGS CWS and SWS systems is regulated under the terms of HCGS NJPDES Permit No. NJ0025411 and is also authorized by the DRBC. Although it requires measurement and reporting, the NJPDES permit does not specify limits on the total withdrawal volume of Delaware River water for HCGS operations (NJDEP, 2003). Actual withdrawals average 66.8 mgd (253 million liters per day), of which 6.7 mgd (25 million liters per day) are returned as screen backwash, and 13 mgd (49 million liters per day) is evaporated. The remainder (approximately 46 mgd [179 million liters per day]) is discharged back to the river (PSEG, 2009b).

The HCGS DRBC contract allows withdrawals up to 16.998 billion gallons (64 billion liters) per year, including up to 4.086 billion gallons (15.4 billion liters) of consumptive use (DRBC, 1984a), (DRBC, 1984b). To compensate for evaporative losses in the system, the DRBC authorization requires releases from storage reservoirs, or reductions in withdrawal, during periods of low-flow conditions at Trenton, NJ (DRBC, 2001). To accomplish this, PSEG is one of several utilities which owns and operates the Merrill Creek reservoir in Washington, NJ. Merrill Creek reservoir is used to release water during low-flow conditions, as required by the DRBC authorization (PSEG, 2009b).

The SWS and cooling tower blowdown water from HCGS is discharged back to the Delaware River through an underwater conduit located 1,500 ft (458 m) upstream of the HCGS SWS intake. The HCGS discharge pipe extends 10 ft (3 m) offshore, and is situated at mean tide level. The discharge from HCGS is regulated under the terms of NJPDES Permit No. NJ0025411 (NJDEP, 2001). The locations of the intake and discharge for the HCGS facility are shown in Figure 2-4.

2.2 AFFECTED ENVIRONMENT

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

2.2.1 Land Use

Salem and HCGS are located at the southern end of Artificial Island, located on the east bank of the Delaware River in Lower Alloways Creek Township, Salem County, NJ. The river is approximately 2.5 mi wide at this location. Artificial Island is a 1,500-ac island of tidal marsh and grassland that was created, beginning early in the 20th century, by the USACE. The island was created by disposal of hydraulic dredge spoils within a progressively enlarged diked area, which was established around a natural bar that projected into the river. The average elevation of the island is about 9 ft above MSL with a maximum elevation of approximately 18 ft MSL (AEC, 1973). The site is located approximately 17 mi south of the Delaware Memorial Bridge, 30 mi southwest of Philadelphia, PA, and 7.5 mi southwest of the City of Salem, NJ (PSEG, 2009d).

PSEG owns approximately 740 ac at the southern end of the island, with Salem located on approximately 220 ac and HCGS occupying about 153 ac. The remainder of Artificial Island remains undeveloped. The U.S. Government owns the portions of the island adjacent to Salem and HCGS (to the north and east), while the State of New Jersey owns the rest of the island, as well as much of the nearby inland property (LACT, 1988a), (LACT, 1988b), (PSEG, 2009a), (PSEG, 2009b). The U.S. Government also owns a 1-mi wide inland strip of land abutting the island (AEC, 1973). The northernmost tip of Artificial Island (owned by the U.S. Government) is within the State of Delaware boundary, which was established based on historical land grants related to the Delaware River tide line at that time (PSEG, 2009a), (PSEG, 2009b).

The area within 15 mi of the site is primarily used for agriculture. The area also includes numerous parks and wildlife refuges and preserves, such as Mad Horse Creek Fish and Wildlife Management Area to the east; Cedar Swamp State Wildlife Management Area to the south in Delaware; Appoquinimink, Silver Run, and Augustine State Wildlife Management areas to the west in Delaware; and Supawna Meadows National Wildlife Refuge to the north. The Delaware Bay and estuary is recognized as wetlands of international importance and an international shorebird reserve (NJSA, 2008). The nearest permanent residences are located 3.4 mi south-southwest and west-northwest of Salem and HCGS in Delaware. The nearest permanent residence in New Jersey is located 3.6 mi east-northeast of the facilities (PSEG, 2009c). The closest densely populated center (with 25,000 residents or more) is located 15.5 mi from Salem and HCGS (PSEG, 2009a), (PSEG, 2009b). There is no heavy industry in the area surrounding Salem and HCGS; the nearest such industrial area is located more than 15 mi north of the site (PSEG, 2009c).

Section 307(c)(3)(A) of the Coastal Zone Management Act (16 USC 1456 (c)(3)(A)) requires that applicants for Federal licenses to conduct an activity in a coastal zone provide to the licensing agency a certification that the proposed activity is consistent with the enforceable policies of the State's coastal zone program. A copy of the certification is also to be provided to the State. Within 6 months of receipt of the certification, the State is to notify the Federal agency whether the State concurs with or objects to the applicant's certification. Salem and HCGS are within New Jersey's coastal zone for purposes of the Coastal Zone Management Act. PSEG's certifications that renewal of the Salem and HCGS licenses would be consistent with the New Jersey Coastal Management Program were submitted to the NJDEP Land Use Regulation

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

2.2.2 Air Quality and Meteorology

2.2.2.1 *Meteorology*

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

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The only NOAA weather station in Salem County with recent data is the Woodstown Pittsgrove Station, located approximately 10 mi northeast of the Salem and NCGS facilities (NOAA, 2010a). A summary of the data collected from this station from 1971 to 2001 indicates that winter temperatures average 35.2 degrees Fahrenheit (°F) (1.8 degrees Celsius [°C]) and summer temperatures average 74.8 °F (23.8 °C). Average annual precipitation in the form of rain and snow is 45.76 inches (116.2 cm), with the most rain falling in July and August and the most snow falling in January (NOAA, 2004).

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Comment [GCB113]: Two space before start of next sentence.

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

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

In 2001, unusually dry conditions were related to two wildfires that burned a total of 54 ac (21.9 ha). In 2009, a series of brush fires destroyed approximately 15 ac (6.1 ha) of farmland and wooded area in Salem County (NOAA, 2010c).

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Climate data are available for the Woodstown Pittsgrove Station from 1901 through 2004, at which time monitoring at this location was ended (NOAA, 2010a). The closest facility which currently monitors climate data, and has an extensive historic record, is the station located at

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the Wilmington New Castle County Airport, located on the opposite side of the Delaware River, approximately 9 mi (14.4 km) northwest of the facilities (NOAA, 2010d).

2.2.2.2 *Air Quality*

Salem County is included in the Metropolitan Philadelphia Interstate Air Quality Control Region (AQCR), which encompasses the area geographically located in five counties of New Jersey, including Salem and Gloucester counties; New Castle County, DE; and five counties of Pennsylvania (40 CFR 81.15). Air quality is regulated by the NJDEP through their Bureau of Air Quality Planning, Bureau of Air Quality Monitoring, and Bureau of Air Quality Permitting (NJDEP, 2009a). The Bureau of Air Quality Monitoring operates a network of monitoring stations for the collection and analysis of air samples for several parameters, including carbon monoxide (CO), nitrogen dioxide, ozone, sulfur dioxide (SO^2), particulate matter, and meteorological characteristics. The closest air quality monitoring station to the Salem and HCGS facilities is in Millville, located approximately 23 mi (36.8 km) to the southeast (NJDEP, 2009a).

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

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

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Sections 101(b)(1), 110, 169(a)(2), and 301(a) of the Clean Air Act (CAA), as amended (42 U.S.C. 7410, 7491(a)(2), 7601(a)), established 156 mandatory Class I Federal areas where visibility is an important value that cannot be compromised. There is one mandatory Class I Federal area in the State of New Jersey, which is the Brigantine National Wildlife Refuge (40 CFR 81.420), located approximately 58 mi (93 km) southeast of the Salem and HCGS facilities. There are no Class I Federal areas in Delaware, and no other areas located within 100 mi (161 km) of the facilities (40 CFR 81.400).

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PSEG has a single Air Pollution Control Operating Permit (Title V Operating Permit), No. BOP080001, from the NJDEP to regulate air emissions from all sources at Salem and HCGS (PSEG, 2009a), (PSEG, 2009b). This permit was last issued on February 2, 2005, and

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expired on February 1, 2010. The facilities qualify as a major source[1] under the Title V permit program and, therefore, are operated under a Title V permit (NJDEP, 2009b). The air emissions sources located at Salem, which are regulated under the permit, include:

Comment [GCB128]: Indicate re-application, under which permit it is operating since expiration in February 1, 2010, and when to expect renewal of permit by NJDEP.

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

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

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

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

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2.2.3 Groundwater Resources

2.2.3.1 *Description*

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

Beneath the shallow water-bearing zone, the Vincentown aquifer is found at a depth of 55 to 135 ft (17 to 41 m) bgs. The Vincentown aquifer is confined and semi-confined beneath Miocene clays of the Kirkwood Formation. Groundwater within the Vincentown aquifer flows toward the south. Water within the Vincentown aquifer is potable and accessed through domestic wells in eastern Salem County, upgradient of the facility. In western Salem County,

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

including near the facility, saltwater intrusion from the Delaware River has occurred, resulting in brackish, non-potable groundwater within this aquifer (PSEG, 2007b).

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

Beneath the Mount Laurel-Wenonah aquifer is a series of clay and fine sand confining units and poor quality aquifers, including the Marshalltown Formation, Englishtown Formation, Woodbury Clay, and Merchantville Formation. These units overlie the Potomac-Raritan-Magothy aquifer, which is found at a depth of 450 ft (145 m), with freshwater encountered to a depth of 900 ft (290 m) bgs at the facility location (PSEG, 2007b). The Potomac-Raritan-Magothy aquifer is a large aquifer of regional importance for municipal and domestic water supply. In order to protect groundwater resources within this aquifer, the State of New Jersey has established Critical Water-Supply Management Area 2, in which groundwater withdrawals are limited and managed through allocations (USGS, 2007). Critical Water-Supply Management Area 2 includes Ocean, Burlington, Camden, Atlantic, Gloucester, and Cumberland counties, as well as the eastern portion of Salem County. The area does not include the western portion of Salem County where the facility is located, so groundwater withdrawals at the facility location are not subject to withdrawal restrictions associated with this management area.

2.2.3.2 *Affected Users*

The use of groundwater by the facility is discussed in Section 2.1.7.1. Groundwater is the source of more than 75 percent of the freshwater supply within the Coastal Plain region, and wells used for public supply commonly yield 500 to more than 1,000 gpm (1,885 to 3,770 lpm) (EPA, 1988). The water may have localized concentrations of iron in excess of 460 miligrams per liter (mg/L) and may be contaminated locally by saltwater intrusion and waste disposal; however, water quality is considered satisfactory overall (NJWSC, 2009).

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

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

2.2.3.3 *Available Volume*

Groundwater within the 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 toward Maryland to the southwest. Groundwater withdrawal from the early part of the 20th century through the 1970s resulted in the development of large-scale cones of depression in the elevation of the piezometric surface and, therefore, the available water quantity within the aquifer (USGS, 1983). Large scale withdrawals of water from the aquifer are known to influence water availability at significant lateral distances from pumping centers (USGS, 1983). In reaction to these observations, water management measures, including limitations on pumping, were instituted by the NJDEP (although not including the Salem and HCGS facility area). As of 2003, NJDEP-mandated decreases in water withdrawals had resulted in general recovery of water level elevations in both the Upper and Middle Potomac-Raritan-Magothy aquifers in the Salem County area (USGS, 2009).

2.2.3.4 *Existing Quality*

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

In 2003, a release of tritium to groundwater from the Salem Unit 1 SFP was identified. The initial indication of the release was the detection of low-level radiation on a worker's shoes in the Unit 1 auxiliary building in 2002. This led to the discovery of a chalk-like radioactive substance on the walls of the mechanical penetration room, which had resulted from the seepage of water from the SFP. The seepage was caused from the blockage of drains by mineral deposits. Response measures, including removal of the mineral deposits and installation of additional drains, were taken and the release was stopped (Arcadis, 2006).

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

In 2004, PSEG developed a remedial action workplan, and a GRS was approved by NJDEP and became operational by September 2005. The GRS operates by withdrawing tritium-impacted groundwater from six pumping wells within the plume, and a mobile pumping unit that can be moved between other wells as needed to maximize withdrawal efficiency. The pumping system reverses the groundwater flow gradient and stops the migration of the plume toward the property boundaries. The tritium-impacted water removed from the groundwater is processed in the facility's NRLWDS. As part of this system, the groundwater is collected in tanks, sampled, and analyzed to identify the quantity of radioactivity and the isotopic breakdown. Upon verification that the groundwater meets NRC discharge requirements, it is released under controlled conditions to the Delaware River through the circulatory water system (PSEG, 2009a). Operation of the groundwater extraction system is monitored by a network of 36 monitoring wells (PSEG, 2009e). This monitoring indicates that maximum tritium concentrations have dropped substantially, from a maximum of 15,000,000 pCi/L to below 100,000 pCi/L. Some concentrations still exceed the New Jersey Ground Water Quality Criterion for tritium of 20,000 pCi/L (PSEG, 2009e). However, groundwater that exceeds this criterion does not extend past the property boundaries (PSEG, 2009a).

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

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

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

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

2.2.4 Surface Water Resources

2.2.4.1 *Description*

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

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

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

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

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

2.2.4.2 *Affected Users*

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

In the tidal portion of the river, water is accessed for use in industrial operations, including power plant cooling systems. A summary of DRBC-approved water users on the tidal portion of the river from 2005 lists 22 industrial facilities and 14 power plants in Pennsylvania, New Jersey, and Delaware (DRBC, 2005). Of these facilities, Salem is by far the highest volume water user in the basin, with a reported water withdrawal volume of 1,067,892 million gallons (4,025,953 million liters) in 2005 (DRBC, 2005). This volume exceeds the combined total withdrawal for all other industrial, power, and public water supply purposes in the tidal portion of the river. The withdrawal volume for HCGS in 2005 was much lower, at 19,561 million gallons (73,745 million liters).

2.2.4.3 *Water Quality Regulation*

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

The DRBC Stream Quality Objectives are used by the NJDEP to establish effluent discharge limits for discharges within the basin. The EPA granted the State of New Jersey the authority to issue NPDES permits, and such a permit implies water quality certification under the Federal Clean Water Act (CWA) Section 401. The water quality and temperature of the discharges for both the Salem and HCGS discharges are regulated by NJDEP under NJPDES Permit Nos. NJ0025411 (for HCGS) and NJ005622 (for Salem).

2.2.4.4 *Salem Nuclear Generating Station NJPDES Requirements*

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

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

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

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

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

Discharge	Description	Required Reporting	Permit Limits
DSN 048C	Input is NRLWDS and Outfall DSN 487B Discharges to outfall DSNs 481A, 482A, 484A, and 485A	Effluent flow volume	None
		Total suspended solids	50 mg/L monthly average 100 mg/L daily maximum
		Ammonia (Total as N)	35 mg/L monthly average 70 mg/L daily maximum
		Petroleum hydrocarbons	10 mg/L monthly average 15 mg/L daily maximum
		Total organic carbon	Report monthly average 50 mg/L daily maximum
DSNs 481A, 482A, 483A, 484A, 485A, and 486A (the same requirements for each)	Input is cooling water, service water, and DSN 048C Outfall is six separate discharge pipes	Effluent flow volume	None
		Effluent pH	6.0 daily minimum 9.0 daily maximum
		Intake pH	None
		Chlorine-produced oxidants	0.3 mg/L monthly average 0.2 and 0.5 mg/L daily maximum
		Temperature	None
DSN 487B	#3 skim tank, and stormwater from north portion	Effluent flow	None
		pH	6.0 daily minimum 9.0 daily maximum
		Total suspended solids	100 mg/L daily maximum
		Temperature	43.3 °C daily maximum
		Petroleum hydrocarbons	15 mg/L daily maximum
		Total organic carbon	50 mg/L daily maximum
DSN 489A	Oil/water separator, turbine sumps, and stormwater from south portion	Effluent flow	None
		pH	6.0 daily minimum 9.0 daily maximum
		Total suspended solids	30 mg/L monthly average 100 mg/L daily maximum
		Petroleum hydrocarbons	10 mg/L monthly average 15 mg/L daily maximum
		Total organic carbon	50 mg/L daily maximum
DSN Outfall FACA	Combined for discharges 481A, 482A, and 483A	Net temperature (year round)	15.3 °C daily maximum
		Gross temperature (June to September)	46.1 °C daily maximum
		Gross temperature (October to May)	43.3 °C daily maximum
DSN Outfall FACB	Combined for discharges 484A, 485A, and 486A	Net temperature (year round)	15.3 °C daily maximum
		Gross temperature (June to September)	46.1 °C daily maximum
		Gross temperature (October to May)	43.3 °C daily maximum
DSN Outfall FACC	Combined for discharges 481A, 482A, 483A, 484A, 485A, and 486A	Influent flow	3,024 mgd monthly average
		Effluent thermal discharge	30,600 MBTU/hr daily maximum

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

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

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

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

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

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

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

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

- additives that may be used, where they may be used, and procedures for proposing changes to additives
- toxicity testing of discharges and, depending on results, toxicity reduction measures
- implementation and operations of intake screens and fish return systems
- wetland restoration and enhancement through the estuary enhancement program

- implementation of a biological monitoring program
- installation of fish ladders at offsite locations
- performance of studies of intake protection technologies
- implementation of entrainment and impingement monitoring
- conduct of special studies, including intake hydrodynamics and enhancements to entrainment and impingement sampling
- funding of construction of offshore reefs
- compliance with DRBC regulations, NRC regulations, and the NOAA Fisheries Biological opinion

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

2.2.4.5 *Hope Creek Generating Station NJPDES Requirements*

The current NJPDES Permit No. NJ0025411 for the HCGS facility was issued in early 2003, with an effective date of March 1, 2003, and an expiration date of February 29, 2008 (NJDEP, 2003). The permit requires that a renewal application be prepared at least 180 days in advance of the expiration date. Correspondence provided with the applicant's ER indicates that a renewal application was filed on August 30, 2007. However, the current status of that renewal is not provided within the ER and attached NJPDES permit (PSEG, 2009b).

The HCGS NJPDES permit regulates water withdrawals and discharges associated with both stormwater and industrial wastewater, including discharges of cooling tower blowdown (NJDEP, 2003). The cooling tower blowdown and other effluents are discharged through an underwater pipe located on the bank of the river, 1,500 ft (458 m) upstream of the SWS intake. The specific discharge locations, and their associated reporting requirements and discharge limits, are presented in Table 2-3.

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

Discharge	Description	Required Reporting	Permit Limits
DSN 461A	Input is cooling water blowdown and DSN 461C Outfall is discharge pipe	Effluent flow	None
		Intake flow	None
		Effluent pH	6.0 daily minimum 9.0 daily maximum
		Chlorine-produced oxidants	0.2 mg/L monthly average 0.5 mg/L daily maximum
		Effluent gross temperature	36.2oC daily maximum
		Intake temperature	None
		Total organic carbon (effluent gross, effluent net, and intake)	None
		Heat content (June to August)	534 MBTU/hr daily maximum
		Heat content (September to May)	662 MBTU/hr daily maximum
DSN 461C	Input is low volume oily waste from oil/water separator Outfall is to DSN 461A	Effluent flow	None
		Total suspended solids	30 mg/L monthly average 100 mg/L daily maximum
		Total recoverable petroleum Hydrocarbons	10 mg/L monthly average 15 mg/L daily maximum
		Total organic carbon	50 mg/L daily maximum
DSN 462B	Sewage treatment plant effluent, discharges to 461A	Effluent flow	None
		Total suspended solids	30 mg/L monthly average 45 mg/L weekly average 83% removal daily minimum
		Biological oxygen demand (BOD)	8 kg/day monthly average 30 mg/L monthly average 45 mg/L weekly average 87.5 percent removal daily minimum
		Oil and grease	10 mg/L monthly average 15 mg/L daily maximum
		Fecal coliform	200 lbs/100 ml monthly geometric 400 lbs/100 ml weekly geometric average
		6 separate metal and inorganic contaminants (cyanide, nickel, zinc, cadmium, chromium, and copper)	None
S16A	Oil/water separator residuals from 461C	24 separate metal and inorganic contaminants	None
		24 separate organic contaminants	None
		Volumes and types of sludge produced and disposed	None
SL1A	STP system residuals from 462B	17 separate metal and inorganic contaminants	None
		Volumes and types of sludge produced and disposed	None

Source: NJDEP, 2005a

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

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

Comment [AB32]: Define this, does it mean "sewage treatment plant"

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

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

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

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

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

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

2.2.4.6 *Radiological Environmental Monitoring Program*

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

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

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

Surface water results indicate that gross beta have been detected at activities that exceeded pre-operational levels at both the indicator and control locations. In 2008, the maximum pre-operational level for gross beta was 110 pCi/L, with an average of 32 pCi/L. Gross beta activities reported in the 2008 indicator samples had a maximum of 300 pCi/L, and an average of 97 pCi/L. Activities reported in the control sample had a maximum of 158 pCi/L, with an average of 73 pCi/L. Gross beta results from 2006 and 2007 were similar, indicating gross beta activities that exceeded pre-operational levels (PSEG, 2007a), (PSEG, 2008a). For all 3 years, tritium and gamma emitters were detected at levels below pre-operational activities (PSEG, 2007a), (PSEG, 2008a), (PSEG, 2009c).

Sediment results for all 3 years indicated that no gamma emitters were detected at levels that exceeded their pre-operational activities (PSEG, 2007a), (PSEG, 2008a), (PSEG, 2009c).

Potable water sample results for all 3 years indicate that gross alpha and gross beta were detected, but at activities that were lower than their pre-operational levels. Tritium and iodine-131 were not detected. Naturally-occurring gamma emitters potassium-40 and radium were detected in all 3 years, although there was no pre-operational data for comparison. No other gamma emitters were detected (PSEG, 2007a), (PSEG, 2008a), (PSEG, 2009c).

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

2.2.5 Aquatic Resources – Delaware Estuary

2.2.5.1 *Estuary Characteristics*

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

At Artificial Island, the estuary is tidal with a net flow to the south and a width of approximately 16,000 ft (5,000 m) (Figure 2-1). The USACE maintains a dredged navigation channel near the center of the estuary and about 6,600 ft (2,011 m) west of the shoreline at Salem and HCGS. The navigation channel is about 40 ft (12 m) deep and 1,300 ft (397 m) wide. On the New Jersey side of the channel, water depths in the open estuary at mean low water are fairly uniform at about 20 ft (6 m). Predominant tides in the area are semi-diurnal, with a period of 12.4 hours and a mean tidal range of 5.5 ft (1.68 m). The maximum tidal currents occur in the channel, and currents flow more slowly over the shallower areas (NRC, 1984), (Najarian Associates, 2004).

Salinity is an important determinant of biotic distribution in estuaries, and salinity near the Salem and HCGS facilities depends on river flow. The NRC (1984) reported that average salinity in this area during periods of low flow ranged from 5 to 18 parts per thousand (ppt) and during periods of higher flow, ranged from 0 to 5 ppt. Najarian Associates (2004) and PSEG Services Corporation (2005b) characterized salinity at the plant as ranging between 0 and 20 ppt and, in summer during periods of low flow, typically exceeding 6 ppt. Based on temperature and conductivity data collected by the USGS at Reedy Island, just north of Artificial Island, Najarian Associates (2004) calculated salinity from 1991 through 2002. Visual examination of their Figure B6 indicates that salinity appears to have a median of about 5 ppt, exceeded 12 ppt in only 2 years and 13 ppt in only 1 year, and never exceeded about 15 ppt during the entire 11-year period. Based on these observations, the NRC staff assumes that salinity in the vicinity of Salem and HCGS is typically from 0 to 5 ppt in periods of low flow (usually, but not always, in the summer) and 5 to 12 ppt in periods of high flow (Table 2-4). Within these larger patterns, salinity at any specific location also varies with the tides (NRC, 2007).

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

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

Source: NRC, 2007

Monthly average surface water temperatures in the Delaware Estuary vary with season. Between 1977 and 1982, water temperatures ranged from -0.9 °C (30.4 °F) in February 1982 to 30.5 °C (86.9 °F) in August 1980. Although the estuary in this reach is generally well mixed, it can occasionally stratify, with surface temperatures 1 ° to 2 °C (2 ° to 4 °F) higher than bottom temperatures and salinity increasing as much as 2 ppt per meter of water depth (NRC, 1984).

Estuarine waters are classified into three categories based on salinity: oligohaline (0 to 5 ppt), mesohaline (5 to 18 ppt), and polyhaline (greater than 18 ppt). These categories describe zones within the estuary. The estuary reach adjacent to Artificial Island is at the interface of the oligohaline and mesohaline zones; thus, it is oligohaline during high flow and mesohaline during low flow conditions. Based on water clarity categories of good, fair, or poor, the EPA (1998) classified the water clarity in this area of the estuary as generally fair, which it described as meaning that a wader in waist-deep water would not be able to see his feet. The EPA classified the water clarity directly upstream and downstream of this reach as poor, which it described as meaning that a diver would not be able to see his hand at arm's length. Most estuarine waters in the Mid-Atlantic have good water clarity, and lower water clarity typically is due to phytoplankton blooms and suspended sediments and detritus (EPA, 1998).

2.2.5.2 *Plankton*

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

<u>Phytoplankton</u>

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

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

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

More recent studies have summarized the data of many older and qualitative surveys and investigations. Phytoplankton in the lower bay (in less turbid water) account for most of the primary production in the system, which is subsequently transferred to other areas by the currents. Detritus is no longer considered a major source of energy in the trophic structure. Several hundred phytoplankton species have been recorded in the Delaware Estuary, but the assemblage is most often dominated by a few highly abundant species. These species include *S. costatum, Asterionella glacialis, Thalassiosira nordenskioeldii, Rhizosolenia* sp., and *Chaetoceros* sp. (Sutton et al., 1996). In the fresher reaches of the Delaware River, assemblages are dominated by the diatom *Skeletonema potamos* and various cyanobacteria and green algae.

Phytoplankton are currently surveyed by the NJDEP. These surveys are conducted in order to monitor harmful algal blooms, and samples are mostly collected for chlorophyll measurements only. Blooms are highly variable between years but most often occur in the spring (NJDEP, 2005b). Algal blooms can have large consequences for the entire estuary because they can contain flagellates that may make fish and shellfish inedible, and they can deplete the oxygen in the water column so severely that large fish kills can result. The EPA also monitors algal blooms using helicopter surveys (NJDEP, 2005c).

<u>Zooplankton</u>

Zooplankton live in the water column but are not primary producers. They serve as a vital link between the micro algae and the larger organisms in the Delaware Estuary, some of which are called secondary producers. These animals consume the algae, but are still very small, have limited mobility, and provide a source of food for many other organisms, including filter feeders, larvae of fish and invertebrates, and larger zooplankton. Two types of zooplankton occur in the water column: holoplankton, which spend their entire life cycle in the water column, and meroplankton, which spend only part of the time in the water column.

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

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

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

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

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

Meroplankton consists of larval fish and invertebrates that have a planktonic stage before their development into a pelagic, demersal, or benthic adult form is complete. This stage provides an important dispersal mechanism, ensuring that larvae arrive in as many appropriate habitats as possible (Sutton et al., 1996). Studies in the Salem pre-operational phase found many such larval organisms in large numbers, including the estuarine mud crab (*Rhithropanopeus harrisii*), fiddler crab (*Uca minax*), grass shrimp (*Palaemonetes pugio*), and copepod nauplii (PSEG, 1983).

Due to the fact that many of the fish species found in the Delaware Estuary are managed, either Federally or by the individual States, there have been extensive studies of ichthyoplankton (larval fish and eggs). Additionally, fish have been monitored by PSEG and the States of New Jersey and Delaware since before the operation of Salem Units 1 and 2. Ichthyoplankton studies initially were general surveys but then were focused on the 11 target species established during the NPDES permitting process. These studies included impingement and entrainment studies and general sampling consisting of plankton tows and beach seines (PSEG, 1984). Versar reviewed an extensive amount of data with respect to ichthyoplankton, including both the power plant studies and more general surveys focused on managed fish species. The ichthyoplankton of the tidal freshwater region upstream was found to be dominated by the alosids: American shad (*Alosa sapidissima*), hickory shad (*A. mediocris*), alewife (*A. pseudoharengus*), blueback herring (*A. aestivalis*), and other anadromous species. Due to alosid lifecycles, both eggs and larvae have seasonal peaks in abundance and distribution, depending on the species. The ichthyoplankton of the transitional region, in which Artificial Island is located, is dominated by the bay anchovy (*Anchoa mitchilli*); other species include the naked goby (*Gobiosoma bosc*), blueback herring, alewife, Atlantic menhaden (*Brevoortia tyrannus*), weakfish (*Cynoscion regalis*), and silverside (*Menidia menidia*). Species diversity was highest in the spring and summer months, but bay anchovy generally always constituted a large portion of the ichthyoplankton samples (Versar, 1991). The lifecycles, habitats, and other characteristics of fish species identified among the ichthyoplankton are described in Section 2.2.5.4.

2.2.5.3 *Benthic Invertebrates*

Benthic invertebrates (or benthos) are organisms that live within (infauna) or on (epifauna) the substrates at the bottom of the water column, including groups such as worms, mollusks, crustaceans, and microorganisms. Parabenthos are organisms that spend some time in or on the substrate but can also be found in the water column, including crabs, copepods, and mysids. The various benthos discussed here are macroinvertebrates – invertebrates large enough to be seen with the naked eye. The species composition, distribution, and abundance of benthic invertebrates is affected by physical conditions, such as salinity, temperature, water velocity, and substrate type. Substrates within the Delaware Estuary include mud, sand, clay, cobble, shell, rock, and various combinations of these.

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

A review of benthic data for the Delaware Estuary was included in a report for the Delaware Estuary Program (Versar, 1991). Benthic data have been collected in the estuary since the early 1800s. Most of the earlier reports were surveys describing species; however, large amounts of quantitative data were collected in the 1970s. Generally, benthic invertebrate species distributions are limited by salinity and substrate type. Additionally, localized poor water quality can have a major effect on species composition. Species found in the lower bay, such as *Spisula solidissima,* are limited by salinity gradients; estuarine species, such as the razor clam (*Ensis directus*) and the polychaete *Heteromastus filiformis*, are found throughout the entire bay; and freshwater and oligohaline species, such as the clam *Gemma gemma*, occur in lower salinity waters in the upper bay. Overall, densities of benthic macroinvertebrates in the Delaware Estuary are lower than in other east coast estuaries and generally are below 1,000 individuals per square meters (m^2). Secondary production, however, appears to be similar to other estuaries, with the bivalves *E. directus*, *Mytillus edulis*, and *Tellina agilis* and the polychaete *Asabellides oculata* responsible for most of the energy produced (Versar, 1991).

The tidal fresh portion of the estuary is dominated by species that are typical of other North American estuaries, such as tubificid worms, chironomid larvae, sphaerid clams, and unionid mussels. These assemblages are greatly influenced by anthropogenic impacts to the water quality in the area due to the proximity of pollutant sources. Highly tolerant species are found here, often with only one extremely dominant species (for example, along one 10-mi [16-km] segment, 90 percent were *Limnodrillus* spp., and 90 percent of these were *L. heffmeisterii*). The transition zone generally is dominated by oligochaetes and amphipods. The bay region has abundant bivalves (*T. agilis* and *E. directus*) and polychaetes (*Glycera dibranchiata* and *H. filiformis*) (Versar, 1991).

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

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

Species composition and abundance of benthic organisms are often used as indicators of ecosystem health. Generally, the greater the diversity of species and the more abundant those species are, the healthier the system is considered. The EPA collected benthic samples in the

Delaware Estuary between 1990 and 1993 in an effort to assess the health of the system. These samples resulted in the determination that 93 percent of the tidal river between the Chesapeake and Delaware Canal and Trenton, NJ was either degraded or severely degraded. South of this area, only 2 percent of the benthic invertebrate community was classified as impaired, and none was considered severely impaired (Delaware Estuary Program, 1995). More recently, the Delaware-Maryland-Virginia coastal bays are considered impacted over one-fourth of their total area. In the Delaware Bay itself, the upper portions are considered severely impacted, the transition area is classified impacted, and the lower bay is mostly considered in good condition, with a large central area impacted, possibly due to scouring from high currents or eutrophication resulting in high organic carbon levels in the sediments (EPA, 1998).

Studies conducted during the 1984 NPDES 316(b) permitting process included data from over 1,000 grab samples in the Delaware Estuary. A total of 57 taxa in 8 phyla were identified. These were dominated by the same species as found in previous studies (*S. viridis*, *Polydora* sp., *P. litoralis*, *B. improvisus*, and *C. polita*). No other changes in the dominant species per substrate type were reported, but additional species (*E. triloba* and the cumacean *Leucon americanus*) were enumerated among the seasonal immigrants. General densities of benthic organisms ranged between 17,000 per m^2 and 25,000 per m^2. Benthic studies were discontinued as part of the monitoring program for PSEG in 1984 due to the determination that benthic invertebrates would not be substantially affected by plant operations (PSEG, 1984).

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

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

<u>Blue Crab</u>

The blue crab is an important ecological, cultural, commercial, and recreational resource in the Delaware Bay. It is found in estuaries on the east coast of the United States from Massachusetts to the Gulf of Mexico (Hill et al., 1989). The blue crab is highly abundant in estuaries and, therefore, in addition to its economic importance, it plays an important role in the coastal ecosystem. It is an omnivore, feeding on many other commercially important species, such as oysters and clams. Young blue crabs are also prey items for other harvested species, especially those that use the estuary as a nursery area (Hill et al., 1989). Natural mortality rates for the blue crab are hard to define as they vary non-linearly with life stage and environmental parameters. The maximum age reached by blue crabs has been estimated to be 8 years (ASMFC, 2004).

Blue crabs mate in low-salinity portions of estuaries during the summer, usually from May through October (ASMFC, 2004). Males can mate several times, but females mate only once, storing the sperm in seminal receptacles for subsequent spawning events (ASMFC, 2004). Once the female has been fertilized, she migrates to higher-salinity regions to complete the spawning process. The fertilized eggs are extruded over several months and remain attached to the abdomen of the female. The eggs hatch and are released after 1 to 2 weeks, initiating a series of larval transitions. The first larval stage is the zoea. Zoea larvae are planktonic filter feeders approximately 0.009 inch (0.25 millimeter [mm]) long and develop in higher-salinity waters outside of the estuary. These larvae molt seven to eight times in 31 to 49 days before progressing to the next stage, the megalops, which are more like crabs, with pincers and jointed legs (Hill et al., 1989). Megalops larvae are approximately 0.04 inches (1 mm) in length and can swim but are found more often near the bottom in the lower estuary (ASMFC, 2004). After 6 to 20 days, this stage molts into the first crab stage, resembling an adult crab. These juveniles migrate up the estuary into lower salinity regions (Hill et al., 1989). This migration takes approximately 1 year, after which the crabs are adults. Initially, sea grass beds are an important habitat, but crabs then make extensive use of marsh areas as nurseries (ASMFC, 2004).

Adult male crabs usually stay in the upper estuary once they are mature, but females will migrate annually to higher-salinity areas to release their young. Crabs bury themselves in the mud during the winter months, and females will do this near the mouth of the estuary so they can release hatchlings in the spring. Adult crabs are unlikely to travel between estuaries, but they are good swimmers and can travel over land. Movements within an estuary are related to life stage, environmental conditions (temperature and salinity), and food availability. Growth and molting rates are controlled by environmental variables (Hill et al., 1989).

Blue crabs are important in energy transfer within estuarine systems (ASMFC, 2004). They play different roles in the ecosystem depending on their life stage. Zoea larvae consume other zooplankton as well as phytoplankton. Megalops larvae are also omnivorous and consume fish larvae, small shellfish, aquatic plants, and each other. Post-larval stages are also omnivorous scavengers, consuming detritus, carcasses, fish, crabs, mollusks, and organic debris. Blue crabs are prey for a variety of predators, depending on life stage. Crab eggs are eaten by fish. Larval stages are eaten by other planktivores, including fish, jellyfish, and shellfish. Juvenile crabs are consumed by shore birds, wading birds, and fish, including the spotted sea trout (*Cynoscion nebulosus*), red drum (*Sciaenops ocellatus*), black drum (*Pogonius cromis),* and sheepshead (*Archosargus robatocephalus*). Adult crabs are consumed by mammals, birds, and large fish, including the striped bass (*Morone saxatitlis)*, American eel (*Anguilla rostrata*), and sandbar shark (*Carcharhinus plumbeus*) (Hill et al., 1989).

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

Horseshoe Crab

The horseshoe crab is an evolutionarily primitive species that has remained relatively unchanged for 350 million years. It is not a true crab but is more closely related to spiders and other arthropods (FWS, 2006). Horseshoe crabs play a major ecological role in the migration patterns of shore birds from the Arctic to the southern Atlantic. They are also used for bait in the American eel and conch (*Busycon carica* and *B. canaliculatum*) fisheries. The biomedical industry uses their blood to detect contaminated medicines. The crabs are bled and released, although up to 15 percent of them do not survive the procedure.

Around the turn of the 20th century, between 1.5 and 4 million horseshoe crabs were harvested annually for use by the livestock and fertilizer industries. By 1960, catches had declined to 42,000 crabs. In 2007, the estimated harvest was 811,000 crabs, a decrease from the 2.75 million caught in 1998. This reduction is partially due to management and partially due to a decrease in demand. Stock status is currently unknown due to lack of commercial fishing data. Evidence from trawl surveys suggests that the population is growing in Delaware Bay. Harvests have been reduced in Delaware, but are increasing in Massachusetts and New York (ASMFC, 2008a). The management plan for the horseshoe crab prohibits harvesting of all horseshoe crabs in New Jersey and Delaware between January 1 and June 7 and females between June 8 and December 31. It also limits New Jersey and Delaware to 100,000 crabs per year (ASMFC, 2008b). Annual revenues from the horseshoe crab fishery amount to approximately $150 million for the biomedical industry and $21 million for the American eel and conch bait industry (FWS 2003). Threats to their habitat include coastal erosion, development (particularly shoreline stabilization structures such as bulkheads, groins, seawalls, and revetments), sea level rise/land subsidence, channel dredging, contaminants, and oil spills in spawning areas. Habitats of concern include nearshore shallow water and intertidal sand flats, and beach spawning areas (ASMFC, 2010a).

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

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

American Oyster

The American oyster is also known as the eastern oyster and the Atlantic oyster. The oyster is a commercially and environmentally important species and has been harvested in Delaware Bay since the early 1800s (Delaware Estuary Program, 2010). Oysters not only support an important fishery in both New Jersey and Delaware, but they are ecologically important as filterers (enhancing water quality) and provide a complex three-dimensional habitat used by a variety of fishes and invertebrates (DNREC, 2010). By the mid 1850s, oyster fisherman had begun transplanting oysters from the naturally occurring seed beds of New Jersey to other areas in the bay for growth, due to concern over the smaller size of oysters being harvested. The natural seed beds are now protected outside of the leasing system, as these are the sources of the oysters transplanted to other beds. In the early 1900s, one to two million bushels were harvested from the bay annually, concurrent with the use of the new oyster dredge. Production remained relatively stable until the mid 1950s when disease decimated the population. Currently the oyster harvest is limited, mainly due to diseases such as MSX ("multinucleated sphere unknown," later classified as *Haplosporidium nelson)* and Dermo (caused by the southern oyster parasite, *Perkinsus marinus*). MSX is thought to have been imported into Delaware Bay in the 1950s from infected Chesapeake Bay populations. As a result, harvests dropped to 49,000 bushels in 1960. When imports were banned, the disease disappeared, but it resurfaces periodically when water temperatures are high. The populations recovered slowly, but in 1985, an additional outbreak of MSX crashed the industry again. In 1990, Dermo decimated the oyster population in the Delaware Bay. Oysters are now directly harvested from the seed beds. A portion of the revenue has been directed at placing shell for increasing the size of existing beds and creating new seed beds down bay (Delaware Estuary Program, 2010).

There is currently a joint effort involving Delaware, New Jersey, and the USACE to reestablish oyster beds and an oyster fishery in the Delaware Bay. The majority of these efforts are focused on increasing recruitment and sustaining a population by shell and bed planting and seeding. Since 2001, despite management, oyster abundance has continued to decline due to below average recruitment. Recruitment enhancement is deemed important to stabilize stock abundance, to permit continuation and expansion of the oyster industry, to guarantee increased abundance that produces the shell necessary to maintain the bed, and to minimize the control of oyster population dynamics by disease, all of which will allow the oyster to play its ecological role as a filterer, enhancing general water quality. Approximately 290,000 and 478,650 bushels of shell were planted in the Delaware Bay in 2005 and 2006, respectively. The program also has a monitoring and assessment portion to evaluate its efficacy (USACE, 2007).

Oysters are found along the Atlantic coast in sounds, bays, estuaries, drowned river mouths, and behind barrier beaches from Canada to the Gulf of Mexico (Burrell, 1986), (Sellers and Stanley, 1984). They are found in the Delaware Bay from the mouth of the bay to Bombay Hook on the Delaware side and to just south of Artificial Island on the New Jersey side

(USACE, 2007). There are three physiological races recognized coast wide, each spawning at different temperatures. The oysters in the Delaware Bay are part of the population that spawns at 20 °C. Spawning is begun by the males who release their sperm and a pheromone into the water column, the females respond by releasing their eggs. Spawning occurs in the summer months, with several events per season. Larvae remain in the water column for 2 to 3 weeks, dispersing with the water currents. While in this stage, larvae pass through several morphological changes from the blastula (3.2 hours) to the gastrula (4.5 hours), trochophore (10 hours), and prodissoconch I stage, at which point they develop a shell and cilia for locomotion. The prodissoconch II stage is a very active swimmer, with eyes, a foot, and a byssal gland. These larvae show evidence of directed motions in relation to the salinity of the water. Most larvae will die before reaching the settlement stage. The next larval stage settles on a hard surface, preferably other oyster shells. The larva attaches to the substrate and looses the foot and vellum, becoming stationary. Adult oysters are sessile and found in beds or reefs in dense masses. They are often the only large organism in the bed and can change water currents enough to affect the deposition rate of the local environment. They are dioecious, but capable of changing sex, with more oysters becoming female as they age. Growth is affected by environmental variables, such as temperature, salinity, intertidal exposure, turbidity, and food availability (Sellers and Stanley, 1984).

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

Oysters are tolerant of a wide array of environmental variables, as they have evolved to live in estuaries, which experience high and low temperatures, high and low salinities, submersion and exposure, and clear to muddy water. Optimal temperatures for adults are between 68 and 86 °F (20 and 30 °C). Salinities higher than 7.5 ppt are required for spawning, but adults will tolerate salinities between 5 and 30 ppt. Because oysters are filter feeders, water velocity is highly important. The water above a bed must be recharged 72 times every 24 hours for maximum feeding. Tidal flows of greater than 5 to 8.5 fps (156 to 260 centimeters per second [cm/sec]) provide for optimal growth (Sellers and Stanley, 1984).

2.2.5.4 *Fish*

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

Representative Species

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

Blueback Herring and Alewife

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

River herring are anadromous, migrating inshore to spawn in freshwater rivers and streams in a variety of habitats. They are reported to return to their natal rivers, suggesting a need for management more focused on specific populations as opposed to establishing fishery-wide limits. Spawning migration begins in spring, with the alewife arriving inshore approximately 1 month before the blueback herring (NMFS, 2009). The entire length of the Delaware River and portions of Delaware Bay are confirmed spawning runs for river herring (NJDEP, 2005d). The adults of both species return to the ocean after spawning. While at sea, river herring are consumed by many predators, including marine mammals, sharks, tuna, and mackerel. While in the estuaries, they are consumed by American eel, striped bass, largemouth bass, mammals, and birds. Interspecific competition between alewife and blueback herring is minimized by several mechanisms, including the timing of spawning, juvenile feeding strategies and diets, and ocean emigration timing. Both blueback herring and alewife can be found in land-locked lakes. These populations are genetically distinct from the anadromous ones (ASMFC, 2009a).

Blueback herring are found in estuaries and offshore along the east coast of the United States from Nova Scotia to Florida. They can reach 16 inches (41 cm) long and have an average life span of 8 years. Males usually mature at 3 to 4 years of age, females at 5 years. Young of the year and juveniles of less than 2 inches (5 cm) are found in fresh and brackish estuarine nursery areas. They then migrate offshore to complete their growth. This species migrates inshore to spawn in late spring, and spends winters offshore in deeper waters. It uses many habitats in the estuaries including submerged aquatic vegetation, rice fields, swamps, and small tributaries outside the tidal zone (NMFS, 2009). Blueback herring prefer swiftly flowing water for spawning in their northern range. Eggs hatch within 5 days and the yolk sac is absorbed within 3 days after hatching. The eggs are initially demersal but soon become pelagic. Juveniles feed on benthic organisms and copepods, cladocerans, and larval dipterans at or just below the water surface (ASMFC, 2009a). While offshore, blueback herring feed on plankton, including ctenophores, copepods, amphipods, mysids, shrimp, and small fish (NMFS, 2009). During the spawning migration (unlike the alewife, which does not feed), the blueback herring feeds on copepods, cladocerans, ostracods, benthic and terrestrial insects, molluscs, fish eggs, hydrozoans, and stratoblasts. They are consumed in all life stages and in all habitats by other fish, birds, amphibians, mammals, and reptiles. Adults in the ocean are consumed by spiny dogfish, American eel, cod, Atlantic salmon, silver hake, white hake, Atlantic halibut, bluefish, weakfish, striped bass, seals, gulls, and terns (ASMFC, 2009a).

Alewife have a smaller range than the blueback herring, from Newfoundland to North Carolina. They reach maturity at approximately 4 years and can live 10 years, reaching up to 15 inches long (NMFS, 2009). They spawn over gravel, sand, detritus, and submerged aquatic vegetation in slow-moving water. Spawning is more likely to occur at night, and a single female may spawn with 25 males simultaneously. The eggs initially stick to the bottom, but they soon become pelagic and hatch within 2 to 25 days. The yolk sac is absorbed within 5 days and the larvae may remain in the spawning areas or migrate downstream to more brackish waters. Juveniles are found in the brackish areas in estuaries, near their spawning location. As they develop and the temperature drops, they migrate toward the ocean, completing this process in the beginning of the winter months. Eggs and juveniles are eaten by white perch, yellow perch, shiners, American eel, grass pickerel, walleye, and alewife; larvae are consumed by a variety of fish, birds, and mammals. Young alewife are also a high quality food source for turtles, snakes, birds, and mink. Juveniles are opportunistic feeders, consuming midges, cladocerans, chironomids, odonates, epiphytic fauna, ostracods, and oligocheates (ASMFC, 2009a). Alewife are schooling pelagic omnivores while offshore, feeding mainly on zooplankton, but also small fishes and their eggs and larvae (NMFS, 2009). Food items include euphausids, calanoid copepods, hyperiid amphipods, chaetognaths, pteropods, decapod larvae, salps, Atlantic herring, other alewife, eel, sand lance, and cunner (ASMFC, 2009a). Alewife not only migrate seasonally to spawn in response to temperatures but also migrate daily in response to zooplankton availability (NMFS, 2009). Adult alewife are eaten by bluefish, weakfish, striped bass, dusky shark, spiny dogfish, Atlantic salmon, goosefish, cod, pollock, and silver hake. Alewife are also important as hosts to parasitic larvae of freshwater mussels, some species of which are threatened or endangered (ASMFC, 2009a).

The river herring fishery has been active in the United States for 350 years. Until the 1960s, it was mainly an inland fishery, but thereafter expanded offshore. Alewife landings peaked in the 1950s and the 1970s, then abruptly declined (NMFS, 2009). Blueback herring landing data are limited, but a severe decline was observed in the early 2000s. In addition to the commercial industry, there is an extensive recreational fishery which harvested over 350,000 fish in 2004. Commercial landings declined from over 50 million lbs (22.6 million kgs; before 1970 to under 1 million lbs [453 thousand kg] in 2007. Blueback herring are exhibiting signs of overfishing in several of the estuary systems on the east coast, including the Connecticut, Hudson, and Delaware rivers (ASMFC, 2009a). River herring population declines have been attributed to overfishing and the loss of historic spawning habitat all along the eastern coast of the United States (NMFS, 2009). Reasons for habitat loss include dam construction, streambank erosion, pollution, and siltation (ASMFC, 2009a). River herring are also often taken as bycatch in other fisheries (NMFS, 2009). New Jersey currently has a small commercial river herring small-mesh gillnet fishery; the catch is mostly used as bait. Delaware also has a small river herring fishery, which is associated with the white perch fishery. Neither State has specific regulations for river herring, but pending legislation in Delaware could eliminate the fishery in that State. Although data are lacking, it is estimated that large numbers of river herring are harvested recreationally for use as bait (ASMFC, 2009a).

American Shad

American shad have been a commercially and culturally important species on the east coast of the United States since colonial times. The range of the American shad extends from Newfoundland to Florida (ASMFC, 2007a). They are most abundant between Connecticut and North Carolina (MacKenzie et al., 1985). Huge numbers of these fish were historically harvested during their annual spring spawning runs. By 1850, 91 million lbs (41,000 metric tons) were harvested annually in the Chesapeake Bay (Chesapeake Bay Program, 2009). The Atlantic catch in 1896 was 50 million lbs (22,680 metric tons) (MacKenzie et al., 1985). By the end of the 19th century, only 17.6 million lbs (8,000 metric tons) were caught, representing a severe decline in the American shad stock, and the fishery began fishing in the waters of the lower bays. Stock has continued to decline, with only 1,000 metric tons landed in the Chesapeake in the 1970s (Chesapeake Bay Program, 2009). By 1983, the Atlantic catch was only 3.5 million lbs (1,585 metric tons). Several States, including Maryland, had closed the American shad fishery by 1985 (MacKenzie et al., 1985).

American shad are schooling anadromous fish, migrating to freshwater to spawn in winter, spring, or summer, with the timing depending on water temperature. Mature shad can spawn up to six times over their lifetimes of 5 to 7 years. Spawning is accomplished by one female and several males swimming to the surface to release their gametes. Preferred substrates include sand, silt, muck, gravel, and boulders. Water velocity must be rapid enough to keep the eggs off the bottom. Eggs are spawned in areas that will allow them to hatch before drifting downstream into saline waters. They hatch in approximately 8 to 12 days, and the yolk sac is absorbed when the larvae are between 0.35 and 0.47 inches (9 and 12 mm) long. At 4 weeks the larvae become juveniles, which spend their first summer in the freshwater systems (Mackenzie et al., 1985). The juveniles migrate toward the ocean in the fall months, cued by water temperature changes, and will remain in the estuary until they are 1 year old (ASMFC, 1998b). In the Delaware River, this happens when the water reaches 68 °F (20 °C), usually in October and November. Juveniles remain in the ocean until they are mature, approximately 3 to 5 years for males and 4 to 6 years for females. American shad are likely to return to their natal rivers to spawn (MacKenzie et al., 1985).

Ecologically, American shad play an important role in the coastal estuary systems, providing food for some species and preying on others. They also transfer nutrients and energy from the marine system to the freshwater areas as many shad die after they spawn (ASMFC, 1998b). Young American shad in the river systems feed in the water column on a variety of invertebrates. While at sea, they feed on invertebrates, fish eggs, and small fish (MacKenzie et al. 1985), (ASMFC, 1998b). During the spawning run, shad consume mayflies and small fish. Shad are preyed upon by many species while they are small, including striped bass, American eels, and birds. Adults are eaten by seals, porpoises, sharks, bluefin tuna (*Thunnus thynnus*), and kingfish (*Scomberomorus regahni*) (Weiss-Glanz et al., 1986). Much of the American shad's life cycle is dictated by changes in ambient temperature. The peak of the spawning run and the ocean emigration happen when the water temperature is approximately 68 °F (20 °C). Deformities develop if eggs encounter temperatures above 72 °F (22 °C) and they do not hatch above 84 °F (29 °C). Juveniles have been shown to actively avoid rises in temperature of 39 °F (4 °C) (MacKenzie et al., 1985).

American shad are managed by the ASMFC. A stock assessment completed in 2007 showed that American shad stocks are still severely depleted and are not recovering, with Atlantic harvests of approximately 550 tons (500 metric tons). The shad coastal intercept fishery in the Atlantic has been closed since 2005, additionally there is a 10 fish limit for the recreational inshore fishery. The reasons for their decline include dams, habitat loss, pollution, and overfishing (ASMFC, 2007a). Increased predation by the striped bass has also been named as a factor in their decline (ASMFC, 1998b). The entire length of the Delaware River is a confirmed spawning run for the American shad. There is no confirmed information available on Delaware Bay itself, although shad would have to migrate through the bay to get to the river (NJDEP, 2005d). Adults are highly abundant in the Delaware Bay, potentially confirming the American shad's use of the estuary as part of the spawning run (ASMFC, 1998b).

Bay Anchovy

The bay anchovy is an abundant forage fish found along the Atlantic coast from Maine to the Gulf of Mexico, including the Yucatan Peninsula. It is a small, schooling, euryhaline fish that grows to approximately 4 inches (10 cm) and can live for several years (Morton, 1989), (Smithsonian Marine Station, 2008). It can be found in freshwater and in hypersaline water over almost any bottom type, including sand, mud, and submerged aquatic vegetation. It is highly important ecologically and commercially due to its abundance and widespread distribution (Morton, 1989). It plays a large role in the food webs that support many commercial and sport fisheries by converting zooplankton biomass into food for piscivores (Morton, 1989), (Newberger and Houde, 1995).

Bay anchovy spawn almost all year, typically in waters of less than 65 ft (20 m) deep. In the Middle Atlantic region, spawning occurs in estuaries in water of at least 54 °F (12 °C) and over 10 ppt salinity. The eggs are pelagic and hatch after about 24 hours; the yolk sac is absorbed after another 25 hours. Newly hatched fish move upstream into lower salinity areas to feed, eventually migrating to the lower estuary in the fall. Young bay anchovies feed mainly on copepods, and adults consume mysids, small crustaceans, mollusks, and larval fish. Copepods have been reported as the primary food source of bay anchovies in the Delaware Bay. Adult bay anchovies are tolerant of a range of temperatures and salinities and move to deeper water for the winter (Morton, 1989).

There is no bay anchovy fishery, so they are not directly economically important. However, they support many other commercial fisheries as they are often the most abundant fish in coastal waters (Morton, 1989). They have been reported to be the most important link in the food web, and are a primary forage item for many other fish, birds, and mammals (Morton, 1989), (Smithsonian Marine Station, 2008), (Newberger and Houde, 1995). Bay anchovy eggs are consumed by various predators, including juvenile fish and gelatinous predators such as sea nettles and ctenophores. Bay anchovy often account for over half the fish, eggs, or larvae caught in research trawls (Smithsonian Marine Station, 2008). Studies in the Chesapeake Bay found that striped bass are heavily dependent on bay anchovies as larvae, juveniles, and adults, especially since the menhaden and river herring populations have declined in recent years (Chesapeake Bay Ecological Foundation, Inc., 2010).

Atlantic Menhaden

Atlantic menhaden have been an important commercial fish along the Atlantic coast since colonial times. Ecologically, they are a vital forage fish for larger piscivorous species, including fish, birds, and mammals, and they play an important role in the aquatic system as filter feeders (ASMFC, 2005a). They are used in the reduction industry (producing fish meal and oil) and are used as bait by both commercial and recreational fisheries. This species has been fished since the early 1800s and landings increased over time as new technologies developed. Their populations suffered in the 1960s when they were severely overfished, but they recovered in the 1970s. The reduction fishery landed 203,320 tons (184,450 metric tons) in 2004 and the bait fishery has become increasingly important, with the most bait fish landed in New Jersey and Virginia. A stock assessment completed in 2003 declared the Atlantic menhaden not overfished, and a review in 2004 resulted in a decision not to require an assessment in 2006 (ASMFC, 2005a). The 2008 Atlantic menhaden fishing season resulted in a catch of 141,133 tons (128,030 metric tons) for the reduction industry (NOAA, 2009a).

Atlantic menhaden are small schooling fish found along the Atlantic coast from Nova Scotia to northern Florida in estuarine and nearshore coastal waters. They migrate seasonally, spending early spring through early winter in estuaries and nearshore waters, with the larger and older fish moving farther north during summer (ASMFC, 2005a). Spawning occurs almost year round along the Atlantic coast (ASMFC, 2001). They spawn offshore in fall and early winter between New Jersey and North Carolina (ASMFC, 2005a). Spawning is concentrated over the continental shelf off the North Carolina capes between December and February, in water 328 to 656 ft (100 to 200 m) deep at mid-depths. The eggs are pelagic and hatch in 1 to 2 days. Once the yolk sac is absorbed at 4 days old, larvae begin to feed on plankton. Areas that do not have sufficient plankton densities may not produce many surviving larvae, leading to a poor year class. Larvae enter estuary nursery areas after 1 to 3 months, between October and June in the Mid-Atlantic. Prejuvenile fish use the shallow, low-salinity areas in estuaries as nurseries, preferring vegetated areas in fresh tidal marshes and swamps, where they become juveniles (Rogers and Van Den Ayvle, 1989). Juveniles spend approximately 1 year in the estuarine nurseries before joining the adult migratory population in late fall (ASMFC, 2005a). Larvae that entered the nursery areas late in the year may remain until the next fall. Once juveniles metamorphose to adults, they switch from individual capture to a filter feeding strategy. Young fish leaving the estuaries tend to migrate south along the North Carolina coast during the winter months. Fish are mature at age 2 or 3 and will then begin the spawning cycle (Rogers and Van Den Ayvle, 1989). Atlantic menhaden can live up to 8 years, but fish older than 6 years are rare (ASMFC, 2001).

Due to their high abundance and positioning in the nearshore and estuarine ecosystems, Atlantic menhaden are ecologically vital along the Atlantic coast (Rogers and Van Den Ayvle, 1989). They are filter feeders, straining plankton from the water column. They provide a trophic link between the primary producers and the larger predatory species in nearshore waters (ASMFC, 2005a). It has been hypothesized that due to their abundance and migratory movements, Atlantic menhaden may change the assemblage structure of plankton in the water column. Larvae in the estuaries feed preferentially upon copepods and copepodites, and they may eat detritus as well. As young fish and adults, they filter feed on anything larger than 7 to 9 micrometers, including zooplankton, large phytoplankton, and chain diatoms (Rogers and Van Den Avyle, 1989). Atlantic menhaden provide a food source for bluefish, striped bass, bluefin tuna, king mackerel, Spanish mackerel, pollock, cod, weakfish, silver hake, tunas, swordfish (*Xiphias gladuis*), and sharks (ASMFC, 2001), (Rogers and Van Den Avyle, 1989). They establish a direct link between the phytoplankton primary producers and the higher level predators, including transferring energy in and out of estuary systems and on and off the coastal shelf (Rogers and Van Den Avyle, 1989). They are especially important in this regard, as most marine fish species cannot use phytoplankton as a food source (ASMFC, 2001). Their filter-feeding habits have also lead to a variety of physiological characteristics, such as high lipid content, enabling survival during periods of low prey availability (Rogers and Van Den Avyle, 1989).

Weakfish

Weakfish are part of a mixed stock fishery that has been economically vital since the early 1800s (ASMFC, 2009b). They were highly abundant in the Delaware Bay. They topped commercial landings in the State of Delaware until the 1990s and were consistently within the top five species in recreational landings (DNREC, 2006a). Weakfish biomass has declined significantly in recent years, with non-fishing pressures such as increased natural mortality, predation, competition, and environmental variables hypothesized as the cause for the decline (ASMFC, 2009b). Commercial landings have fluctuated since the beginning of the fishery, without apparent trend or sufficient explanation (ASMFC, 2009b), (Mercer, 1989). Landings along the Atlantic coast peaked in the 1970s at 36 million lbs (over 16 million kg), then declined throughout the 1980s, ending in a low of 6 million lbs (approximately 2.7 million kg) in 1994. Management measures increased stock and commercial harvest until 1998, when the fishery declined again, this time continuously until 2008 (ASMFC, 2009b). Between 1995 and 2004, commercial landings in Delaware dropped by 82 percent and the recreational harvest dropped by 98 percent, reflecting a coast-wide drop of 78 percent (DNREC, 2006a). The results of the 2009 stock assessment defined the fishery as depleted, but not overfished, with natural sources of mortality listed as the cause of the low biomass levels. The ASMFC is currently developing an amendment to the management plan to address the decline (ASMFC, 2009b).

Weakfish range along the Atlantic coast from Nova Scotia to southern Florida, but are more common between New York and North Carolina (ASMFC, 2009b). Their growth varies, with northern populations becoming much larger (up to 32 inches [810 mm]) and living longer (11 years) than the more southern populations (28 inches [710 mm] and 6 years). Within the Delaware Bay, a survey in 1979 found the oldest females (age 9 years) to be an average of 710 mm long, and the oldest males (6 years) to be an average of 27 inches [681 mm] long (Mercer, 1989). Spring warming induces inshore migration from offshore wintering areas and spawning (ASMFC, 2009b). Weakfish are batch spawners, continuously producing eggs during the spawning season, allowing more than one spawning event per female (ASMFC, 2002). Larval weakfish migrate into estuaries, bays, sounds, and rivers to nursery habitats where they remain until they are 1 year old, after which they are considered mature (ASMFC, 2009b), (Mercer, 1989). Spawning occurs in estuaries and nearshore areas between May and July in the New York Bight (Delaware Bay to New York). Eggs are pelagic and hatch between 36 and 40 hours after fertilization. Larvae become demersal soon after this, when they have reached 8 mm in length. Juvenile weakfish use the deeper waters of estuaries, tidal rivers, and bays extensively but are not often found in the shallower areas closer to shore. Within the Delaware Bay, juvenile weakfish have been shown to migrate toward lower salinities in the summer, higher salinities in the fall, and offshore for the winter months. Adults migrate inshore seasonally to spawn in large bays or the nearshore ocean. Spawning is initiated with warming water temperatures. As temperatures cool for the winter, weakfish migrate to ocean wintering areas, the most important of which is the continental shelf between the Chesapeake Bay and North Carolina (Mercer, 1989).

Weakfish play an important ecological role as both predators and prey in the estuarine and nearshore food webs (Mercer, 1989). Adults feed on peneid and mysid shrimps, anchovies, clupeid fishes, other weakfish, and a variety of other fishes, including butterfish, herrings, silversides, Atlantic croaker, spot, scup, and killifishes. Younger weakfish consume mostly mysids and other zooplankton and invertebrates, including squids, crabs, annelid worms, and clams (Mercer, 1989), (ASMFC, 2002). More fish species are taken as the fish grow to larger sizes. In the Chesapeake Bay eelgrass beds, weakfish have been shown to be important top carnivores, feeding mostly on blue crabs and spot. Weakfish are tolerant of a relatively wide variety of temperatures and salinities. In the Delaware Bay, weakfish have been collected in temperatures between approximately 62.6 and 82.4 °F (17 and 28 °C) and salinities of 0 to 32 ppt (Mercer, 1989).

Spot

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

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

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

Atlantic Silverside

Atlantic silverside are a highly abundant forage fish on the Atlantic coast, providing a food resource for many commercially and recreationally important fish species, such as striped bass

(*Morone saxatilis*), Atlantic mackerel (*Scomber scombrus*), and bluefish (*Pomatomus saltatrix*). Atlantic silverside are found in salt marshes, estuaries, and tidal creeks along the Atlantic coast from Nova Scotia to Florida. It can be the most abundant fish in these habitats. There is no direct commercial or recreational fishery for this species, although many recreational fishers net and use these minnows as bait (Fay et al., 1983a).

Spawning by the Atlantic silverside is initiated by a combination of water temperature, photoperiod, tidal cycle, and lunar cycle. Spawning occurs in the intertidal zones of estuaries between March and July in the Mid-Atlantic Region. The initial spawning event is during the daytime, usually accompanied by a high tide and a full or new moon. Subsequent events are spaced by 14 or 15 days, tracking the lunar cycle (Fay et al., 1983a). Most fish die after their first spawning season (fish may spawn between 5 and 20 times in one season), but some individuals do return for a second season (NYNHP, 2009). Atlantic silverside spawning is a complex behavior in which fish swim parallel to the shore until the appropriate tidal level is reached, then the school rapidly turns shoreward to spawn in the shallows in areas where eggs may attach to vegetative substrates. Eggs are demersal and adhesive, sticking to eel grass, cordgrass, and filamentous algae. They hatch after 3 to 27 days, depending on temperature. The yolk sac is absorbed between 2 and 5 days later. Atlantic silverside become either males or females, but the sex of an individual fish is determined by water temperature during the larval stage. Thus, colder temperatures produce more females and warmer temperatures produce more males. Larvae usually inhabit shallow, low-salinity (8 to 9 ppt) water in estuaries and are most often found at the surface. Transformation to the juvenile stage is usually at 0.86 inches (20 mm) in length, and juveniles continue to grow until late fall, when they reach adult size. Juveniles and adults are found in intertidal creeks, marshes, and shore areas in bays and estuaries during spring, summer, and fall. During winter in the Mid-Atlantic Region, they often migrate to deeper water within the bays or offshore (Fay et al., 1983a).

Ecologically, the Atlantic silverside is an important forage fish and plays a large role in the aquatic food web and in linking terrestrial production to aquatic systems. Little is known about the larval diet. Due to their short life span and high winter mortality (up to 99 percent), they play a vital part in the export of nutrients to the near and offshore ecosystem. Juvenile and adult fish are opportunistic omnivores and eat copepods, mysids, amphipods, cladocerans, fish eggs, squid, worms, molluscan larvae, insects, algae, diatoms, and detritus. They feed in large schools over gravel and sand bars, open beaches, tidal creeks, river mouths, and tidally-flooded zones of marsh vegetation. Eggs, larvae, juveniles, and adults are eaten by striped bass, Atlantic mackerel, bluefish, egrets, terns, gulls, cormorants, blue crabs, mummichogs (*Fundulus heteroclitus*), and shorebirds (Fay et al., 1983a).

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

<u>Atlantic Croaker</u>

Atlantic croaker are an important commercial and recreational fish on the Atlantic coast and are the most abundant bottom-dwelling fish in this region. They have been taken as part of a mixed stock fishery since the 1880s. Commercial landings appear to be cyclical, with catches ranging between 2 million and 30 million lbs (0.9 and 13.6 million kg). This may be due to variable annual recruitment, which appears to be dependent on natural environmental variables.

Recreational landings have been increasing, with 10.6 million lbs (4.8 million kg) caught in 2005. The 2003 stock assessment (reported in 2004) determined that Atlantic croaker were not overfished in the Mid-Atlantic Region (ASMFC, 2007b). An amendment to the management plan was developed in 2005 using the 2004 stock assessment data, establishing fishing mortality and spawning stock biomass targets and thresholds. There are no recreational or commercial management measures in this amendment, but some States have adopted internal management measures for the Atlantic croaker fishery (ASMFC, 2005b).

Atlantic croaker are a migratory species, although movements have not been well defined. They appear to move inshore in the warmer months and southward in winter (ASMFC, 2007b). They range from Cape Cod to Argentina and are uncommon north of New Jersey. Gulf of Mexico and Atlantic populations appear to be genetically separate (ASMFC, 2005b). They are estuarine dependant at all life stages, especially as postlarvae and juveniles (Lassuy, 1983). Spawning occurs at 1 to 2 years of age in nearshore and offshore habitats between July and December (ASMFC, 2007b). Atlantic croaker can live for up to 12 years, and will spawn more than once in a season. Eggs are pelagic and are found in polyhaline and euryhaline waters. Larvae have been found from the continental shelf to inner estuaries. Recruitment to the nursery habitats in the estuaries depends largely on currents and tides. Recruitment of young fish to the shallow marsh habitats of estuaries is variable but appears to show seasonal peaks depending on latitude. This peak is in August through October in the Delaware River. The long spawning period and the variable recruitment peaks make the aging of recruits to estuary areas difficult; ages could vary from 2 to 10 months of age at recruitment. Larvae complete their development into juveniles in brackish shallow bottom habitats. Juveniles slowly migrate downstream, preferring stable salinity regimes in deeper water, and eventually enter the ocean in late fall as adults. They prefer mud bottoms with detritus and grass beds, which provide a stable food source, but they are considered generalists (ASMFC, 2005b).

Atlantic croaker are bottom feeders eating benthic invertebrate fauna, such as polychaetes, mollusks, ostracods, copepods, amphipods, mysids, and fish. Larvae tend to consume large amounts of zooplankton, and juveniles feed on detritus. Their predators include striped bass, southern flounder, bluefish, weakfish, and spotted seatrout. They are able to live with other competitive fishes (such as spot) by using temporal and spatial habitat niches within the overall bottom environment. Juvenile Atlantic croaker are sensitive to pollution and anoxic areas as these conditions deplete or change the composition of their prey. Shoreline alterations, such as bulkheads and rock jetties, can also negatively affect juvenile populations. Adult croaker are usually found in estuaries in spring and summer and move offshore for the winter; their distribution is related to temperature and depth. They prefer muddy and sandy substrates that can support plant growth, but have also been found over oyster reefs. They are euryhaline, depending on the season, and are sensitive to low oxygen levels (ASMFC, 2005b).

White Perch

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

White perch are schooling fish that can grow up to 10 inches (25.4 cm) long in freshwater and 15 inches (38.1 cm) long in brackish water and may live up to 10 years (Pennsylvania Fish and Boat Commission, 2010), (MDNR, 2008). They spawn in a wide variety of habitats, such as rivers, streams, estuaries, lakes, and marshes, usually in freshwater. Water speed and turbidity are not important in choosing a spawning location. Spawning is induced by rising water temperature and occurs in April through May in freshwater and May through July in estuaries (Stanley and Danie, 1983). Marine and estuarine populations migrate to freshwater areas to spawn and, thus, are anadromous (Pennsylvania Fish and Boat Commission, 2010). Spawning is accomplished by a single female and several males. The eggs attach to the bottom immediately. Females may spawn two or three times per season and older fish produce many more eggs than younger ones. Eggs hatch in 30 to 108 hours, depending on water temperature. Hatchlings remain in the spawning area for up to 13 days. They then drift downstream or with estuarine currents, becoming more demersal as they grow. Larvae can tolerate up to 5 ppt salinity, and adults can tolerate full seawater. Juveniles are often found in upper estuarine nurseries, where they may stay for a year, preferring habitats with silt, mud, or plant substrates. Older juveniles have been reported to move to offshore beach and shoal areas during the day, but return to the more protected nursery areas at night. Maturity is usually reached by the second year, but may take up to 4 years. Growth to maturity and beyond is affected by temperature, food supply, and population density, with growth becoming stunted in high density areas (Stanley and Danie, 1983).

Ecologically, white perch play several important roles throughout their lifecycle. The white perch is omnivorous, depending on age, season, and food availability. It will feed on both plankton and benthic species, but concentrates on fish after it is fully grown. Freshwater populations feed on aquatic insects, crustaceans, fishes, and detritus (Stanley and Danie, 1983). Estuarine populations consume fish (such as alewife, gizzard shad, and smelt), amphipods, crayfish, shrimp, squid, crabs, and fish eggs (Stanley and Danie, 1983), (Pennsylvania Fish and Boat Commission, 2010). White perch are preyed upon by Atlantic salmon, brook trout, chain pickerel, smallmouth bass, largemouth bass, and other piscivorous fish and terrestrial vertebrates. Juveniles are often eaten by copepods (Stanley and Danie, 1983).

<u>Striped Bass</u>

Striped bass are historically one of the most important fishery species along the Atlantic coast from Maine to North Carolina, with recreational landings exceeding commercial landings (ASMFC, 2003), (ASMFC, 2008d). Their population has recovered since a sharp decline from its peak in the 1970s of 15 million lbs (6,800 metric tons) to 3.5 million lbs (1,590 metric tons) by 1983 (ASMFC, 2008d). In 1981, ASMFC approved a management plan focusing on size limits and spawning season closures to recover population levels. This plan proved ineffective, and several States closed the fishery entirely, reopening in the early 1990s once the population had grown. Several amendments were made to the management plan, and the fishery was declared recovered in 1995 (ASMFC, 2003), (ASMFC, 2008d). The most recent amendment in 2003 focused on increasing the proportion of the population over 15 years of age and creating a biomass target and threshold (ASMFC, 2003). The 2007 stock assessment declared the fishery recovered, fully exploited, and not overfished. This recovery is considered one of the greatest successes in the fisheries management field, with commercial and recreational landings totaling 3.8 million fish (29.3 million lbs [13,290 metric tons] recreationally) in 2006 (ASMFC, 2008d). The recovery of the striped bass fishery has been hypothesized to be the cause of the decline in weakfish, which it preys upon (DNREC, 2006b). Striped bass are found on the Atlantic coast from the St. Lawrence River in Canada to northern Florida. They are highly abundant in both the Delaware Bay and Chesapeake Bay. Females can grow up to 65 lbs (29.4 kg) and live for 29 years, whereas males over 12 years old are uncommon (Fay et al., 1983b).

Striped bass migrate along the coast seasonally and are anadromous, spawning in rivers and estuaries after reaching an age of 2 years (males) to 4 years (females) (ASMFC, 2008d). There are known riverine and estuarine spawning areas in the upper Delaware and Chesapeake bays. Spawning occurs in April through June in the Mid-Atlantic Region, with some of the most important spawning areas found in the upper Chesapeake Bay and the Chesapeake-Delaware Canal (Fay et al., 1983b). In the Delaware River, the main spawning grounds are located between Wilmington, DE, and Marcus Hook, PA (Delaware Division of Fish and Wildlife, 2010b). Males arrive in the spawning area first. Up to 50 males will spawn with a single female at the water surface. The eggs are pelagic and hatch from 29 to 80 hours after fertilization, depending on the temperature. The yolk sac is absorbed in 3 to 9 days, during which time water turbulence is required to keep the larvae from sinking to the bottom. The larvae then develop into the finfold stage, lasting approximately 11 days, then transform to the postfinfold stage, lasting up to 65 days. Both eggs and larvae tend to remain in the spawning area throughout these developmental stages. Fish are considered juveniles in between the lengths of 1 and 12 inches (2.5 and 30.5 cm) for males and 1 and 20 inches (2.54 and 50.8 cm) for females. Most juveniles also remain in the estuaries where they were spawned until they reach adult size, tending to move downstream after the first year. On the Atlantic coast, some adults leave the estuaries and join seasonal migrations to the north in the warmer months, while others remain in the estuaries. Some of these adults will also migrate into coastal estuaries to overwinter. Reproduction is highly variable, with several poorly successful seasons between each strong year class. Variability in adult and juvenile behavior and the unpredictable importance of strong year classes makes management of the fishery challenging. There are four different stocks identified along the Atlantic coast, including the Roanoke River-Albemarle Sound, Chesapeake Bay, Delaware River, and Hudson River stocks (Fay et al., 1983b).

Striped bass are tolerant of a wide variety of environmental variables, but require specific habitats for successful reproduction. Adults spawn in a large variety of habitats, but only some of these produce an adequate amount of surviving young. Higher water flows and colder winters are hypothesized to produce successful year classes. Eggs are tolerant of temperatures between 57.2 and 73.4 °F (14 and 23 °C), salinities of 0 to 10 ppt, dissolved oxygen of 1.5 to 5.0 mg/L, turbidity of 0 to 500 mg/L, pH of 6.6 to 9.0, and a current velocity of 1.4 to 197 inches/sec (30.5 to 500 cm/sec). Larvae are slightly more tolerant of variables outside these ranges, and juveniles are even more tolerant (Fay et al., 1983b). Young and juveniles tend to be found over sandy bottoms in shallow water, but can also inhabit areas over gravel, mud, and rock. Adults are found in a wide variety of bottom types, such as rock, gravel, sand, and submerged aquatic vegetation (ASMFC, 2010b). Larvae and juveniles consume nauplii, copepods, chironomid larvae, and fish eggs and larvae. Young striped bass eat mysids, insect larvae, gobies, shrimp, amphipods, and small fish. Adults are mainly piscivorous, consuming schooling bait fish such as bay anchovy, Atlantic menhaden, spot, and croaker, but they will also consume invertebrates in the spring, including blue crabs, amphipods, and mysids (Fay et al., 1983b), (DNREC, 2006b). Young striped bass are fed upon by weakfish, bluefish, white perch, and other large fishes; larvae and eggs are eaten by a variety of predators. Adult striped bass probably compete with weakfish and bluefish, and juveniles are likely to compete with white perch in the nursery areas (Fay et al., 1983b). Striped bass do not feed while on spawning runs (DNREC, 2006b).

Bluefish

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

Comment [AB33]: Should this be 2010e or 2010f instead?

Bluefish are a migratory schooling fish, found in estuaries and over the continental shelf in tropical and temperate waters globally. They occur in the Atlantic from Nova Scotia to northern Mexico. Adults migrate north during the summers, between Cape Hatteras and New England, winters are spent to the south, near Florida in the Gulf Stream. They reach sexual maturity at age 2 and spawn in the open ocean (Pottern et al., 1989). There is a single spawning event that begins in the south in the late winter and continues northward into the summer as the fish migrate (ASMFC, 1998c). Eggs are pelagic and hatch in approximately 48 hours, and larvae drift with the offshore currents until coastal waters become warmer (Pottern et al., 1989), (ASMFC, 1998c). These larvae transform to a pelagic-juvenile stage in 18 to 25 days, improving swimming ability (NOAA, 2006). Spring spawned juveniles then migrate into bays and estuaries at 1 to 2 months old, where they complete their development, joining the adult population in the fall (Pottern et al., 1989). Summer spawned juveniles enter the estuaries for only a short time before migrating south for the winter (ASMFC, 1998c). Some juveniles will spend a second summer in the estuaries (Pottern et al., 1989). Bluefish can live for up to 12 years and reach lengths of 39 inches (91.4 cm) and weights of 31 lbs (14 kg) (ASMFC, 2006b).

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

Bluefish are highly sensitive to temperature regimes, with an optimum range of 64.4 to 68 °F (18 to 20 °C). Temperatures above or below this range can induce rapid swimming, loss of interest in food, loss of equilibrium, and changes in schooling and diurnal behaviors. They are relatively euryhaline, found in estuaries at 10 ppt and waters of up to 38 ppt in the ocean. As they are pelagic, they are not well adapted to the periodic low oxygen levels that are occasionally found in estuaries (Pottern et al., 1989). They have been found to be excluded from estuarine areas where Atlantic silversides are spawning due to the low oxygen levels induced by the high activity of such a large number of fish (ASMFC, 1998c).

Species with Essential Fish Habitat

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

Many managed species are mobile and migrate seasonally, so some species are managed coast-wide, others are managed by more than one fishery management council, and still others are managed for the entire coast by a single council. In the Delaware Bay, various fisheries species are managed by the ASMFC, the New England Fisheries Management Council (NEFMC), the Mid-Atlantic Fishery Management Council (MAFMC), and the South Atlantic Fishery Management Council (SAFMC). Several species are regulated by the States of New Jersey and Delaware as well, in some cases with more rigid restrictions than those of the regional councils.

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

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

North: 39 ° 30.0 'N	South: 39 ° 20.0 'N
East: 75 ° 30.0 'W	West: 75 ° 40.0 'W

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

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

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

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

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

X indicates designated EFH within this area. Blank indicates no designated EFH in this area. n/a indicates that the species does not have this life stage or has no EFH designation for this life stage.
Sources: NOAA, 2010e; NOAA, 2010f

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

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

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

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

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

Source: NRC, 2007

Winter Flounder

Winter flounder (*Pleuronectes americanus*) are highly abundant in estuarine and coastal waters and, therefore, are one of the most important commercial and recreational fisheries species on the Atlantic coast (Buckley, 1989). They are managed by the NEFMC and ASMFC as part of the multispecies groundfish fishery. This plan manages a total of 15 demersal species (NEFMC, 2010). The winter trawl fishery was established in the 1920s when northern trawlers began to make use of the waters off Cape Hatteras. This fishery targets multiple species, and landings between 1974 and 1978 totaled approximately 18.5 million lbs (8.4 million kg) annually (Grimes et al., 1989). Winter flounder are also very popular recreational fish, with the recreational catch sometimes exceeding the commercial catch (Buckley, 1989). Biomass in the New England-Mid-Atlantic winter flounder stock declined from 30,000 million tons in 1981 to 8,500 million tons in 1992, and the fishery was declared overexploited. As of 1999, biomass remains significantly lower than prior to overexploitation (NOAA, 1999a). As part of the management program, EFH has been established for the winter flounder along the Atlantic coast. The Delaware Bay's mixing and saline waters are EFH for all parts of the winter flounder lifecycle, including eggs, larvae, juveniles, adults, and spawning adults (NEFMC, 1998a).

There are two major populations of winter flounder in the Atlantic, one is found in estuarine and coastal waters from Newfoundland to Georgia, the other is found offshore on Georges Bank and Nantucket Shoal (Buckley, 1989). In the Mid-Atlantic, it is most common between the Gulf of Saint Lawrence and the Chesapeake Bay (Grimes et al., 1989). They spawn in coastal waters beginning in December in the south Atlantic, through June in Canada (February and March in the Delaware Bay region). Spawning occurs in depths of 6.5 to 262 ft (2 to 80 m) over sandy substrates in inshore coves and inlets between 31 to 32.5 ppt (Buckley, 1989), (NOAA, 1999a). Sexual maturity is dependent on size, rather than age, with southern individuals (age 2 or 3) reaching spawning size more rapidly than northern fish (age 6 or 7). The eggs are demersal, stick to the substrate, and are most often found at salinities between 10 and 30 ppt (Buckley, 1989). They hatch in 2 to 3 weeks, depending on water temperature (NOAA, 1999a). The yolk sac is absorbed at 12 to 14 days, and metamorphosis to the juvenile stage is complete in 49 to 80 days, also dependant on temperature (Buckley, 1989). Larvae are planktonic initially, but become increasingly benthic with developmental stage (NOAA, 1999a). Juveniles and adults are completely benthic, with juveniles preferring a sandy or silty substrate in estuarine areas (Buckley, 1989). Juveniles move seaward as they grow, remaining in estuaries for the first year (Buckley, 1989), (Grimes et al., 1989). Adult movements appear to be dictated by water temperature as well, with three distinct population ranges: Georges Bank, north of Cape Cod, and south of Cape Cod. South of Cape Cod, winter flounder will spend the colder months in inshore and estuarine waters, moving further offshore in the warmer summer months (Buckley, 1989). Winter flounder can live for up to 15 years and may reach 22.8 inches (58 cm) in length (NOAA, 1999a).

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

Winter flounder are found at temperatures between 32 and 77 °F (0 and 25 °C), but will burrow into the sediments above 71.6 °F (22 °C). Higher temperatures for extended periods can cause wide-scale mortality. They are relatively euryhaline, tolerating salinities of 5 to 35 ppt (Buckley, 1989). Larvae are susceptible to thermal shock; 4 minutes at temperatures elevated by 28 to 30 °C will produce 100 percent mortality (Buckley, 1989). Increases of less than 80.6 °F (27 °C), however, appear to be well tolerated if the shock lasts for less than 32 minutes (NOAA, 1999a). Additionally, winter flounder catch has been negatively correlated with high temperatures in the preceding 30 months, and a minor increase in temperature of less than 32.9 °F (0.5 °C) may cause a decrease in recruitment (Grimes et al., 1989).

Windowpane Flounder

Windowpane flounder (*Scopthalmus aquosus*) is one of the 15 groundfish species managed by the NEFMC under the multispecies plan (NEFMC, 2010). Although it is not directly targeted by the fishery, it is caught as bycatch in the groundfish trawls, although they are exploited for human consumption (NOAA, 1999b), (Morse and Able, 1995). The groundfish fishery has been highly important for the economy of the New England region, with 100 million dollars in landings reported in 2000 (NEFMC, 2010). Due to their demersal habitat, windowpane flounder are found in close association with other groundfish species, such as yellowtail flounder (*Limanda ferruginea*), ocean pout (*Macrozoarces americanus*), little skate (*Raja erinacea*), northern searobin (*Prionotus carolinus*), and spiny dogfish (*Squalus acanthias*) (NOAA, 1999b). Between 1975 and 1982, landings of windowpane flounder fluctuated between 532 and 838 million tons. Between 1984 and 1990, landings increased to between 890 and 2,065 million tons, after which they gradually declined to between 39 and 85 million tons during the time range of 2002 to 2007 (NEFSC, 2008).

Windowpane flounder are found in estuaries, coastal waters, and over the continental shelf along the Atlantic coast from the Gulf of Saint Lawrence to Florida. They are most abundant in bays and estuaries south of Cape Cod in shallow waters over sand, sand and silt, or mud substrates (NOAA, 1999b). They spawn from April to December, but in the Mid-Atlantic Region, spawning occurs with two peaks in the spring (May) and fall (September) (NOAA, 1999b), (Morse and Able, 1995). They tend to spawn on the bottom of the water column in waters of 16 to 19 °C (Morse and Able, 1995). The eggs are pelagic and buoyant and hatch in approximately 8 days. Larvae begin life as plankton, but soon settle to the bottom (at 0.39 to 0.78 inches [10 to 20 mm] in length) and become demersal. This settling occurs in estuaries and over the shelf for spring spawned fish, and these individuals are found in the polyhaline portions of the estuary throughout the summer. Fall spawned fish settle mostly on the shelf. Juveniles will migrate to coastal waters from the estuaries as they grow larger during the autumn; they overwinter in deeper waters. Adults remain offshore throughout the year and are highly abundant off of southern New Jersey. Sexual maturity is reached between 3 and 4 years of age, and growth generally does not exceed 18.1 inches (46 cm) (NOAA, 1999b).

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

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

Summer Flounder

The summer flounder, also known as fluke, is a highly important commercial and recreational species along the Atlantic coast. The commercial and recreational fishery is managed by both the ASMFC and the MAFMC, under the summer flounder, scup, and black sea bass fishery management plan. The recreational harvest makes up a sizeable portion of the total and is occasionally larger than the commercial harvest. Stock biomass declined in the 1980s after a peak landing total of 26,100 million tons in 1983. Between 1986 and 1995, total landings averaged 13,100 million tons per year, and have fluctuated between 8,600 and 12,500 since then. In 1999, the summer flounder stock was considered overexploited, but as of 2005, the stock has been considered not overfished (NOAA, 1999c), (NEFSC, 2006a). In 2009, the ASMFC increased total allowable landings due to the results of the 2008 stock assessment. Although the stock is currently considered not overfished, it has not reached rebuilt status (ASMFC, 2008e).

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

The summer flounder is a demersal fish found in coastal waters over sandy substrates from Nova Scotia to Florida, but it is most abundant between Cape Cod and Cape Fear (ASMFC, 2008e). It occurs in bays and estuaries in spring, summer, and autumn, and migrates offshore for the winter (NEFSC, 2006a). Migrating adults tend to return to the same bay or estuary every year (NOAA, 1999c). Spawning occurs in autumn and early winter, as the fish are migrating for the winter over the continental shelf (NEFSC, 2006a), (NOAA, 1999c). Eggs are pelagic and buoyant, as are the early stages of larvae. Larvae hatch between 56 and 216 hours after fertilization, depending on temperature, and begin to feed after 3 to 4 days (NOAA, 1999c). Larvae are transported inshore between October and May, where they develop in estuaries and bays (NEFSC, 2006a), (ASMFC, 2008e). Larvae become demersal as soon as the right eye migrates to the top of the head. They then bury themselves in the substrate while they are in the inshore nursery areas. Within the estuaries, marsh creeks, seagrass beds, mud flats, and open bay areas are important habitats for juveniles. Some juveniles stay in the estuary habitat until their second year, while others migrate offshore for the winter. Juveniles are found in the deeper parts of the Delaware Bay throughout the winter (NOAA, 1999c). Sexual maturity is reached by age 2, females may live up to 20 years and reach 26.5 lbs (12 kg) in weight, but males generally live for only 10 years (NEFSC, 2006a).

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

Atlantic Butterfish

Atlantic butterfish is an important commercial fish species that is also caught as bycatch in other fisheries, such as the fluke, squid, mixed groundfish, and silver hake fisheries (NEFSC, 2006b), (NEFSC, 2004). Butterfish are an ecologically important species as forage fish for many larger fishes, marine mammals, and birds. The fishery has been in operation since the late 1800s. Between 1920 and 1962, U.S. landings averaged 3,000 million tons annually (NOAA, 1999e). U.S. commercial landings averaged 3,200 million tons annually between 1965 and 2002. They peaked in 1984 at 11,972 million tons, with an estimated annual bycatch of 1,000 to 9,200 million tons. A record low catch occurred in 2005 at 432 million tons (NEFSC, 2006b). The Atlantic butterfish fishery is managed by the MAFMC under the Atlantic mackerel, squid, and butterfish fishery management plan (NEFSC, 2006b). Due to a lack of data, it has not been established if overfishing is currently occurring, but during the last stock assessment in 1993, it was established that biomass was at medium levels, the catch was not excessive, and recruitment was high (NEFSC, 2004). NOAA has designated EFH for Atlantic butterfish in the Delaware Bay (NOAA, 2010h). According to the NOAA EFH source document, larvae, juveniles, and adults are common in the Delaware Bay, with larvae and adults found in the saline zones and juveniles found in both the mixing and the saline zones. Juveniles and adults are also common in the saline zones of the Delaware inland bays; thus, these areas are considered EFH for this species (NOAA, 1999e).

Comment [AB34]: NOAA 1999e is not listed in the References section.

Comment [AB35]: NOAA 1999e is not listed in the References section.

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

Comment [AB36]: Not listed in the References section.

Comment [AB37]: Not listed in the References section.

seasonally, moving south and offshore in the Middle Atlantic Bight for the winter, and inshore in the spring (NOAA, 1999e). Sexual maturity is reached by age 1; fish rarely live more than 3 years and normally reach a weight of up to 1.1 lbs (0.5 kg) (NEFSC, 2006b).

Comment [AB38]: Not listed in the References section.

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

Comment [AB39]: Not listed in the References section.

Comment [AB40]: Not listed in the References section.

2.2.6 Terrestrial Resources

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

2.2.6.1 *Artificial Island*

As discussed above in the site description, Artificial Island, on which the Salem and HCGS facilities were constructed, is a man-made island approximately 3 mi (4.8 km) long and 5 mi (8 km) wide that was created by the deposition of dredge spoil material. All terrestrial resources on the island have become established since creation of the island began approximately 100 years ago. Consequently, Artificial Island contains poor quality soils and very few trees. Approximately 75 percent of the island is undeveloped and dominated by tidal marsh, which extends from the higher areas along the river, eastward to the marshes of the former natural shoreline of the mainland (Figure 2-9). The terrestrial, non-wetland habitats of the island consist principally of areas covered by grasses and other herbs, with some shrubs and planted trees present in developed areas. Small, isolated, freshwater impoundments and associated wetland areas are also present.

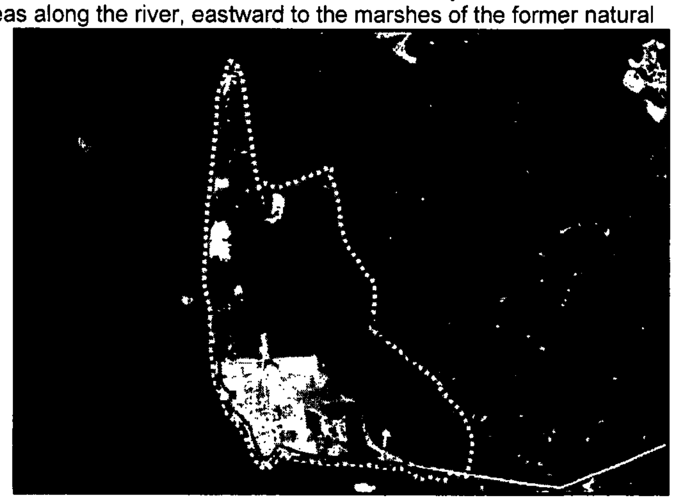

Figure 2-9. Aerial Showing the Boundaries of Artificial Island (dotted yellow), PSEG Property (red dashed), and Developed Areas (solid blue)

The Salem and HCGS facilities were constructed on adjacent portions of the PSEG property, which occupies the southwest corner of Artificial Island. The PSEG property is low and flat with elevations rising to about 18 ft (5.5 m) above the level of the river at the highest point. Developed areas covered by facilities and pavement occupy over 70 percent of the site (approximately 266 ac [108 ha]). Maintained areas of grass, including two baseball fields, cover about 12 ac (5 ha) of the site interior. The remaining 25 percent of the PSEG property (approximately 100 ac [40 ha]) consists primarily of marsh dominated by the common reed (*Phragmites australis)* and several cordgrass species (*Spartina* spp.) (PSEG, 2009b). The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) classifies all land on the project site as urban, while the soils on Artificial Island are Udorthents consisting of dredged fine material (NRCS, 2010). The National Wetlands Inventory (NWI) identifies an inland marsh/swamp area on the periphery of the project site adjacent to Hope Creek Road and two small freshwater ponds immediately north of the HCGS reactor. NWI classifies the rest of Artificial Island as estuarine emergent marsh, with the exception of the northernmost 1 mi (1.6 km) of the island, which is occupied by freshwater emergent wetlands and freshwater ponds (FWS, 2010a).

The site is within the Middle Atlantic coastal plain of the eastern temperate forest ecoregion (EPA, 2007). The tidal marsh vegetation of the site periphery and adjacent areas is dominated by the common reed, but other plants present include big cordgrass (*Spartina cynosuroides*), salt marsh cordgrass (*S. alterniflora*), saltmeadow cordgrass (*S. patens*), and saltmarsh bulrush (*Scirpus robustus*) (PSEG, 2009b). Fragments of this marsh community exist along the eastern edge of the PSEG property. The non-estuarine vegetation on the undeveloped areas within the facilities consists mainly of small areas of turf grasses and planted shrubs and trees around buildings, parking lots, and roads.

The animal species present on Artificial Island are likely typical of those inhabiting estuarine tidal marshes and adjacent habitats within the Delaware Estuary. Tidal marshes in this region are commonly used by many migrant and resident birds because they provide habitat for breeding, foraging, and resting (PSEG, 2004b). In 1972, Salem pre-construction surveys conducted within a 4 mi (6 km) radius of the project site recorded 44 avian species, including many shorebirds, wading birds, and waterfowl associated with open water and emergent marsh areas of the estuary. During construction of the Salem facility, several avian species were observed on the project site, including the red-winged blackbird (*Agelaius phoeniceus*), common grackle (*Quiscalus quiscula*), northern harrier (*Circus cyaneus*), song sparrow (*Melospiza melodia*), and yellowthroat (*Geothlypis trichas*) (AEC, 1973). HCGS construction studies reported the occurrence of 178 bird species within 10 mi (16 km) of the project site. Approximately half of these species were recorded primarily from tidal marsh and the open water of the Delaware River (habitat similar to the project site), and roughly 45 of the 178 total observed species were classified as permanent resident species (PSEG, 1983). The osprey (*Pandion haliaeetus*) has been observed nesting on transmission line towers on Artificial Island (PSEG, 1983), (NRC, 1984), (NJDFW, 2009b). Resident songbirds, such as the marsh wren (*Cistothorus palustris*), and migratory songbirds, such as the swamp sparrow (*Melospiza georgiana*), have been observed using the nearby Alloway Creek Estuary Enhancement Program restoration site for breeding purposes (PSEG, 2004b). These and other marsh species likely occur in the marsh habitats on Artificial Island.

Mammals reported to occur on Artificial Island, in the area of the Salem and HCGS facilities before their construction, include the eastern cottontail (*Sylvilagus floridanus*), Norway rat (*Rattus norvegicus*), and house mouse (*Mus musculus*) (AEC, 1973). Signs of raccoon (*Procyon lotor*) have been observed near Salem, and other mammals likely to occur in the vicinity of the two facilities include the white-tailed deer (*Odocoileus virginianus*), muskrat (*Ondatra zibethica*), opossum (*Didelphis marsupialis*), and striped skunk (*Mephitis mephitis*). Surveys conducted in association with the construction of HCGS identified 45 mammals that could be expected to occur within 10 mi (16 km) of the project site (PSEG, 1983). Of the 45 species identified, 8 were species associated with marsh habitats, such as the meadow vole (*Microtus pennsylvanicus*) and marsh rice rat (*Oryzomys pulustris*).

Eight of 26 reptile species observed during surveys related to the early operation of HCGS were recorded from tidal marsh (PSEG, 1983). Three species, the snapping turtle (*Chelydra serpentina*), northern water snake (*Natrix sipedon*), and eastern mud turtle (*Kinosternon subrubrum*), prefer freshwater habitats but also occur in brackish marsh. The northern diamondback terrapin (*Malaclemys terrapin*) inhabits saltwater and brackish habitats and could occur in tidal marsh adjacent to the project site.

Two wildlife management areas (WMAs) managed by the NJDFW are located near Salem and HCGS:

- Abbotts Meadow WMA encompasses approximately 1,000 ac (405 ha) and is located about 4 mi (6.4 km) northeast of HCGS.
- Mad Horse Creek State WMA encompasses roughly 9,500 ac (3,844 ha), of which the northernmost portion is situated approximately 0.5 mi (0.8 km) from the site. The southern portion of this WMA includes Stowe Creek, which is designated as an important bird area (IBA) in New Jersey. The Stowe Creek IBA provides breeding habitat for several pairs of bald eagles (*Haliaeetus leucocephalus*), which are State-listed as endangered, and the adjacent tidal wetlands support large populations of the northern harrier, which is also State-listed as endangered, as well as many other birds dependent on salt marsh/wetland habitats (National Audubon Society, 2010).

2.2.6.2 *Transmission Line Right-of-Ways*

Section 2.2.1 describes the existing power transmission system that distributes electricity from Salem and HCGS to the regional power grid. There are four 500-kV transmission lines within three ROWs that extend beyond the PSEG property on Artificial Island. Two ROWs extend northeast approximately 40 mi (64 km) to the New Freedom substation south of Philadelphia. The other ROW extends north then west approximately 25 mi (40 km), crossing the Delaware River and ending at the Keeney substation in Delaware (Figure 2-8).

In total, the three ROWs for the Salem and HCGS power transmission system occupy approximately 4,376 ac (1,771 ha) and pass through a variety of habitat types, including marshes and other wetlands, agricultural or forested land, and some urban and residential areas (PSEG, 2009a). When the ROWs exit Salem and HCGS, they initially pass through approximately 3 mi (5 km) of estuarine emergent marsh east of the property boundary. The primary land cover type then crossed by the north and south New Freedom ROWs (approximately 30 mi [48 km]) within their middle segments is a mixture of agricultural and forested land. The Keeney ROW exits HCGS and heads north, traversing approximately 5 mi (8 km) of emergent marsh and swamp paralleling the New Jersey coast, before it crosses 8 mi (13 km) of agricultural, sparsely forested, and rural residential property. The Keeney corridor then continues west across the Delaware River for approximately 3.25 mi (5.25 km) until it reaches the Red Lion substation. From the substation, the Red Lion-Keeney portion of the line within the Keeney ROW remains exclusively within Delaware, crossing primarily highly developed, residential land.

For approximately the last one-quarter of the length, the New Freedom ROWs, before their termination at the New Freedom substation, traverse the New Jersey Pinelands National Reserve (PNR) (NPS, 2006). Temperate broadleaf forest is the major ecosystem type of the reserve, which was designated a U.S. Biosphere Reserve in 1988 by the United Nations Educational, Scientific and Cultural Organization (UNESCO). Biosphere Reserves are areas of terrestrial and coastal ecosystems with three complementary roles: conservation, sustainable development, and logistical support for research, monitoring, and education (UNESCO, 2010). PNR is protected and its future development is guided by the Pinelands Comprehensive Management Plan, which is implemented by the New Jersey Pinelands Commission. The commission is also responsible for regulating the maintenance of all bulk electric transmission (greater than 69 kV) ROWs in the Pinelands area and, therefore, oversees maintenance of the portions of the north and south Salem/HCGS New Freedom ROWs that fall within the PNR (New Jersey Pinelands Commission, 2009). The two New Freedom corridors also cross the Great Egg Harbor River, a designated National Scenic and Recreational River located within the PNR. This 129-mi (208-km) river system (including 17 tributaries) starts in suburban towns near Berlin, NJ and meanders for approximately 60 mi (97 km), gradually widening as tributaries enter, until terminating at the Atlantic Ocean.

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

2.2.7 Threatened and Endangered Species

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

2.2.7.1 *Aquatic Species of the Delaware Estuary*

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

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

Scientific Name	Common Name	Status[a]		
		Federal	New Jersey	Delaware
Reptiles				
Caretta caretta	Loggerhead sea turtle	T	E	E
Chelonia mydas	Green sea turtle	T	T	E
Lepidochelys kempii	Kemp's ridley sea turtle	E	E	E
Dermochelys coriacea	Leatherback sea turtle	E	E	E
Fish				
Acipenser brevirostrum	Shortnose sturgeon	E	E	-
A. oxyrinchus oxyrinchus	Atlantic sturgeon	C	-	E

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

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

Sea turtles are air-breathing reptiles with large flippers and streamlined bodies. They inhabit tropical and subtropical marine and estuarine waters around the world. Of the seven species in the world, six occur in waters of the United States, and all are listed as threatened or endangered. The four species identified by the NMFS as potentially occurring in the Delaware Estuary are the threatened loggerhead (*Caretta caretta*) and green (*Chelonia mydas*) sea turtles and the endangered Kemp's ridley (*Lepidochelys kempii*) and leatherback (*Dermochelys coriacea*) sea turtles. Kemp's ridley, loggerhead, and green sea turtles have been documented in the Delaware Estuary at or near the Salem and HCGS facilities, while the leatherback sea turtle is less likely to occur in the vicinity (NMFS, 2010b).

Kemp's ridley, loggerhead, and green sea turtles have a similar appearance, though they differ in maximum size and coloration. The Kemp's ridley is the smallest species of sea turtle; adults average about 100 lbs (45 kg) with a carapace length of 24 to 28 inches (61 to 71 cm) and a shell color that varies from gray in young individuals to olive green in adults. The loggerhead is the next largest of these three species; adults average about 250 lbs (113 kg) with a carapace length of 36 inches (91 cm) and a reddish brown shell color. The green is the largest of the three; adults average 300 to 350 lbs (136 to 159 kg) with a length of more than 3 ft (1 m) and brown coloration (its name comes from its greenish colored fat). The leatherback is the largest species of sea turtle and the largest living reptile; adults can weigh up to about 2,000 lbs (907 kg) with a length of 6.5 ft (2 m). The leatherback is the only sea turtle that lacks a hard, bony shell. Instead, its carapace is approximately 1.5 inches (4 cm) thick with seven longitudinal ridges and consists of loosely connected dermal bones covered by leathery connective tissue. The Kemp's ridley has a carnivorous diet that includes fish, jellyfish, and mollusks. The loggerhead has an omnivorous diet that includes fish, jellyfish, mollusks, crustaceans, and aquatic plants. The green has a herbivorous diet of aquatic plants, mainly seagrasses and algae, that is unique among sea turtles. The leatherback has a carnivorous diet of soft-bodied, pelagic prey, such as jellyfish and salps (NMFS, 2010c).

All four of these sea turtle species nest on sandy beaches; none nest on the Delaware River (NMFS, 2010c). They are generally distributed in tropical and subtropical waters worldwide, and there is evidence that they return to their natal beaches to nest. The leatherback has the widest distribution of all the species, as it has physiological adaptations that allow survival and foraging in much colder water than the other species (NMFS and FWS, 2007a). Major threats to these sea turtles include the destruction of beach nesting habitats and incidental mortality from commercial fishing activities. Sea turtles are killed by many fishing methods, including longline, bottom, and mid-water trawling, dredges, gillnets, and pots/traps. The required use of turtle exclusion devices has reduced bycatch mortality. Additional sources of mortality due to human activities include boat strikes and entanglement in marine debris (NMFS and FWS, 2007a), (NMFS and FWS, 2007b), (NMFS and FWS, 2007c), (NOAA, 2010i).

Shortnose Sturgeon

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

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

The shortnose sturgeon is found along the Atlantic coast from Canada to Florida in a variety of habitats. They occur in fast-flowing riverine waters, estuaries, and, in some locations, offshore marine areas over the continental slope. They are anadromous, spawning in coastal rivers and later migrating into estuaries and nearshore environments during the non-spawning periods. They do not appear to make long distance offshore migrations like other anadromous fishes (NOAA, 2010j). Migration into freshwater to spawn occurs between late winter and early summer, dependent on latitude (NEFSC, 2006). Spawning occurs in deep, rapidly flowing water over gravel, rubble, or boulder substrates (FWS, 2001a). Eggs are deposited on hard surfaces to which they adhere before hatching after 9 to 12 days. The yolk sac is absorbed in an additional 9 to 12 days (NMFS, 1998). Juveniles remain in freshwater or the fresher areas of estuaries for 3 to 5 years, they then move to more saline areas, including nearshore ocean waters (NEFSC, 2006). Shortnose sturgeon can live up to 30 years (males) to 67 years (females), can grow up to 4.7 ft (143 cm) long, and can reach a weight of 51 lbs (23 kg). Age at sexual maturity varies within their range from north to south, with individuals in the Delaware

Bay area reaching maturity at 3 to 5 years for males and approximately 6 years for females (NOAA, 2010j). Shortnose sturgeon are demersal and feed on benthos. Juveniles feed on benthic insects, such as *Hexagenia* sp., *Chaoborus* sp., *Chironomus* sp., and small crustaceans (*Gammarus* sp., *Asellus* sp., *Cyathura polita*) (NMFS, 1998). Adults feed over gravel and mud substrates, in deep channels and nearshore ocean waters (FWS, 2001a), where they consume mostly mollusks and larger crustaceans (NOAA, 2010j). Prey species for adults include *Physa* sp., *Heliosoma* sp., *Corbicula manilensis*, *Amnicola limnosa*, *Valvata* sp., *Pisidium* sp., *Elliptio complanata*, *Mya arenaria*, *Macoma balthica*, gammarid amphipods, and zebra mussels (*Dreissena polymorpha*) (NMFS, 1998). Additional food items for both juveniles and adults include worms, plants, and small fish (NEFSC, 2006).

In the Delaware Estuary, shortnose sturgeon most often occur in the Delaware River and may be found occasionally in the nearshore ocean. Their abundance is greatest between Trenton, NJ and Philadelphia, PA. Adults overwinter in large groups between Trenton and Bordentown, NJ, but little is known of the distribution of juveniles in the Delaware Estuary (USACE, 2009). A review of the status of the shortnose sturgeon was initiated in 2007 and was still underway as of 2008, when the latest biennial report to Congress regarding the ESA was completed. Due to its distinct populations, the status of the species varies depending on the river in question. The population estimate for the Delaware Estuary (1999–2003) was 12,047 adults. Current threats to the shortnose sturgeon also vary among rivers. Generally, over the entire range, most threats are related to dams, pollution, and general industrial growth in the 1800s. Drought and climate change are considered aggravators of the existing threats due to lowered water levels which can reduce access to spawning areas, increase thermal injury, and concentrate pollutants. Additional threats include discharges, dredging, or disposal of material into rivers; development activities involving estuaries or riverine mudflats and marshes; and mortality due to bycatch in the shad gillnet fishery. The Delaware River population is most threatened by dredging operations and water quality issues (NMFS, 2008).

<u>Atlantic Sturgeon</u>

Atlantic sturgeon (*Acipenser oxytinchus oxyrinchus*) are an evolutionarily ancient fish, remaining relatively unchanged for the past 70 million years. They were originally considered a junk fish, used as fertilizer and fuel. As the demand for caviar grew, they were harvested for human consumption. By 1870, a large commercial fishery for Atlantic sturgeon was established. This fishery crashed in approximately 100 years due to overfishing, exacerbated by the fact that this species takes a very long time to reach sexual maturity. They were caught for many reasons: their flesh and eggs were processed for human consumption, their skin was made into leather products such as book bindings, and their swim bladders were used to make gelatin and small windows. Landings at the turn of the century averaged 7 million lbs per year. They declined to 100,000 to 250,000 lbs by the 1990s. The ASMFC adopted a Fishery Management Plan (FMP) in 1990 that implemented harvest quotas. The FMP was amended in 1998 with a coast-wide moratorium on Atlantic sturgeon harvest that will remain in place until 2038. This moratorium was mirrored by the Federal Government in 1999, prohibiting harvest in the exclusive economic zone offshore (ASMFC, 2009c). Recommendations in the FMP with respect to habitat conservation include: (1) identifying, characterizing, and protecting critical spawning and nursery areas; (2) identifying critical habitat characteristics of spawning staging and oceanic areas; (3) determining environmental tolerance levels (dissolved oxygen, pH, temperature, river flow, salinity, etc.) for all life stages; and (4) determining the effects of contaminants on all life stages, especially eggs, larvae, and juveniles (ASMFC, 2010c).

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

Atlantic sturgeon are found along the Atlantic coast in the ocean, large rivers, and estuaries from Labrador to northern Florida. They have been extirpated from most coastal systems except for the Hudson River, the Delaware River, and some South Carolina systems (ASMFC, 2010c). They are anadromous, migrating inshore to coastal estuaries and rivers to spawn in the spring. A single fish will only spawn every 2 to 6 years (ASMFC, 2009c). Spawning is accomplished by broadcasting eggs in fast-flowing, deep water with hard bottoms (ASMFC, 2010c). Eggs are demersal and stick to the substrate after 20 minutes of dispersal time. Larvae are pelagic, swimming in the water column, and become benthic juveniles within 4 weeks (ASMFC, 2009c). Juveniles remain where they hatch for 1 to 6 years before migrating to the ocean to complete their growth (ASMFC, 2009c). Little is known about the distribution and timing of juveniles and their migration, but aggregations at the freshwater/saltwater interface suggest that these areas are nurseries (ASMFC, 2010c). At between 30 and 36 inches (76 to 91 cm) in length, juveniles move offshore (NOAA, 2009b). Data are lacking regarding adult and sub-adult distribution and habitats in the open ocean (ASMFC, 2010c). Atlantic sturgeon can live for up to 60 years and can reach 14 ft (4.3 m) and 800 lbs (363 kg). Sexual maturity is reached by females between 7 and 30 years of age and by males between 5 and 24 years (ASMFC, 2009c).

Atlantic sturgeon are benthic predators and feed on mussels, worms, shrimps, and small fish (ASMFC, 2009c). Juveniles are known to consume sludgeworms, annelid worms, polycheate worms, isopods, amphipods, chironomid larvae, mayfly and other insect larvae, small bivalve mollusks, mysids, and amphipods. Little is known of the adult and sub-adult feeding habits in the marine environment, but some studies have found that these life stages consume mollusks, polychaetes, gastropods, shrimps, amphipods, isopods, and small fish. Juveniles and adults may compete for food with other benthic feeders, such as shortnose sturgeon, suckers (*Moxotoma* sp.), winter flounder (*Pleuronectes americanus*), tautog (*Tautoga onitis*), cunner (*Tautagolabrus adspersus*), porgies (Sparidae), croakers (Sciaenidae), and stingrays (*Dasyatis* sp.). Juveniles are preyed upon by sea lampreys (*Petromyzon marinus*), gar (*Lepisosteus* sp.), striped bass, common carp (*Cyprinus carpio*), northern pikeminnows (*Ptychocheilus oregonensis*), channel catfish (*Ictalurus punctatus*), smallmouth bass (*Micropterus dolomieu*), walleye (*Sander vitreus*), fallfish (*Semotilus corporalis*), and grey seals (*Halichoerus grypus*) (ASMFC, 2009d).

The Delaware River and associated estuarine habitats may have historically supported the largest Atlantic sturgeon stock on the east coast. Juveniles were once caught as bycatch in numbers large enough to be a nuisance in the American shad fishery. It has been estimated that over 180,000 females spawned annually in the Delaware River before 1870. Juveniles have more recently been captured in surveys near Trenton, NJ. Gillnet surveys by the Delaware Department of Natural Resources and Environmental Control (DNREC) have captured juveniles frequently near Artificial Island and Cherry Island Flats. The DNREC also tracks mortality during the spawning season. In 2005 and 2006, 12 large adult fish carcasses were found with severe external injuries, presumed to be caused by boat strikes (ASMFC, 2009d).

2.2.7.2 *Terrestrial and Freshwater Aquatic Species*

There are seven terrestrial species with a Federal listing status of threatened or endangered that have recorded occurrences or the potential to occur either in Salem County, in which the Salem and HCGS facilities are located, or the additional counties crossed by the three ROWs (Gloucester and Camden counties in New Jersey, and New Castle County in Delaware). These species include a turtle, a beetle, and five plants (Table 2-9) (FWS, 2010b).

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

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

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

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
Passerculus sandwichensis	savannah sparrow	-	T/T	Salem	Open habitats such as alfalfa fields, grasslands, meadows, fallow fields, airports, along the coast; and within salt marsh edges as well[1]
Podilymbus podiceps	pied-billed grebe	-	E/S	Salem	Freshwater marshes associated with bogs, lakes, or slow-moving rivers[1]
Pooecetes gramineus	vesper sparrow	-	E	Gloucester, Salem	Pastures, grasslands, cultivated fields containing crops, and other open areas[1]
Strix varia	barred owl	-	T/T	Gloucester, Salem	Remote, contiguous, old growth wetland forests, including deciduous wetland forests; and Atlantic white cedar swamps associated with stream corridors[1]
Reptiles and Amphibians					
Ambystoma tigrinum	eastern tiger salamander	-	E	Gloucester, Salem	Uplands and wetlands containing breeding ponds, forests, and burrowing-appropriate soil types such as old fields, and deciduous or mixed woods[1]
Bufo woodhousii fowleri	Fowler's toad	-	SC	Camden, Gloucester, Salem	Wooded areas, river valleys, floodplains, agricultural areas, areas with deep friable soils; burrows underground or hides under rocks, plants, or other cover when inactive; eggs and larvae develop in shallow water of marshes, rain pools, ponds, lakes, reservoirs, and flooded areas[16]

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
Clemmys guttata	spotted turtle	-	SC	Camden, Gloucester, Salem	Wetlands with clean, shallow, slow-moving water with muddy or mucky bottoms, including aquatic and emergent vegetation, shallow ponds, wet meadows, swamps, bogs, fens, sedge meadows, wet prairies, shallow cattail marshes, sphagnum seepages, small woodland streams, and roadside ditches; during mating and nesting seasons, open fields and woodlands, and along roads[12]
Clemmys insculpta	wood turtle	-	E	Gloucester	Forests, meadows, or open fields near freshwater streams, creeks, or relatively remote rivers[1]
C. muhlenbergii	bog turtle	T	E DE: E	Camden, Gloucester, Salem, New Castle	Open, wet, grassy pastures or bogs with soft, muddy bottoms[1]
Crotalus horridus horridus	timber rattlesnake	-	E	Camden	Deciduous upland forest or pineland habitats, often near cedar swamps and along stream banks[1]
Hyla andersoni	pine barrens treefrog	-	E	Camden, Gloucester, Salem	Specialized acidic habitats such as Atlantic white cedar swamps and pitch pine lowlands with open canopies, dense shrub layers, and heavy ground cover[1]
Malaclemys terrapin terrapin	northern diamondback terrapin	-	SC	Camden, Gloucester, Salem	Marshes bordering salt or brackish tidal waters, mudflats, shallow bays, and coves; tidal estuaries with adjacent sandy uplands for nesting[22]
Pituophis melanoleucus	northern pine snake	-	T	Camden, Gloucester, Salem	Dry pine-oak forest types growing on infertile sandy soils[1]

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
Terrapene carolina carolina	eastern box turtle	-	SC	Camden, Gloucester, Salem	Forested habitats with sandy soils and a source of water such as a stream, pond, lake, marsh, or swamp; thickets; old fields; pastures; and vegetated dunes; sandy, open areas for nesting sites[12]
Invertebrates					
Alasmidonta undulata	triangle floater	-	T	Gloucester	Stable substrates in waters of moderate flow in small rivers and headwater streams[26]
Callophrys irus	frosted elfin	-	T	Camden	Dry clearings and open areas, savannas, power line ROWs, and roadsides[1]
Lampsilis cariosa	yellow lampmussel	-	T	Gloucester	Medium to large rivers, lakes, and ponds; substrate types - sand, silt, cobble, and gravel; larval hosts - white perch and yellow perch[22]
Lampsilis radiata	eastern lampmussel	-	T	Camden, Gloucester, Salem	Small streams, large rivers, ponds, and lakes; prefers sand or gravel substrates[22]
Leptodea ochracea	tidewater mucket	-	T	Camden, Gloucester	Freshwater with tidal influence on the lower coastal plain; pristine rivers[32]
Ligumia nasuta	eastern pond mussel	-	T	Camden, Gloucester	Lakes, ponds, streams, and rivers of variable depths with muddy, sandy, or gravelly substrates[32]
Lycaena hyllus	bronze copper		E	Salem	Brackish and freshwater marshes, bogs, fens, seepages, wet sedge meadows, riparian zones, wet grasslands, and drainage ditches[1]
Nicrophorus americanus	American burying beetle	E	E	Camden, Gloucester	Open areas, primarily coastal grassland/scrub[1]
Pontia protodice	checkered white	-	T	Camden	Open areas, savannas, old fields, vacant lots, power line ROWs, forest edges[1]

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
Pyrgus wyandot	Appalachian grizzled skipper	-	E	Gloucester	Semi-open shale slopes with exposed crumbly rock or soil, sparse herbaceous vegetation, surrounded by scrub oak or oak-hickory woodlands; larval host plant - Canada cinquefoil (*Potentilla canadensis*); tufted grasses like broomsedge (*Andropogon virginicus*), spring beauty (*Claytonia* spp.), phlox (*Phlox subulata*), and birdsfoot violet (*Viola pedata*)[22]
Plants					
Aeschynomene virginica	sensitive joint vetch	T	E	Camden, Gloucester, Salem	Fresh to slightly salty (brackish) tidal marshes[2]
Aplectrum hyemale	putty root	-	E	Gloucester	Moist, deciduous upland to swampy forests[3]
Aristida lanosa	wooly three-awn grass	-	E	Camden, Salem	Dry fields, uplands, and pink-oak woods; primarily in sandy soil[4]
Asimina triloba	pawpaw	-	E	Gloucester	Shady, open-woods areas in wet, fertile bottomlands, or upland areas on rich soils[5]
Aster radula	low rough aster	-	E	Camden, Gloucester, Salem	Wet meadows, open boggy woods, and along the edges; or openings in wet spruce or tamarack forests[6]
Bouteloua curtipendula	side oats grama grass	-	E	Gloucester	Rocky, open slopes, woodlands, and forest openings up to an elevation of approximately 7,000 ft[5]
Cacalia atriplicifolia	pale Indian plantain	-	E	Camden, Gloucester	Dry, open woods, thickets, and rocky openings[6]

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
Calystegia spithamaea	erect bindweed	-	E	Camden, Salem	Dry, open, sandy to rocky sites such as pitch pine/scrub oak barrens, sandy roadsides, riverbanks, and ROWs[7]
Cardamine longii	Long's bittercress	-	E	Gloucester	Shady tidal creeks, swamps, and mudflats[8]
Carex aquatilis	water sedge	-	E	Camden	Swamps, bogs, marshes, very wet soil, ponds, lakes, marshy meadows, and other wetland-type sites[9]
C. bushii	Bush's sedge	-	E	Camden	Dry to mesic grasslands and forest margins[3]
C. cumulata	clustered sedge	-	E	Camden	Damp, open rocky areas with shallow, sandy soils[8]
C. limosa	mud sedge	-	E	Gloucester	Fens, sphagnum bogs, wet meadows, and shorelines[3]
C. polymorpha	variable sedge	-	E	Gloucester	Dry, sandy, open areas of scrub, forests, swampy woods, and along banks and marsh edges[8]
Castanea pumila	chinquapin	-	E	Gloucester, Salem	High ridges and slopes within mixed hardwood forests, dry pinelands, and ROWs[5]
Cercis canadensis	redbud	-	E	Camden	Rich, moist wooded areas in the forest understory, stream banks, and abandoned farmlands[5]
Chenopodium rubrum	red goosefoot	-	E	Camden	Moist, often salty soils along the Atlantic coast[10]
Commelina erecta	slender dayflower	-	E	Camden	Along roadsides and stream banks; in gardens and prairies in sandy or clayey soils[5]

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

Scientific Name	Common Name	Status		County[(c)]	Habitat[(d)]
		Federal[(a)]	State[(a),(b)]		
E. tenellum	rough cotton-grass	-	E	Camden, Gloucester	Bogs and other wet, peaty substrates[(3)]
Eupatorium capillifolium	dog fennel thoroughwort	-	E	Camden	Coastal meadows, fallow fields, flatwoods, marshes, and disturbed sites[(15)]
E. resinosum	pine barren boneset	-	E	Camden, Gloucester	Tidal marshes, wetlands, open swamps, wet ditches, sandy acidic soils of grass-sedge bogs, pocosin-savannah ecotones, beaver ponds, and shrub swamps[(17)]
Euphorbia purpurea	Darlington's glade spurge	-	E	Salem	Rich, cool woods along seeps, streams, or swamps[(17)]
Glyceria grandis	American manna grass	-	E	Camden	Grassy areas[(6)]
Gnaphalium helleri	small everlasting	-	E	Camden	Dry woods, often in sandy soil[(13)]
Gymnopogon brevifolius	short-leaf skeleton grass	-	E	Gloucester	Dryish clay-loam soils, calcareous glades, and relict prairies[(23)]
Helonias bullata	swamp pink	T	E	Camden, Gloucester, Salem, New Castle	Swamps and groundwater-influenced, and perennially water-saturated forested wetlands[(17)]
Hemicarpha micrantha	small-flower halfchaff sedge	-	E	Camden	Emergent shorelines, but rarely freshwater tidal shores[(3)]
Hottonia inflata	featherfoil	-	E	Salem	Quiet, shallow water of pools, streams, ditches, and occasionally in wet soil[(20)]
Hydrastis canadensis	golden seal	-	E	Camden	Mesic, deciduous forests, often on clayey soil[(3)]
Hydrocotyle ranunculoides	floating marsh-pennywort	-	E	Salem	Ponds, marshes, and wet ground[(19)]

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
Hypericum adpressum	Barton's St. John's-wort	-	E	Salem	Pond shore[7]
Isotria meleoloides	small-whorled pogonia	T	-	-	Mixed deciduous forests in second- or third-growth successional stages, coniferous forests; typically light to moderate leaf litter, open herb layer, moderate to light shrub layer, and relatively open canopy; flats or slope bases near canopy breaks[3]
Juncus caesariensis	New Jersey rush	-	E	Camden	Borders of wet woods, wet springy bogs, and swamps[3]
J. torreyi	Torrey's rush	-	E	Camden	Edge of sloughs, wet sandy shores; along slightly alkaline watercourses; swamps; sometimes on clay soils, alkaline soils, and calcareous wet meadows[3]
Kuhnia eupatorioides	false boneset	-	E	Camden	Limestone edges of bluffs, rocky wooded slopes, and rocky limestone talus[11]
Lemna perpusilla	minute duckweed	-	E	Camden, Salem	Mesotrophic to eutrophic, quiet waters with relatively mild winters[3]
Limosella subulata	awl-leaf mudwort	-	E	Camden	Freshwater marshes[18]
Linum intercursum	sandplain flax	-	E	Camden, Salem	Open, dry, sandplain grasslands or moors; sand barrens; mown fields; and swaths under power lines, usually in small colonies[23]
Luzula acuminate	hairy wood-rush	-	E	Gloucester, Salem	Grassy areas[6]
Melanthium virginicum	Virginia bunchflower	-	E	Camden, Gloucester, Salem	Fens, bottomland prairies; mesic upland forests; mesic upland prairies; along streams, roadsides, and railroads[11]
Micranthemum micranthemoides	Nuttall's mudwort	-	E	Camden, Gloucester	Possibly extinct – last seen anywhere in 1941; freshwater tidal shores of northeast and mid-Atlantic rivers, including the Hudson, Delaware, Potomac, and Anacostia[16]

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a),(b]		
Muhlenbergia capillaries	long-awn smoke grass	-	E	Gloucester	Sandy, pine openings; dry prairies; and exposed ledges[6]
Myriophyllum tenellum	slender water-milfoil	-	E	Camden	Sandy soil and water to 5 ft deep[13]
M. pinnatum	cut-leaf water-milfoil	-	E	Salem	Floodplain marsh; associated with *Asclepias perrenis*, *Salix caroliniana*, and *Ludwigia repens*[16]
Nelumbo lutea	American lotus	-	E	Camden, Salem	Mostly floodplains of major rivers in ponds, lakes, pools in swamps and marshes, and backwaters of reservoirs[3]
Nuphar microphyllum	small-yellow pond-lily	-	E	Camden	Lakes, ponds, sluggish streams, ditches, sloughs, and occasionally tidal waters[3]
Onosmodium virginianum	Virginia false-gromwell	-	E	Camden, Gloucester, Salem	Sandy soil and dry open woods[10]
Ophioglossum vulgatum pycnostichum	southern adder's tongue	-	E	Salem	Rich wooded slopes, shaded secondary woods, forested bottomlands, and floodplain woods, south of Wisconsin glaciations[3]
Panicum aciculare	bristling panic grass	-	E	Gloucester	Sandy, coastal plains that undergo rises and falls in water levels, coastal plain ponds, limestone depression ponds, and shallow cypress ponds[17]
Penstemon laevigatus	smooth beardtongue	-	E	Gloucester	Rich woods and fields[6]
Plantago pusilla	dwarf plantain	-	E	Camden	Dry sand prairies, hill prairies, cliffs, rocky glades, sandy fields, and areas of gravel along railroads or roadsides[27]
Platanthera flava flava	southern rein orchid	-	E	Camden	Floodplain forests; white cedar, hardwood, and cypress swamps; riparian thickets; and wet meadows[3]
Pluchea foetida	stinking fleabane	-	E	Camden	Swamps, marshes, ditches, and coastal savannahs[28]

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
Polemonium reptans	Greek-valerian	-	E	Salem	Moist, stream banks and deciduous woods[6]
Polygala incarnate	pink milkwort	-	E	Camden, Gloucester	Fields, prairies, and meadows[6]
Prunus angustifolia	chickasaw plum	-	E	Camden, Gloucester, Salem	Woodland edges, forest openings, open woodlands, savannahs, prairies, plains, meadows, pastures, roadsides, and fence rows[6]
Pycnanthemum clinopodioides	basil mountain mint	-	E	Camden	Dry south or west facing slopes on rocky soils; open oak-hickory forests, woodlands, or savannas with exposed bedrock[11]
P. torrei	Torrey's mountain mint	-	E	Gloucester	Open, dry, including red cedar barrens, rocky summits, roadsides and trails; and dry upland woods[8]
Quercus imbricaria	shingle oak	-	E	Gloucester	Rich bottomlands and dry to moist uplands[6]
Q. lyrata	overcup oak	-	E	Salem	Lowlands, bottoms, wet forests, streamside forests, and periodically inundated areas[3]
Rhododendron atlanticum	dwarf azalea	-	E	Salem	Moist, flat, pine woods, and savannas[6]
Rhynchospora globularis	coarse grass-like beaked-rush	-	E	Camden, Gloucester, Salem	Sandy and rocky stream banks, sink-hole ponds, upland prairies, and open rocky and sandy areas[11]
R. knieskernii	Knieskern's beaked-rush	T	E	Camden	Moist to wet pine barrens, borrow pits, and sand pits[3]
Sagittaria teres	slender arrowhead	-	E	Camden	Swamps of acid waters and sandy pool shores, and mostly along the Atlantic Coastal Plain[3]
Scheuchzeria palustris	arrow-grass	-	E	Camden, Gloucester	Lake margins, bogs, and marshes[3]

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
Schwalbea americana	chaffseed	E	E	Camden	Acidic, sandy, or peaty soils in open flatwoods; streamhead pocosins; pitch pine lowland forests; longleaf pine/oak sandhills; seepage bogs; palustrine pine savannahs; ecotonal areas between peaty wetlands; and xeric sandy soils[17]
Scirpus longii	Long's woolgrass	-	E	Camden	Marshes[3]
S. maritimus	saltmarsh bulrush	-	E	Camden	Water body margins, marshes, alkali, and saline wet meadows[6]
Scutellaria leonardii	small skullcap	-	E	Salem	Fields, meadows, and prairies[6]
Spiranthes laciniata	lace-lip ladies' tresses	-	E	Gloucester	Primarily on coastal plain marshes, swamps, dry to damp roadsides, meadows, ditches, fields, cemeteries, and lawns; occasionally in standing water[3]
Stellaria pubera	star chickweed	-	E	Camden	Alluvial bottomlands and rich deciduous woods[3]
Triadenum walteri	Walter's St. John's wort	-	E	Camden	Buttonbush swamps, swamp woods, thickets, and stream banks[21]
Utricularia biflora	two-flower bladderwort	-	E	Gloucester, Salem	Shores and shallows[13]
Valerianella radiata	beaked cornsalad	-	E	Gloucester	Pastures, prairies, valleys, creek beds, wet meadows, roadsides, glades, and railroads[11]
Verbena simplex	narrow-leaf vervain	-	E	Camden, Gloucester	Fields, meadows, and prairies[6]
Vernonia glauca	broad-leaf ironweed	-	E	Gloucester, Salem	Dry fields, clearings, and upland forests[21]
Vulpia elliotea	squirrel-tail six-weeks grass	-	E	Camden, Gloucester, Salem	Grass-like or grassy habitats[6]
Wolffiella floridana	sword bogmat	-	E	Salem	Quiet waters in warm-temperature regions with relatively mild winters and mesotrophic[3]

Scientific Name	Common Name	Status		County[c]	Habitat[d]
		Federal[a]	State[a],[b]		
Xyris fimbriarta	fringed yellow-eyed grass	-	E	Camden	Low pine savanna, bogs, seeps, peats and mucks of pond shallows, and sluggish shallow streams[3]

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

(b) State status shown is for the counties shown. All are for New Jersey except where a Delaware status (DE:) is shown for New Castle County.

New Jersey: State status for birds separated by a slash (/) indicates a dual status. First status refers to the breeding population in the State, and the second status refers to the migratory or winter population in the State. S = Stable species (a species whose population is not undergoing any long-term increase/decrease within its natural cycle); U = Undetermined (a species about which there is not enough information available to determine the status). SC = Species Concern (a species showing evidence of decline, may become threatened) (NJDEP, 2008c).

Delaware: Delaware does not maintain T&E species lists by county. Upon request, Delaware provided PSEG the locations of species of greatest conservation need that occur within 0.5 mi (0.8 km) of the transmission corridor in New Castle County (DNREC, 2009). State Rank S1 = extremely rare in the State (typically 5 or fewer occurrences); S2 = very rare within the State (6 to 20 occurrences); S3 = rare to uncommon in Delaware; B = Breeding; N = Non-breeding (DNREC, 2009).

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

(d) Habitat Information Sources:

(1) NJDEP, 2004b
(2) FWS, 2008a
(3) eFloras.org, 2003
(4) Utah State University, 2010
(5) USDA, 2006
(6) University of Texas at Austin, 2010
(7) New England Wild Flower Society, 2003
(8) NYNHP, 2010
(9) USDA, 2010
(10) neartica.com, 2010
(11) Missouriplants.com, 2010
(12) Michigan Natural Features Inventory, 2010
(13) University of Wisconsin, 2010
(14) Missouri Botanical Gardens, 2010
(15) Alabamaplants.com, 2010
(16) NatureServe, 2009

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

(17) CPC, 2010a
(18) Calflora, 2010
(19) University of Washington Burke Museum of Natural History and Culture, 2006
(20) Ohio Department of Natural Resources, 1983; Ohio Department of Natural Resources, 1994
(21) Pennsylvania Natural Heritage Program, 2007
(22) Massachusetts Division of Fisheries and Wildlife, 2009
(23) Georgia Department of Natural Resources, 2008
(24) USDA, 1999
(25) University of Georgia, 2010
(26) South Carolina Department of Natural Resources, 2010
(27) Hilty, 2010
(28) Wernert, 1998

Six of these species (all except one plant) also have a State listing status of endangered in New Jersey, and the turtle has a state status of endangered in both New Jersey and Delaware (NJDEP, 2008c), (DNREC, 2008). In letters provided in accordance with the consultation requirements under Section 7 of the ESA, the FWS confirmed that no Federally-listed species under their jurisdiction are known to occur in the vicinity of the Salem and HCGS facilities (FWS, 2009a), (FWS, 2009b). However, two of the species Federally-listed as threatened were identified by the New Jersey Field Office of the FWS as having known occurrences or other areas of potential habitat along the New Freedom North and South transmission line ROWs: the bog turtle (*Clemmys muhlenbergii*) and the swamp pink (*Helonias bullata*) (FWS, 2009a). These species are discussed below.

Bog Turtle

The bog turtle (now also referred to as *Glyptemys muhlenbergii*) has two discontinuous populations. The northern population, which occurs in Connecticut, Delaware, Maryland, Massachusetts, New Jersey, New York, and Pennsylvania, was Federally-listed as threatened in 1997 under the ESA (16 USC 1531 et seq.). The southern population was listed as threatened due to its similarity of appearance to the northern population. The southern population occurs mainly in the Appalachian Mountains from southern Virginia through the Carolinas to northern Georgia and eastern Tennessee. The bog turtle was Federally-listed due to declines in abundance caused by loss, fragmentation, and degradation of early successional wet-meadow habitat, and by collection for the wildlife trade (FWS, 2001b). The northern population was listed as endangered by the State of New Jersey in 1974 (NJDFW, 2010b). In New Jersey, bog turtles are mainly restricted to rural areas of the State, including Salem, Sussex, Warren, and Hunterdon counties. Nevertheless, New Jersey is home to one of the largest strongholds in the bog turtle's range, and as of 2003, there were over 200 individual wetlands that supported this species (NJDFW, 2010c).

The bog turtle is one of the smallest turtles in North America. Its upper shell is 3 to 4 inches (7.6 to 10.2 cm) long and light brown to black in color, and each side of its black head has a distinctive patch of color that is red, orange, or yellow. Its life span is generally 20 to 30 years, but may be 40 years or longer. In New Jersey, the bog turtle usually is active from April through October (mating occurs mostly between May and June) and hibernates the remainder of the year, often within the groundwater-washed root systems of woody plants (FWS, 2004), (NJDFW, 2010c). Hibernation usually occurs in more densely vegetated areas in the interfaces between open areas and wooded swamps with small trees and shrubs, such as alder, gray birch, red maple, and tamarack. After mating, the female turtle typically digs a hole in which to deposit her eggs, though in some areas, eggs are laid on top of the ground in sedge tussocks. Clutches vary from one to five eggs, and hatchlings usually emerge in September, but there is evidence that the eggs can also overwinter and hatch the next spring (FWS, 2001b).

The bog turtle is diurnal and semi-aquatic, and forages on land and in water for its varied diet of plants (seeds, berries, duckweed), animals (insect larvae, snails, beetles), and carrion. The most abundant and preferred food source found in their habitat is the common slug (FWS, 2001b), (FWS, 2004), (NJDFW, 2004). Northern bog turtles primarily inhabit wetlands fed by groundwater or associated with the headwaters of streams and dominated by emergent vegetation. These habitats typically have shallow, cool water that flows slowly and vegetation that is early successional, with open canopies and wet meadows of sedges (*Carex* spp.). Other herbs commonly present include spike rushes (*Eleocharis* spp.) and bulrushes (*Juncus* spp. and *Scirpus* spp.) (FWS, 2001b). Bog turtle habitats in New Jersey are typically characterized by native communities of low-lying grasses, sedges, mosses, and rushes; however, many of these areas are in need of restoration and management due to the encroachment of woody species and invasive species, such as the common reed (*Phragmites australis*), cattail (*Typha* spp.), and Japanese stiltgrass (*Microstegium vimineum*) (NJDFW, 2010d). Later successional species may discourage bog turtle occupation as they shade the basking areas in a habitat. Livestock grazing maintains the early successional stage, providing favorable conditions for bog turtles (NJDFW, 2010b).

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

Swamp Pink

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

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

Swamp pink is a wetland plant that is thought to be limited to shady areas. It needs soil that is saturated but not persistently flooded. It usually grows on hummocks in wetlands, which keep the roots moist but not submerged. Specific habitats include Atlantic white-cedar swamps, swampy forested wetlands that border small streams, meadows, and spring seepage areas. It is most commonly found with other wetland plants, such as Atlantic white cedar (*Chamaecypa tisthyoides*), red maple (*Acer rubrum*), sweet pepperbush (*Clethra alnifolia*), sweetbay magnolia (*Magnolia virginiana*), sphagnum moss (*Sphagnum* spp.), cinnamon fern (*Osmunda cinnamomea*), skunk cabbage (*Symplocarpus foetidus*), pitch pine (*Pinus rigida*), American larch (*Larix laricina*), black spruce (*Picea mariana*), and laurel (*Kalmia* spp.). The overstory plants can also provide some protection from grazing by deer (FWS, 2010c), (CPC, 2010b).

As of 1991, when a recovery plan for swamp pink was completed, New Jersey supported over half the known populations of the species, with 139 records and 71 confirmed occurrences. It was considered locally abundant in Camden County, with most of the occurrences on the coastal plain in pinelands fringe areas in the Delaware River drainage. Fifteen sites were confirmed in Delaware, also in the coastal plain province in the counties of New Castle, Kent, and Sussex (FWS, 1991). A 5 year review was completed in 2008 to assess progress on the recovery plan. Due to field investigations, there are now 227 known occurrences of swamp pink; however, several prior populations are now considered historic and many of the new and previously existing populations are now ranked poorly and many are in decline. New Jersey completed several preserve designs or conservation plans to conserve 21 existing populations between 1991 and 2001. In addition, 11 agreements with landowners have been reached between the FWS and individuals in New Jersey, though these agreements do not provide permanent protection (FWS, 2008b).

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

2.2.8 Socioeconomic Factors

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

The socioeconomic region of influence (ROI) for Salem is defined as the areas in which Salem employees and their families reside, spend their income, and use their benefits, thereby affecting the economic conditions of the region. The Salem ROI consists of a four-county region where approximately 85 percent of Salem employees reside: Salem, Gloucester, and Cumberland counties in New Jersey and New Castle County in Delaware. The ROI for HCGS is defined as the areas in which HCGS employees and their families reside. The HCGS ROI consists of the same four-county region, where 82 percent of HCGS employees reside. Salem and HCGS staff include shared corporate and matrixed employees, 79 percent of whom reside in the four-county region. The following sections describe the housing, public services, offsite land use, visual aesthetics and noise, population demography, and the economy in the ROI for Salem and HCGS.

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

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

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

Source: PSEG, 2010c

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

2.2.8.1 *Housing*

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

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

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

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

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

Sources: USCB, 2000a; USCB, 2009

2.2.8.2 *Public Services*

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

Water Supply

Approximately 85 percent of Salem employees, 82 percent of HCGS employees, and 79 percent of shared PSEG corporate and matrixed employees reside in Salem, Gloucester, and Cumberland counties in New Jersey and New Castle County in Delaware (PSEG, 2010c). Information for the major municipal water suppliers in the three New Jersey counties, including firm capacity and peak demand, is presented in Table 2-12. Population served and water source for each system is also provided. The primary source of potable water in Cumberland County is groundwater withdrawn from the Cohansey-Maurice watershed. In Gloucester County, the water is primarily groundwater obtained from the Lower Delaware watershed. The major suppliers in Salem County obtain their drinking water supply from surface water or groundwater from the Delaware Bay watershed.

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

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

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

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

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

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

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

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

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

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

Comment [AB41]: Should this be EPA, 2010c?

Education

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

Transportation

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

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

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

2.2.8.3 *Offsite Land Use*

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

Salem County, New Jersey

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

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

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

Lower Alloways Creek Township has a master plan to guide development, which includes a land use plan (LACT, 1992). The plan encourages development in those areas of the township most capable of providing necessary services, continuation of agricultural use, and restriction on development in the conservation district (primarily wetlands). The land use plan includes an industrial district adjacent to Artificial Island. The master plan was updated in the *2005 Master Plan Reexamination Report* (Alaimo Group, 2005), which looked at key issues and reaffirmed the importance of preserving farmland, open space, and environmental resources.

Cumberland County, New Jersey

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

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

Gloucester County, New Jersey

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

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

New Castle County, Delaware

New Castle County, the northernmost county in the State of Delaware, is located east of Salem County across the Delaware River. The county encompasses slightly more than 426 mi^2 and has an estimated resident population of 529,641, which is a 5.9 percent increase from 2000 to 2008. It is the most populous of the three counties in Delaware (USCB, 2009). The three major land uses in New Castle County are agriculture (29 percent), residential (28 percent), and forests (15 percent) (New Castle County, 2007). In 2007, the county had a total of 347 farms (less than 14 percent of all farms in the State) located on approximately 67,000 ac of land. This reflects a decrease of 6 percent in land used for farming compared to 2000 (USDA, 2007).

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

2.2.8.4 *Visual Aesthetics and Noise*

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

The main vertical components of the Salem and HCGS building complex are the HCGS natural draft cooling tower (514-ft [157-m] tall), the most prominent feature on Artificial Island, and the three-domed reactor containment buildings (190 to 200-ft [57.9 to 60.9-m] tall). The structures are most visible from the Delaware River. Portions of the Salem and HCGS building complex can be seen from many miles away, in particular the cooling tower and the plume it produces. The complex can easily be seen from the marsh areas and the river itself, while in the more populated areas, it is often blocked by trees or houses and can only be seen from certain angles. The structures within the Salem and HCGS building complex are for the most part made of concrete and metal, with exposed non-concrete buildings and equipment painted light, generally neutral colors, such as brown and blue (AEC, 1973), (PSEG, 1983). The overhead transmission lines leading away to the north, northeast, and east can also be seen from many directions as they cross over the low profile expanses of the marshes. Farther inland, portions of the transmission lines are visible, especially as they pass over roads and highways.

Sources of noise at Salem and HCGS include the cooling tower, transformers, turbines, circuit breakers, transmission lines, and intermittent industrial noise from activities at the facilities. Noise studies were conducted prior to the operation of the Salem generating units. The transformers were each estimated to produce between 82 and 85 adjusted decibels (dBA) at 6 ft away, and the turbines were each estimated to produce 95 dBA at 3 ft away. The combined noise from all sources was estimated at 36 dBA at the site boundary. The noise from the plant at the nearest residence, approximately 3.5 mi from the Salem and HCGS facilities, was estimated to be approximately 27 dBA. The U.S. Department of Housing and Urban Development (HUD) criterion guidelines for non-aircraft noise define 45 dBA as the maximum noise level for the "clearly acceptable" range. Therefore, noise from the Salem generating units was considered acceptable to nearby receptors (AEC, 1971). Additional pre-operational studies were conducted for HCGS. An ambient noise survey, within a radius of 5 mi, established that most of the existing sound levels were within New Jersey's limits for industrial operations, as measured at residential property boundaries. The exceptions were sound levels measured at five locations in unpopulated areas near the facility, presumably reflecting construction activities at HCGS and vehicular traffic on the facility access road. Additional noise sources from aircraft could also have contributed to these high readings (PSEG, 1983).

2.2.8.5 *Demography*

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

Table 2-14 shows population projections and growth rates from 1970 to 2030 in Cumberland, Gloucester, and Salem counties in New Jersey and New Castle County in Delaware. All of the four counties experienced continuous growth during the period 1970 to 2000, except for Salem County, which saw a 1.5 percent decline in population between 1990 and 2000. Gloucester County experienced the greatest rate of growth during this period. Beyond 2000, county populations are expected to continue to grow in the next decades, with Gloucester County projected to experience the highest rate of growth.

Table 2-14. Population and Percent Growth in Cumberland, Gloucester, and Salem Counties, New Jersey, and New Castle County, Delaware from 1970 to 2000 and Projected for 2010 to 2030

Year	Cumberland County		Gloucester County		Salem County		New Castle County	
	Population	Percent Growth(a)	Population	Percent Growth(a)	Population	Percent Growth(a)	Population	Percent Growth(a)
1970	121,374	—	172,681	—	60,346	---	385,856	----
1980	132,866	9.5	199,917	15.8	64,676	7.2	398,115	3.2
1990	138,053	3.9	230,082	15.1	65,294	1.0	441,946	11.0
2000	146,438	6.1	254,673	10.7	64,285	-1.5	500,265	13.2
2010	157,745	7.7	289,920	13.8	66,342	3.2	535,572	7.1
2020(b)	164,617	4.4	307,688	6.1	69,433	4.7	564,944	5.5
2030(b)	176,784	7.4	338,672	10.1	74,576	7.4	586,387	3.8

— = Not applicable

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

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

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

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

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

	Cumberland, NJ	Gloucester, NJ	Salem, NJ	New Castle, DE	ROI
Total Population	**146,438**	**254,673**	**64,285**	**500,265**	**965,661**
Race (percent of total population, Non-Hispanic or Latino)					
White	72.1	88.0	82.8	74.6	78.5
Black or African American	23.7	9.1	15.0	21.0	17.7
American Indian and Alaska Native	0.9	0.2	0.3	1.7	0.3
Asian	1.1	1.5	0.6	2.7	2.0
Native Hawaiian and Other Pacific Islander	0.03	0.02	0.02	0.03	0.03
Some other race	0.1	0.09	0.09	0.1	0.12
Two or more races	2.0	1.1	1.2	1.3	1.3
Ethnicity					
Hispanic or Latino	27,823	6,583	2,498	26,293	63,197
Percent of total population	19.0	2.6	3.9	5.3	6.5
Minority Populations (including Hispanic or Latino ethnicity)					
Total minority population	60,928	36,411	13,114	146,505	256,958
Percent minority	41.6	14.3	20.4	29.3	26.6

Source: USCB, 2000d

Comment [AB42]: Should this percentage added to the "Percent minority" in the last row equal 100%?

Transient Population

Within 50 mi (80 km) of Salem and HCGS, colleges and recreational opportunities attract daily and seasonal visitors who create demand for temporary housing and services. In 2000, in the four-county ROI, 0.5 percent of all housing units were considered temporary housing for seasonal, recreational, or occasional use. Table 2-16 provides information on seasonal housing for the counties located within the Salem and HCGS ROI (USCB, 2000b). In 2008, there were 49,498 students attending colleges and universities located within 50 mi (80 km) of Salem and HCGS (NCES, 2009).

Table 2-16. Seasonal Housing in the Salem Nuclear Generating Station and Hope Creek Generating Station Region of Influence in 2000

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

Source: USCB, 2000c

Migrant Farm Workers

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

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

The 2007 Census of Agriculture collected information on migrant farm and temporary labor. Table 2-17 provides information on migrant farm workers and temporary (less than 150 days) farm labor within 50 mi (80 km) of Salem and HCGS. According to the 2007 Census of Agriculture, 15,764 farm workers were hired to work for less than 150 days and were employed on 1,747 farms within 50 mi (80 km) of Salem and HCGS. The county with the largest number of temporary farm workers (4,979 persons on 118 farms) was Atlantic County, NJ (USDA, 2007). Salem County had 804 temporary farm workers on 121 farms; Cumberland County had 1,857 temporary workers on 141 farms, and Gloucester County had 1,228 on 110 farms (USDA, 2007). New Castle County reported 320 temporary workers on 52 farms.

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

Table 2-17. Migrant Farm Worker and Temporary Farm Labor within 50 Miles of Salem Nuclear Generating Station and Hope Creek Generating Station

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

(a) Includes counties with approximately more than half their area within a 50-mi radius of Salem and HCGS.
Source: USDA, 2007

2.2.8.6 *Economy*

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

Employment and Income

Between 2000 and 2007, the civilian labor force in Salem County decreased 4.4 percent to 18,193. During the same time period, the civilian labor force in Gloucester County and Cumberland County grew 18.5 percent and 5.8 percent, respectively, to the 2007 levels of

92,154 and 48,468. In New Castle County, DE, the civilian labor force increased slightly (0.9 percent) to 284,647 between 2000 and 2007 (USCB, 2010a).

In 2008, trade, transportation, and utilities represented the largest sector of employment in the three New Jersey counties, followed by education and health services in Salem and Gloucester counties and manufacturing in Cumberland County (NJDLWD, 2010a), (NJDLWD, 2010b), (NJDLWD, 2010c). The trade, transportation, and utilities sector employed the most people in New Castle County, DE in 2008, followed closely by the professional and business services sector (DDL, 2009). A list of some of the major employers in Salem County is provided in Table 2-18. The largest employer in the county in 2006 was PSEG with over 1,300 employees.

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

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

Source: Salem County, 2007

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

Income information for the four-county ROI is presented in Table 2-19. Median household incomes in Gloucester and New Castle counties were each above their respective State median household income averages, while Salem and Cumberland counties had median household incomes below the State of New Jersey average. Per capita incomes in Salem, Gloucester, and Cumberland counties were each below the State of New Jersey average, while the New Castle County per capita income was above the State of Delaware average. In Salem and Cumberland counties, 9.9 and 15.1 percent of the population, respectively, was living below the official poverty level, which is greater than the percentage for the State of New Jersey as a whole (8.7 percent). Only 7.5 percent of the Gloucester County population was living below the poverty level. In Delaware, 9.9 percent of the New Castle County population was living below the poverty level, while the State average was 10.4 percent.

Table 2-19. Income Information for the Salem Nuclear Generating Station and Hope Creek Generating Station Region of Influence, 2008

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

Source: USCB, 2008

Unemployment

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

Taxes

The owners of Salem and HCGS pay annual property taxes to Lower Alloways Creek Township. From 2003 through 2009, PSEG and Exelon paid between $1,191,870 and $1,511,301 annually in property taxes to Lower Alloways Creek Township (Table 2-20). During the same time period, these tax payments represented between 54.2 and 59.3 percent of the township's total annual property tax revenue. Each year, Lower Alloways Creek Township forwards this tax money to Salem County, which provides most services to township residents. The property taxes paid annually for Salem and HCGS during 2003 through 2009 represent approximately 2.5 to 3.5 percent of Salem County's total annual property tax revenues during that time period. As a result of the payment of property taxes for Salem and HCGS to Lower Alloways Creek Township, residents of the township do not pay local municipal property taxes on residences, local school taxes, or municipal open space taxes; they only pay Salem County taxes and county open space taxes (PSEG, 2009a), (PSEG, 2009b).

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

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

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

In addition, PSEG and Exelon pay annual property taxes to the City of Salem for the Energy and Environmental Resource Center, located in Salem. From 2003 through 2009, between $177,360 and $387,353 in annual property taxes for the center were paid to the city (Table 2-21).

Table 2-21. Energy and Environmental Resource Center Property Tax Paid and Percentage of City of Salem Tax Revenues, 2003 to 2009

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

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

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

In 1999, the State of New Jersey deregulated its utility industry (EIA, 2008). Any changes to the tax assessment for Salem or HCGS would already have occurred and are reflected in the tax payment information provided in Table 2-20. Potential future changes to Salem and HCGS property tax rates due to deregulation would be independent of license renewal.

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

2.2.9 Historic and Archaeological Resources

This section presents a brief summary of the region's cultural background and a description of known historic and archaeological resources at the Salem/HCGS site and its immediate vicinity. The information presented was collected from area repositories, the New Jersey State Historic Preservation Office (SHPO), the New Jersey State Museum (NJSM), and the applicant's ER (PSEG, 2009a), (PSEG, 2009b).

2.2.9.1 *Cultural Background*

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

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

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

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

Paleo-Indian Period

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

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

Archaic Period

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

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

Woodland Period

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

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

Contact Period

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

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

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

<u>Historic Period</u>

The first European settlement in the vicinity of the Salem/HCGS site occurred in 1638, when a Swedish fort was established along the Delaware River in the present day town of Elsinborough (Barber, 1844). This settlement was short lived, as the location was plagued with mosquitoes and was eventually deemed untenable. Later attempts to settle the area by Swedish, Finnish, and Dutch groups also met with limited success. In 1675, the Englishman John Fenwick and his group of colonists landed along the Delaware River, north of the original Swedish settlement at Elsinborough (Brown, 2007). They established "Fenwicks Colony" and the town of Salem. In 1790, the population of Salem County was 10,437. By 1880, the county's population had more than doubled in size, reaching 24,579. Today, approximately 65,000 people inhabit Salem County (USCB, 2010a).

Comment [AB43]: Not listed in References section.

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

Comment [AB44]: Not listed in References section.

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

<u>Previously Identified Resources</u>

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

Comment [AB45]: Not listed in References section.

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

Potential Archaeological Resources

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

2.3 RELATED FEDERAL PROJECT ACTIVITIES

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

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

- Coast Guard Training Center, Cape May (New Jersey)
- Dover Air Force Base (Delaware)
- Aberdeen Test Center (Maryland)
- United States Defense Government Supply Center, Philadelphia (Pennsylvania)
- Federal Correctional Institution, Fairton (New Jersey)
- Federal Detention Center, Philadelphia (Pennsylvania)
- New Jersey Coastal Heritage Trail
- Great Egg Harbor National Scenic and Recreational River (New Jersey)
- New Jersey Pinelands National Reserve
- Captain John Smith Chesapeake National Historic Trail (Delaware, Maryland)
- Chesapeake Bay Gateways Network (Delaware, Maryland)

- Hopewell Furnace – National Historic Site (Pennsylvania)
- Cape May National Wildlife Refuge (New Jersey)
- Supawna Meadows National Wildlife Refuge (New Jersey)
- Eastern Neck National Wildlife Refuge (Maryland)
- Bombay Hook National Wildlife Refuge (Delaware)
- Prime Hook National Wildlife Refuge (Delaware)
- Independence National Historical Park (Pennsylvania)

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

Although it is not a Federal project, the potential construction of a fourth unit at the Salem and HCGS site would require action by a Federal agency. PSEG intends to submit an early site permit application to the NRC regarding possible construction of a new nuclear power plant unit at the Salem and HCGS site on Artificial Island (PSEG, 2010e).

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

2.4 REFERENCES

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

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

~~16 United States Code (USC) 1802(10).~~

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

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

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

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

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