Attachment 6

Fact Sheet

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
NEW ENGLAND - REGION I
5 POST OFFICE SQUARE, SUITE 100 (OEP06-1)
BOSTON, MASSACHUSETTS 02109-3912

FACT SHEET

DRAFT NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT TO DISCHARGE TO WATERS OF THE UNITED STATES PURSUANT TO THE CLEAN WATER ACT (CWA)

NPDES PERMIT NUMBER: **MA0003557**

PUBLIC NOTICE START AND END DATES: May 18, 2016 – July 18, 2016

NAME AND MAILING ADDRESS OF APPLICANT:

Entergy Nuclear Generation Company
Pilgrim Nuclear Power Station
600 Rocky Hill Road
Plymouth, MA 02360

NAME AND ADDRESS OF FACILITY WHERE DISCHARGE OCCURS:

Pilgrim Nuclear Power Station
600 Rocky Hill Road
Plymouth, MA 02360

RECEIVING WATER(S): **Cape Cod Bay**

RECEIVING WATER CLASSIFICATION(S): **Class SA**

SIC CODE: **4911 (Electric Services)**

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1.0 PROPOSED ACTION, TYPE OF FACILITY, AND DISCHARGE LOCATION

Entergy Nuclear Generation Company (Entergy), the permittee, owns and operates Pilgrim Nuclear Power Station (PNPS) in Plymouth, MA. PNPS is a 670 megawatt (MW) electric generating station adjacent to Cape Cod Bay in Plymouth, MA. The facility discharges wastewater from a combination of once-through cooling water, traveling screen washwater, treated process wastewaters, miscellaneous low volume wastewaters, and storm water.

The site was purchased in 1967 for the main purpose of constructing PNPS. Commercial operation of the station began in December of 1972 by Boston Edison Company and this permit was subsequently transferred to Entergy with a change of ownership in 1999. The PNPS facility occupies approximately 140 acres and utilizes one-through cooling water from Cape Cod Bay for its condenser. Entergy also owns an additional 1500 acres adjacent to the plant site that has been placed in a forest management trust. PNPS is located on the western shore of Cape Cod Bay and occupies one (1) mile of continuous shoreline frontage. The site can be accessed by land or from Cape Cod Bay. See Figures 1 and 2 for local and regional site locus maps.

The major features of the PNPS site are the reactor and turbine buildings, the off-gas retention building, the radwaste building, the diesel generator building, the intake structure and main discharge canal, the switchyard, the main stack, administration buildings, and the former recreational facilities. Refer to Figure 3 for the site layout including the intake embayment, discharge channel, and permitted outfalls.

PNPS has one boiling water reactor unit and a steam-driven turbine generator system. The PNPS fuel is low-enriched uranium dioxide with maximum enrichment of 4.6 percent by weight uranium-235 and fuel burn-up levels of 48,000 megawatt-days per metric ton uranium. The primary containment for the reactor is a pressure suppression system, which includes a drywell, pressure suppression chamber, vent system, isolation valves, containment cooling system, and other service equipment. The containment is designed to withstand an internal pressure of 62 pounds per square inch (PSI) above atmospheric pressure and to act as a radioactive materials barrier. A secondary containment completely encloses both the primary containment and fuel storage areas and acts as a radioactive material barrier as well.

A quantitative description of the discharge in terms of significant effluent parameters based upon historical discharge data is shown on Attachment A. The data are shown for what is referred to in this fact sheet as the monitoring period, which covers the period of January 2008 through March 2016.

On April 29th, 1991, the U.S. Environmental Protection Agency (EPA) and the Massachusetts Department of Environmental Protection (MassDEP) issued PNPS (then owned by Boston Edison Company) a NPDES permit (Current Permit) under the federal Clean Water Act (CWA) and the Massachusetts Clean Waters Act, respectively, to govern the facility's withdrawal of water from Cape Cod Bay for cooling uses and its discharges of pollutants to Cape Cod Bay as part of a variety of wastewater streams. These wastewater streams consist of condenser non-contact cooling water [circulating water (CW) system] (Outfall 001), thermal backwash for bio-fouling control (Outfall 002), intake screen wash water (Outfalls 003 and 012), plant service cooling water [service water (SW) system, also referred to as Salt Service Water (SSW) system] (Outfall 010), and neutralizing sump waste commingled with demineralizer reject water, station heating water, and SW (Outfalls 011 and 014). Additionally, two outfalls discharge stormwater (Outfalls 004 and 007), one outfall discharges stormwater commingled with fire water storage tank discharge (Outfall 006), and one outfall discharges stormwater commingled with most of the flows from Outfall 011 (Outfall 005). See Figure 4 for the water flow diagram.

Under normal operating conditions when electricity is being generated, continuous discharges at the facility include flows from Outfalls 001[1] and 010. All other discharges, from Outfalls 002, 003, 004, 005, 006, 007, 011, 012, and 014 are intermittent.

Table 1 - Outfall Summary

Outfall Serial Number	Description of Discharge
001	Once-through non-contact cooling water – chlorinated
002	Thermal and non-thermal backwash water
003	Screenwash water (traveling screens) to intake embayment – dechlorinated
004, 006, 007	Storm water from yard drains, including electrical vault water
005	Storm water from yard drains, including electrical vault water, demineralizer reject water
010	Service water (SW) for turbine building closed cycle cooling water (TBCCW) and reactor building closed cycle cooling (RBCCW) systems– chlorinated
011	Internal outfall - Various wastewaters from station heating and service water systems and demineralizer reject water
012	Screenwash water to discharge canal - dechlorinated
014 (new outfall)	Discharges from waste neutralization sump including TBCCW and RBCCW systems, standby liquid control (SLC) system

The facility also discharges from two outfalls which are not included in the current NPDES permit: a radwaste system discharge, which is currently sampled for boron, nitrates, and radioactivity and a small miscellaneous stormwater discharge, which only discharges under extreme storm conditions and has not discharged in the last 5 years. The radwaste system discharge shall be in accordance with the U.S. Nuclear Regulatory Commission (USNRC) operational requirements at 10 C.F.R. Part 20 and USNRC technical specifications set forth in the facility's operating license, DPR-35. The miscellaneous stormwater discharge that was

[1] CW flow to the discharge canal [001] is usually continuous, except for condenser backwashes (including thermal backwashes [002]), and when both CW pumps are shut off during refueling outages.

reported by the permittee during the permit term is acknowledged and authorized by this permit and designated Outfall 013.

Additives at the facility consist of sodium hypochlorite [chlorination of Outfall 001 (CW system) and 010 (SW system)], sodium thiosulfate [dechlorination of screenwash water for Outfalls 003 and 012)], sodium nitrite and tolyltriazole (corrosion inhibitors present in periodic discharges through Outfalls 011 and 014), and sodium pentaborate (added to produce boronated water). No biocides other than chlorine, in the form of sodium hypochlorite solution, are used at the facility. Use of any other biocide shall be approved as described on Page 3, footnote 5 of the permit.

The current permit (1991 Permit) was issued and effective on April 29, 1991, was modified on August 30th, 1994, and expired on April 29, 1996. On September 19th, 1995, Boston Edison, the permittee at the time, submitted a timely and complete permit renewal application. Since the permit renewal application was deemed timely and complete by EPA, the permit was administratively continued pursuant to 40 C.F.R. § 122.6. In a letter dated July 7, 1999, the permittee requested transfer of ownership from Boston Edison Company to Entergy. Entergy submitted a permit reapplication update on December 1, 1999.

Additionally, Entergy has submitted additional information in Response to Requests for Information under Section 308(a) of the CWA from EPA dated September 10, 1999, June 9, 2000, October 25, 2004 (which was supplemented by an additional request on July 31, 2007), August 18, 2014, and June 30, 2015 (for electrical vault water sampling).

Certain operational changes at PNPS have been granted approval since the last permit issuance, including the following:

- A letter from EPA dated June 30, 1995, approved the use of Tolyltriazole, a corrosion inhibitor, in various Pilgrim Station systems [station heating systems, and reactor building and turbine building closed cooling-water systems (RBCCW and TBCCW), which discharge through Outfall 011].
- EPA approved, subject to annual review, removal of the PNPS discharge canal fish barrier net on November 23, 1994.
- Two daily, manual grab samples of the service water (SW) System continuous chlorination for total residual oxidants (chlorine) were approved by EPA in lieu of continuous chlorination monitoring on August 26, 1998.
- On October 1, 1998 (AR #74), EPA approved the discharge of demineralizer reject water to Outfall 005.

On October 13, 2015, citing poor market conditions, reduced revenues and increased operational costs, Entergy announced that it would shut PNPS down, essentially terminating electricity generation at the facility, no later than June 1, 2019.[2] In a press release of April 14, 2016, Entergy announced that it would be refueling the Pilgrim facility in 2017 to continue providing

[2] Press Release, Entergy, Entergy to Close Pilgrim Nuclear Power Station in Massachusetts No Later than June 1, 2019 (Oct. 13, 2015), AR#515.

electricity and will be ceasing operations on May 31, 2019.[3] On December 18, 2015, the Independent System Operator of New England (ISO-NE) accepted Entergy's Non-Price Retirement request for the facility.[4] Because Entergy has advised EPA that some discharges and water withdrawals will continue after the cessation of electricity generation, the draft permit reflects post-shutdown operations and discharges as appropriate. However, since the permittee cannot fully anticipate all changes in permitted flows that will take place post-shutdown, this permit may be modified post-shutdown if warranted.

2.0 DESCRIPTION OF PROCESSES AND DISCHARGES

2.1 Nuclear Steam Supply System Operation

The Boiling Water Reactor (BWR) that is employed by PNPS is designed to: produce electrical energy through conversion, via a turbine driven generator, of a portion of thermal energy contained in the steam supplied from the reactor; condense the turbine exhaust steam into water; and return the water to the reactor as heated feedwater with a major portion of the gaseous, dissolved, and particulate impurities removed. The major components of the power generation system are: turbine generator, main condenser, condensate pumps, condensate demineralizers, reactor feed pumps, feedwater heaters, and condensate storage system. The heat rejected to the main condenser (the waste heat inherent in any thermodynamic cycle) is removed by the circulating water (CW) system.

The saturated steam produced by the reactor is passed through the high pressure turbine where the steam is expanded and then exhausted through moisture separators. Moisture is removed in the moisture separators and the steam is then passed through the low pressure turbines where the steam is again expanded. From the low pressure turbines, the steam is exhausted into the condenser where the steam is condensed and de-aerated, and then returned to the cycle as condensate.

2.2 Cooling Water Intake Structure (CWIS)

Cape Cod Bay is the source of cooling water and service water for PNPS. The facility uses a once-through cooling system in which seawater is withdrawn from the bay via an embayment formed by two breakwaters and is discharged into a 900-ft-long discharge canal immediately adjacent to the intake embayment. (See Figure 3) The CWIS provides 311,000 gpm, or 448 MGD, of condenser cooling water via two (2) circulating water (CW) pumps and can provide up to 13,500 gpm, or 19.4 MGD, of cooling water to the service water system via five (5) service water (SW) pumps. The intake structure also supplies flow, as demanded, to the Fire Protection System Pumps. PNPS obtains its potable and reactor makeup water from the Town of Plymouth's municipal water system. See Figure 5 for a plan view and cross sectional views of PNPS' CWIS.

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[3] *Id.*

[4] Letter from Stephen J. Rourke, Vice President, ISO-NE, to Marc Plotkin, Vice President, Entergy Nuclear Power Marketing (Dec. 18, 2015), (AR# 514) *available at* http://www.iso-ne.com/static-assets/documents/2015/12/entergy_537.pdf.

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

Under normal operation, seawater is heated in the condenser to approximately 27 to 30°F above the intake temperature, with the permit limit being 32°F. With the cooling water flow being relatively constant at 311,000 gpm throughout the year, the discharge temperature is almost entirely a function of the intake water temperature. The purpose of the main condenser is to serve as a heat sink (*i.e.*, a mechanism for heat removal) for the turbine exhaust steam, the turbine bypass steam, and for other flows. The PNPS main condenser is a twin shell, horizontal titanium tube, seawater cooled unit and is located in the Turbine Building below the main turbine’s low-pressure sections. The location of the condenser below the main turbine is indicative of its function, whereby the cooling water of the CW system condenses the steam exhausted from the turbine, which is then returned to the reactor as feedwater. The arrangement of CW piping allows backwashing of the condenser by section to remove possible debris accumulated on the inlet tube sheets. See Figure 6 for a schematic of the cooling process flow.

From the condenser, water flows through a buried concrete conveyance to the discharge canal. This discharge is designated as Outfall 001. The conveyance consists of a 13 foot by 17 foot reinforced concrete box culvert that runs for about 235 feet, followed by a 10.5 foot diameter concrete pipe that runs for about 250 feet. Upon exiting the concrete pipe, discharged water enters a 900 foot long trapezoidal discharge canal separated from the intake embayment by a breakwater. The discharge from the SW system also discharges through this canal. See Figure 3 for a schematic of the intake embayment and discharge channel.

The discharge canal was created by two breakwaters that are oriented perpendicular to the shoreline, one of which is shared with the intake embayment. The channel sides are sloped at a 2:1 horizontal-to-vertical ratio. The bottom is 30 foot wide at an elevation of 0 ft MLW, or 4.8 ft below MSL. The channel bottom remains at this elevation until it converges with the shore, which has a slope of approximately 4:1 at the channel mouth. The discharge canal is extended over the beach to mean low water (MLW) by rock-fill jetties. The jetties are of rubble mound construction and are protected by heavy capstone. The jetties have a nominal elevation of +16 MLW sloping down to a height of 4 ft at MLW. The elevation of the bed of the discharge canal is 0 ft MLW. The discharge canal jetties also serve to promote rapid mixing in Cape Cod Bay for heat dissipation and to protect the CWIS and discharge structures from wave action. At low tide, the water in the discharge canal is several feet higher than sea level, and the discharge is rapid and turbulent, estimated at 8.1 feet per second (fps). At high tide, the velocity is estimated at 1.4 fps, because the cross sectional area of flow in the channel is greater. Discharge of the heated water creates a thermal plume in the nearshore area of PNPS.

Outfalls 001 [condenser cooling water (CW system)], 002 (thermal backwash), and 010 [plant service cooling water (SW system)] are "once-through" discharge points. The source water for these outfalls is Cape Cod Bay. Outfalls 003 and 012 (intake screen wash) and 011 and 014 (waste neutralization sump) use Cape Cod Bay water and/or City of Plymouth municipal (drinking) water. Outfalls 004, 005, 006, 007, and 013 are designated storm water outfalls. In addition to stormwater, Outfall 005 also intermittently discharges a portion of the flows from Outfall 011, with the remainder being discharged through Outfall 014. In addition to stormwater, Outfall 006 discharges fire water storage tank water (municipal water) during maintenance.

2.3 Cooling and Auxiliary Water Systems

Located in the seawater pump wells of the CWIS, two vertical, mixed-flow, wet-type pumps provide a continuous supply to the CW system. Each 1450-horsepower pump has a capacity of 155,500 gallons per minute (gpm). The water is pumped from the intake structure to the condenser via two buried concrete pipes measuring 7.5 feet in diameter. Measurements taken at the breakwaters during mid-tide level with both pumps running indicate that the average intake velocity is 0.05 fps. At the intake, before the screens, the velocity is about 1 fps during all tidal conditions. Through the traveling screens, the velocity has been estimated by calculation to be 1.57 fps. The velocity is approximately 0.15 fps near the east fish-return sluiceway, which is located in the intake embayment just east of the intake structure.

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

Chlorination of the CW system also takes place, on a periodic basis, and typically occurs during spring, summer, and fall, when the circulating water system is chlorinated two hours per day (one hour for each pump). Sodium hypochlorite is also added inboard of the bar rack to control fouling.

2.4 Traveling Screens

Prior to water flowing through either the cooling water pumps or the service water pumps, water passes through one of four (4), ten (10) foot wide traveling screens. The screens work to prevent small debris and small aquatic organisms from being entrained into the cooling water or service water systems. Each screen is constructed of 53 segments with ¼-inch by ½-inch stainless steel wire mesh. Each segment has a stainless steel lip that is used to lift debris and organisms and direct them into a fish-return sluiceway.

The traveling screens are not rotated continuously but are operated on average, 3 to 4 times each day, depending on the scenarios listed below. The screens normally operate at 5 fps, but can be operated at up to 20 fps during storm events that could cause extreme debris loading. The screens operate under the following circumstances or conditions:

- When there is an indication that fish are being impinged at a rate exceeding 20 fish per hour, at which time the traveling screens are turned continuously until the impingement rate drops below 20 fish per hour for two consecutive sampling events.
- During impingement sampling that is required by the permit's marine life monitoring program. Each impingement sampling event is conducted for a minimum of 30 minutes, three (3) times per week.
- When the difference in water level on each side of the screen reaches a specified threshold at an alarm set point. The threshold is typically set at six (6) inches. This level difference signifies that too much debris has collected on the screen. Level differences are rare and usually the result of a storm event.
- During chlorination, which occurs each day for two hours when the main cooling water system is chlorinated inboard of the trash rack to control fouling.
- Whenever water temperatures are less than 30 degrees Fahrenheit (F).
- At a minimum, once per each 12-hour shift, usually at the beginning and end of each shift, and lasting for a few hours.

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

Impinged fish are washed into a seamless concrete fish-return sluiceway and usually returned to the intake embayment approximately 300 feet east of the intake structure. The original wet sluiceway, newly designated in this permit as Outfall 012, was installed in 1972 and was connected to the discharge canal. In 1979, the east sluiceway was installed and connected to the intake embayment. This discharge is designated as Outfall 003. During storms, some of the wash water may be discharged via the original sluiceway to the discharge canal through Outfall 012.

See Figure 7 for a schematic showing the two (2) fish return locations associated with these outfalls. An interchangeable baffle plate is utilized to divert the flow to one sluiceway or the other from the screenhouse. The baffle plate directs organisms and debris; however, some water flows over this structure and into the alternate sluiceway. The east sluiceway (Outfall 003) was designed to maintain a minimum 6-inch depth and a water velocity of less than 8 fps, is covered with galvanized wire screen, and has no sharp turns. The discharge point of the east sluiceway is at the mean low water (MLW) level. On occasion, the end of the east sluiceway has been seen above the water level, causing any organisms present to experience a "free fall" scenario. The west sluiceway discharge is above the MLW level in the discharge canal.

2.5 Thermal Backwash

Three to five times each year, the plant's output is reduced to about 50 percent of its maximum capacity and a thermal backwash is conducted to control biological fouling. The backwash procedure involves heating non-chlorinated seawater from the condensers up to about 105 °F and then pumping this water to flow back through the traveling screens and out to the intake embayment. The treatment is maintained for up to one (1) hour at each intake bay separately. Scheduling of the thermal backwash treatments is coordinated with the highest tide to achieve maximum coverage, preventing mussels from growing in the upper elevations of the intake structure. There are also occasional non-thermal backwashes conducted as necessary, which do not use heated water. This discharge is designated as Outfall 002 and the monitoring requirements are described below in Section 6.2. See Figure 8 for a schematic of the thermal backwash configuration.

2.6 Liquid Radioactive Waste Processing Systems and Effluent Controls

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

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

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

If the liquid radioactive waste meets the facility's Offsite Dose Calculation Manual (ODCM) criteria for controlled release, it can be discharged on a controlled basis into the circulating water discharge canal through the liquid radioactive waste discharge header. As the liquid waste passes through the discharge header, the radioactivity level is continuously monitored. The discharge is automatically terminated if the activity exceeds preset levels. The facility's ODCM is used in accordance with the facility's USNRC operating license.

Drainage of liquid radioactive wastes from the Turbine and Reactor Building closed-cycle cooling water systems (TBCCW & RBCCW) as a result of plant outages are discharged through Outfall 011, as described in detail below.

3.0 Receiving Water Description

PNPS is located on the northwest shore of Cape Cod Bay in the Town of Plymouth, MA, as shown in Figure 2. Cape Cod Bay is a circular embayment of the Atlantic Ocean off the coast of eastern Massachusetts. All discharges from PNPS discharge to Cape Cod Bay, which is designated as Class SA High Quality Waters by the MassDEP under the Commonwealth of Massachusetts Surface Water Quality Standards (SWQS). *See* 314 CMR 4.06(4).[5]

Class SA waters are described in the SWQS (314 CMR 4.05(4)(a)) as:

> These waters are designated as an excellent habitat for fish, other aquatic life and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation. In certain waters, excellent habitat for fish, other aquatic life and wildlife may include, but is not limited to, seagrass. Where designated in the tables to 314 CMR 4.00 for shellfishing, these waters shall be suitable for shellfish harvesting without

[5] http://www.mass.gov/eea/docs/dep/service/regulations/314cmr04.pdf

depuration (Approved and Conditionally Approved Shellfish Areas). These waters shall have excellent aesthetic value.

The Massachusetts Division of Marine Fisheries (DMF) has identified Cape Cod Bay in the vicinity of the PNPS discharge as approved for shellfishing. The only exception is the shoreline area bordering the PNPS facility and extending to the edge of this designated area (CCB41), in which shellfishing is prohibited.

4.0 LIMITATIONS AND CONDITIONS

The effluent limitations and all other requirements described herein may be found in the draft permit. The basis for the limits and other permit requirements are described below. The Discharge Monitoring Report (DMR) data for the period of January 2008 through December 2014 were reviewed as part of developing the Draft Permit. This time period is referred to in this Fact Sheet as the "monitoring period." This DMR data is summarized in Attachment A and includes data for process and cooling water from Outfalls 001, 002, 003, 010 and 011. The limited monitoring data from the stormwater outfalls is discussed below in Section 6.4.

5.0 PERMIT BASIS: STATUTORY AND REGULATORY AUTHORITY

5.1 General Requirements

The Clean Water Act (CWA) prohibits the discharge of pollutants to waters of the United States without authorization from a National Pollutant Discharge Elimination System (NPDES) permit unless such a discharge is otherwise authorized by the statute. The NPDES permit is the mechanism used to implement technology-based and water quality-based effluent limitations and other requirements, including monitoring and reporting, at the facility-specific level. This draft NPDES permit was developed in accordance with various statutory and regulatory requirements established in or pursuant to the CWA and any applicable State regulations. The regulations governing the EPA NPDES permit program are generally found at 40 C.F.R. Parts 122, 124, 125, and 136.

EPA bases NPDES permit limits on applicable technology-based and water quality-based requirements. Subpart A of 40 C.F.R. Part 125 establishes criteria and standards for the imposition of technology-based treatment requirements in permits under Section 301(b) of the CWA, including the application of EPA-promulgated effluent limitations and case-by-case determinations of effluent limitations under Section 402(a)(1) of the CWA. *See* 40 C.F.R. § 125.3. The development of water quality-based standards is governed by a variety of legal requirements, including CWA §§ 301(b)(1)(C), 303, 401 and 510, as well as 40 C.F.R. § 122.44(d) and Part 131. Permit limits must, at a minimum, satisfy federal technology standards, but also must satisfy any more stringent water quality-based requirements that may apply. Put differently, between technology-based and water quality-based requirements, whichever is more stringent governs the permit. In addition, when setting permit limits, EPA must consider the requirements in the existing permit in light of the CWA's "anti-backsliding" requirements, which generally bar a reissued permit from relaxing limits as compared to the limits in an earlier permit, unless a specific anti-backsliding exception applies. *See* 33 U.S.C. § 1342(*o*); 40 C.F.R. § 122.44(*l*).

5.2 Technology-Based Requirements

5.2.1 General

Technology-based treatment requirements represent the minimum level of control that must be imposed under Sections 301(b) and 402 of the CWA (see also 40 C.F.R. Part 125, Subpart A). Technology-based limits are set to reflect the pollutant removal capability of particular treatment technologies that satisfy various narrative treatment technology standards set forth in the CWA. These standards, in essence, define different levels of treatment capability. Specifically, pollutant discharges must be limited to a degree that corresponds with the best practicable control technology currently available (BPT) for certain conventional pollutants, the best conventional control technology (BCT) for other conventional pollutants, and the best available technology economically achievable (BAT) for toxic and non-conventional pollutants. *See* 33 U.S.C. §§ 1311(b)(1)(A), (b)(2)(A), (E), (F); 40 C.F.R. § 125.3(a). For “new sources” of pollutant discharges, *see* 40 C.F.R. §§ 122.2 (definition of “new source”); 122.29(a), discharges of pollutants must be limited to a degree corresponding to the “best available demonstrated control technology” (BADT), 33 U.S.C. §§ 1316(a), (b).

In general, the statute requires that facilities like PNPS comply with technology-based effluent limitations as expeditiously as practicable, but in no case later than March 31, 1989. *See* 40 C.F.R. §125.3(a)(2). Since the statutory deadline for meeting applicable technology-based effluent limits has passed, NPDES permits must require immediate compliance with any such limits included in the permit. When appropriate, however, schedules by which a permittee will attain compliance with new permit limits may be developed and issued in an administrative compliance order under CWA § 309(a) or some other mechanism.

When EPA has promulgated national effluent limitation guidelines (ELGs) applying the statute’s narrative technology standards (such as the BAT standard) to pollutant discharges from a particular industrial category, then those ELGs provide the basis for any technology-based effluent limits included in NPDES permits issued to individual facilities within that industrial category. 33 U.S.C. §§ 1342(a)(1)(A), (b); *see also* 40 C.F.R. §§ 122.43(a) and (b), 122.44(a)(1), 125.3. In the absence of a categorical ELG, however, EPA develops technology-based effluent limits by applying the narrative technology standards on a case-by-case, Best Professional Judgment (BPJ) basis. 33 U.S.C. § 1342(a)(1)(B); *see also* 40 C.F.R. §§ 122.43(a), 122.44(a)(1), 125.3(c). When developing technology-based effluent limitations, EPA considers the terms of the particular technology standard in question, as specified in the statute and regulations, *id.*, along with a variety of factors enumerated in the statute and regulations for each specific technology standard. 33 U.S.C. § 1314(b); *see also* 40 C.F.R. § 125.3(d). In developing ELGs, EPA’s analysis is conducted for an entire industrial category or sub-category. In the absence of an ELG, EPA develops technology-based limits on a BPJ basis for a particular permit by conducting the analysis on a site-specific basis. As one court has explained:

> [i]n what EPA characterizes as a "mini-guideline" process, the permit writer, after full consideration of the factors set forth in section 304(b), 33 U.S.C. § 1314(b), (which are the same factors used in establishing effluent guidelines), establishes the permit conditions "necessary to carry out the provisions of [the CWA]." § 1342(a)(1). These conditions include the appropriate ... BAT effluent limitations for the particular point source. ... [T]he resultant BPJ limitations are as correct and as statutorily supported as permit limits based upon an effluent limitations guideline.

NRDC v. EPA, 859 F.2d 156, 199 (D.C. Cir. 1988).

5.2.2 ELGs for the Steam Electric Power Generating Point Source Category

EPA promulgated ELGs for the Steam Electric Power Generating Point Source Category (the Steam Electric ELGs) in 1982. See 40 C.F.R. Part 423. The provisions of this part are applicable to discharges resulting from the operation of a generating unit by an establishment primarily engaged in the generation of electricity for distribution and sale which results primarily from a process utilizing fossil-type fuel (coal, oil, or gas) or nuclear fuel in conjunction with a thermal cycle employing the steam water system as the thermodynamic medium. *See* 40 C.F.R. § 423.10. Since the operations at PNPS fall within those defined in this industrial category, they are covered by these ELGs. Revised ELGs for the Steam Electric Category were proposed on June 7, 2013 and the Final Rule for these ELGs was published on November 3, 2015 and became effective on January 4, 2016. *See* 80 Fed. Reg. 67,838 (Nov. 3, 2015). EPA has applied the revised ELGs in the draft permit. The Steam Electric ELGs set BPT standards for certain pollutants contained in low volume wastes, fly ash and bottom ash transport water, metal cleaning wastes, cooling water, and cooling tower blowdown. In addition, the ELGs set BAT standards for certain pollutants in cooling water, cooling tower blowdown, and chemical metal cleaning wastes. When an applicable categorical standard has not been developed, technology-based limits would instead be developed on a BPJ, case-by-case basis. *See* 40 C.F.R. § 125.3(c)(3).

The revised Steam Electric ELGs that apply to this facility are similar to the previous ELGs and include the following effluent limits based on BPT or BAT:

a. for low volume waste sources:
  (1) 100.0 mg/L as a maximum and 30.0 mg/L as a 30-day average for Total Suspended Solids (TSS), and
  (2) 20 mg/L as a maximum and 15 mg/L as a 30-day average for oil and grease (O&G);

b. for all discharges, except once-through cooling water: 6.0-9.0 SU for pH;

c. for all discharges: no discharge of polychlorinated biphenyl compounds (PCBs);

d. for once-through cooling water: 0.2 mg/L as a maximum for total residual chlorine (or total residual oxidants for intake water containing bromides); and

e. for cooling tower blowdown: 0.5 mg/L as a maximum and 0.2 mg/L as an average for free available chlorine.

The Steam Electric ELGs, however, establish categorical effluent limitations under the various technology standards for only some of the pollutants discharged by facilities in this industry. The Steam Electric ELGs do not include effluent limitations on the discharge of heat. In the absence of technology-based effluent guidelines, the permit writer is authorized under Section 402(a)(1)(B) of the CWA to establish effluent limitations on a case-by-case basis using Best Professional Judgment (BPJ). Therefore, any technology-based thermal discharge limits would be based on a BPJ application of the BAT technology standard, which is applicable to non-conventional pollutants such as heat. As discussed further below, however, the permit's thermal discharges limits may, instead, be based on water quality-based requirements or a thermal discharge variance under CWA § 316(a)). 33 U.S.C. § 1326(a).

In addition to the Steam Electric ELGs, Sector O of the 2015 Multi-Sector General Permit (MSGP) (Steam Electric Generating Facilities) contains Stormwater Pollution Prevention Plan (SWPPP) components, along with a benchmark monitoring concentration of 1.0 mg/L total iron. *See* 2015 MSGP, Part 8.O.7. Since PNPS is engaged in the activities covered by this sector, EPA has included technology-based permit conditions for stormwater discharges from these MSGP provisions in the SWPPP requirements of the draft permit in Section 9.0 below.

5.3 Water Quality-Based Requirements

Water quality-based limitations are required in NPDES permits when EPA and the State determine that effluent limits more stringent than technology-based limits are necessary to maintain or achieve state or federal water quality standards (WQS). CWA § 301(b)(1)(C), 33 U.S.C. § 1311(b)(1)(C). State WQS consist of three parts: (a) designated uses for a water body or a segment of a water body; (b) numeric and/or narrative water quality criteria sufficient to protect the assigned designated use(s); and (c) antidegradation requirements to ensure that once a use is attained it will not be degraded. The Massachusetts Surface Water Quality Standards (MA SWQS), found at 314 CMR 4.00, include these elements. These standards also include requirements for the regulation and control of toxic constituents and require that EPA criteria, established pursuant to Section 304(a) of the CWA, shall apply for pollutants not otherwise listed in the MA SWQS, unless MassDEP has established a site-specific criterion. NPDES permit limits must be set to assure that these state WQS requirements will be satisfied in the waters receiving the permitted discharge.

When using chemical-specific numeric criteria to develop permit limits, both the acute and chronic aquatic-life criteria, expressed in terms of maximum allowable in-stream pollutant concentration, are used. Acute aquatic-life criteria are considered applicable to daily time periods (maximum daily limit) and chronic aquatic-life criteria are considered applicable to monthly time periods (average monthly limit). Chemical-specific limits may be set under 40 C.F.R. § 122.44(d)(1) and are implemented under 40 C.F.R. § 122.45(d).

A facility's design flow is used when deriving constituent limits for daily, monthly or weekly time periods, as appropriate. Also, the dilution provided by the receiving water is factored into this process where appropriate. Narrative criteria from the state's water quality standards may apply to require limits on the toxicity in discharges where (a) a specific pollutant can be identified as causing or contributing to the toxicity but the state has no numeric standard, or (b) the toxicity cannot be traced to a specific pollutant.

Water quality-based effluent limitations may be established based on a calculated dilution factor derived from the available dilution in the particular receiving water at the point of discharge. In coastal and marine waters, Massachusetts SWQS require the State to "establish the extreme hydrologic conditions at which aquatic life criteria must be applied on a case-by-case basis. In all cases, existing uses shall be protected and the selection shall not interfere with the attainment of designated uses." 314 CMR 4.03(3)(c).

As stated above, NPDES permits must contain effluent limits more stringent than technology-based limits when necessary to maintain or achieve state WQS. The permit must address any pollutant or pollutant parameter (conventional, non-conventional, toxic and whole effluent toxicity) that is or may be discharged at a level that will cause, have "reasonable potential" to cause, or contribute to an excursion above any WQS. 40 C.F.R. §122.44(d)(1). An excursion occurs if the projected or actual in-stream concentration exceeds the applicable criterion or a narrative criterion or designated use is not satisfied. In determining reasonable potential, EPA considers a number of factors, including (a) existing controls on point and non-point sources of pollution; (b) pollutant concentration and variability in the effluent and receiving water as determined from the permit application, monthly DMRs, and State and Federal Water Quality Reports; (c) sensitivity of the species to toxicity testing; (d) known water quality impacts of processes on wastewater; and, where appropriate, (e) dilution of the effluent in the receiving water.

5.4 Section 316(a) of the Clean Water Act

Heat is defined as a pollutant under Section 502(6) of the CWA. 33 U.S.C. § 1362(6). As with other pollutants, discharges of heat (or "thermal discharges") must, in general, satisfy both technology-based standards (specifically, the BAT standard) and any more stringent water quality-based requirements that may apply. With regard to water quality requirements, state WQS typically include numeric temperature criteria, and may also include narrative criteria and designated uses that apply to particular water body classifications and could necessitate restrictions on thermal discharges.

Beyond technology-based and water quality-based requirements, CWA § 316(a), 33 U.S.C. § 1326(a), authorizes the permitting authority to grant a variance under which thermal discharge limits less stringent than technology-based and/or water quality-based requirements may be authorized if the biological criteria of Section 316(a) are satisfied. Furthermore, the Massachusetts SWQS provide that:

> alternative effluent limitations established in connection with a variance for a thermal discharge issued under [CWA § 316(a)] and 314 CMR 3.00 are in compliance with 314 CMR 4.00. As required by [CWA § 316(a)] and 314 CMR 3.00, for permit and variance renewal, the applicant must demonstrate that alternative effluent limitations continue to comply with the variance standard for thermal discharges.

314 CMR 4.05(4)(a)(2)(c) (for Class SA waters). Therefore, thermal discharge limits set pursuant to a variance under CWA § 316(a) are deemed by the state to satisfy Massachusetts SWQS.

To qualify for a variance under CWA § 316(a), a permit applicant must demonstrate to the permitting agency's satisfaction that thermal discharge limits based on technology and water quality standards would be more stringent than necessary to assure the protection and propagation of a balanced, indigenous population (BIP) of shellfish, fish and wildlife in and on the body of water into which the discharge is made. 33 U.S.C. § 1326(a); 40 C.F.R. §§ 125.70, 125.73(a). The applicant must also show that its requested alternative thermal discharge limits will assure the protection and propagation of the BIP, considering the cumulative impact of its thermal discharge together with all other significant impacts on the species affected. 40 C.F.R. §§ 125.73(a), (c)(1)(i). If satisfied that the applicant has made such a demonstration, then the permitting authority may impose thermal discharge limits that, taking into account the interaction of the thermal discharge with other pollutants, will assure the protection and propagation of the BIP. 33 U.S.C. § 1326(a); 40 C.F.R. §§ 125.70, 125.73(a) and (c)(1)(i).

While a new facility obviously must make a prospective demonstration that its desired future thermal discharges will assure the protection and propagation of the BIP, a facility with an existing thermal discharge can perform either a prospective or a retrospective demonstration in support of its request for a § 316(a) variance. More specifically, "existing dischargers may base their demonstration upon the absence of prior appreciable harm in lieu of predictive studies." 40 C.F.R. § 125.73(c)(1). Alternatively, even if there has been prior appreciable harm, the applicant may base its variance request on a demonstration that "the desired alternative effluent limitations (or appropriate modifications thereof) will nevertheless assure the protection and propagation of a balanced, indigenous community of shellfish, fish and wildlife in an on the body of water into which the discharge is made." *Id.* § 125.73 (c)(1)(ii).

As stated above, if the demonstration is satisfactory to the permitting authority, then it may issue a permit with alternative, variance-based thermal discharge limits. If the demonstration fails to support the requested variance-based thermal discharge limits, however, then the permitting authority shall deny the variance request. In that case, the permitting authority shall either impose limits based on the otherwise applicable technology-based and water quality-based requirements or, in its discretion, impose different variance-based thermal discharge limits that are justified by the permit record. *In re Dominion Energy Brayton Point, LLC*, 12 E.A.D. 490, 500 & n.13, 534 n.68, 552 n.97 (EAB 2006). As part of its March 2000 section 308 letter submittal to EPA, Entergy included material that was considered a demonstration in support of extending the previously granted 316(a) variance from the 1991 permit. (AR #81, 384, and 393) See Section 7 below for a discussion of the thermal limits and the 316(a) variance and Fact Sheet Attachments B and C, which support these limits and the continuation of the variance.

5.5 Requirements for Cooling Water Intake Structures under CWA § 316(b)

PNPS withdraws water from Cape Cod Bay through one cooling water intake structure (CWIS); this water is used both for cooling at the main condenser and supported systems for producing electricity and for cooling safety-related equipment, including facility shut-down systems. The withdrawal of seawater through PNPS' CWIS is subject to the requirements of CWA § 316(b). 33 U.S.C. § 1326(b). Section 316(b) mandates that any standard set for a point source under CWA §§ 301 or 306 must "require that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact." This is referred to as the Best Technology Available (BTA) standard and it is discussed in more detail in Section 8.0, below and in Attachment D.

5.6 Anti-backsliding

A permit may not be renewed, reissued or modified with less stringent limitations or conditions than those contained in the previous permit unless in compliance with the anti-backsliding requirements of the CWA. *See* 33 U.S.C. § 1342(*o*); 40 C.F.R. § 122.44(*l*). EPA's anti-backsliding provisions prohibit the relaxation of permit limits, standards, and conditions except under certain circumstances. Effluent limits based on BPJ, water quality, and state certification requirements must also meet the anti-backsliding provisions found at Section 402(*o*) and 303(d)(4) of the CWA. The draft permit does not contain permit limits or conditions that are less stringent than the existing permit. Therefore, the anti-backsliding provisions are met.

5.7 Antidegradation

Federal regulations found at 40 C.F.R. § 131.12 require states to develop and adopt a statewide antidegradation policy that maintains and protects existing instream water uses and the level of water quality necessary to protect the existing uses, and maintains and protects the quality of the waters that exceed levels necessary to support propagation of fish, shellfish, and wildlife and to support recreation in and on the water. The Massachusetts Antidegradation Regulations, found at 314 CMR 4.04, apply to any new or increased activity that would lower water quality or affect existing or designated uses, including increased loadings to a waterbody from an existing activity. All existing instream uses and the level of water quality necessary to protect the existing uses of the receiving waters shall be maintained and protected.

There are no new or increased discharges being proposed with this permit reissuance. Therefore, EPA believes that the MassDEP is not required to conduct an antidegradation review regarding this permit reissuance.

5.8 State Certification

Under Section 401(a)(1) of the CWA, 33 U.S.C. § 1341(a)(1), EPA is required to obtain certification from the state in which the discharge is located that the provisions of the new permit will comply with all state water quality standards and other applicable requirements of state law, in accordance with Section 301(b)(1)(C) of the CWA. 33 U.S.C. § 1311(b)(1)(C); *see also* 33 U.S.C. § 1341(d). EPA permits typically include any conditions required in the state's certification as being necessary to ensure compliance with state water quality standards or other applicable requirements of state law. See 33 U.S.C. § 1341(d); 40 C.F.R. § 124.55(a)(2). Regulations governing state certification are set out at 40 C.F.R. §§ 124.53 and 124.55. EPA regulations pertaining to permit limits based upon water quality standards and state requirements are contained in 40 C.F.R. § 122.44(d).

6.0 EXPLANATION OF PERMIT'S EFFLUENT LIMITATIONS

In Sections 5.2 and 5.3 above, EPA explained in general terms the technology-based and water quality-based requirements of the CWA. In this Section, EPA explains how it has applied these requirements in developing the draft NPDES permit for PNPS. As a whole, the draft permit's conditions are based on a combination of technology-based and water quality-based requirements, as well as a CWA §316(a) variance for thermal discharges.

The discussion below, and the draft permit itself, address PNPS's many outfalls as well as its many different types of pollutant discharges and its withdrawals of Cape Cod Bay water for cooling uses. Monitoring requirements are also addressed, as are individual permit changes requested by PNPS.

6.1 Outfall 001

The circulating water (CW) system discharges condenser non-contact cooling water through Outfall 001. The CW system withdraws salt water from Cape Cod Bay which is chlorinated with sodium hypochlorite on an intermittent basis (up to 2 hours/day) before entering the cooling system. Chlorine is the only biocide approved for use at PNPS; no other biocide shall be used without prior EPA approval. The permittee currently adds sawdust to the CW system to find and seal condenser leaks as necessary.

Sampling for Outfall 001 is conducted in the discharge canal, below the footbridge, downstream from where the flow from Outfall 001 commingles with flows from Outfalls 003, 004, 005, 010, 011, and 014. Since the majority of water in the discharge canal (greater than 95% under most conditions) consists of flow from Outfall 001, this sampling point is believed to be representative of the Outfall 001 discharge. The permittee believes that the structural changes that would be necessary to sample Outfall 001 (installation of a sample pump in the outfall) prior to commingling with other flows would be significant in relation to the benefits achieved, since the majority flow volume in the discharge canal consists of cooling water flow.

Due to the announced shutdown of the PNPS as discussed in Section 1.0 above, which is expected to occur no later than June 1, 2019, this permit has developed two sets of conditions for Outfalls 001 and 010, to reflect the significant reduction in intake and effluent flows which will occur after the shutdown. The effluent limits pages of the draft permit are separated into three (3) specific sections. The first, Part I.A, lists the effluent limits that apply up through the date of the termination of electricity generation (shutdown), while Part I.B applies from the date of shutdown and through expiration, and Part I.C applies to certain outfalls prior to and after shutdown, such as those for stormwater.

6.1.1 Flow

The current permit includes an effluent limitation at Outfall 001 for monthly average flow of 447 MGD and daily maximum flow of 510 MGD. The monthly average flow limit reflects the design intake flow at PNPS of the 2 CW pumps and is based on pump capacity curves. Review of DMR data (January 2008 through December 2014) reveals that these flow limitations have not been exceeded on any occasion. The monthly average flow rate has ranged from 217.7 – 446.4 MGD and daily maximum flow has been recorded consistently at 446.4 MGD. The daily maximum limit of 510 MGD is not achievable by the facility based on the design capacity of the CW pumps. Therefore, the monthly average flow limit for Outfall 001 has been maintained at 447 MGD and the daily maximum flow limit has been reduced to 447 MGD, to reflect the maximum design flow of the intake.

In its permit reapplication, the permittee requested removal of the effluent limitations for flow. However, volumetric flow rate is analogous to capacity in terms of the criteria for best technology available (BTA) in § 316(b) of the CWA. Volumetric flow rate is a significant parameter in § 316(b) demonstration studies as well as in determining heat loadings to the receiving water. Heat is considered to be a nonconventional pollutant. Accordingly, EPA will retain the effluent limitations on circulating cooling water flow rate for Outfall 001 in the draft permit as described above.

After shutdown, the permittee will need to operate one of the 2 CW pumps occasionally to support shutdown operations. The permittee believes that this intake would be used for a few hours at a time and for not more than 5% of the time. (Joe Egan – email of 10/28/15) Therefore, the flow limits for Outfall 001 post-shutdown, as shown in Part I.B.1 of the permit, have been reduced to a monthly average of 11.2 MGD with a daily maximum of 224 MGD. The monthly average flow represents one CW pump being used for up to 5% of the time, whereas the 224 MGD represents the cooling water rate of the pump.

6.1.2 pH

The current permit requires that the pH shall not vary by more than 0.5 standard units from that of the intake water. However, there were no specific monitoring requirements established for pH in the current permit.

The Steam Electric Power Generating Point Source Category (40 C.F.R. Part 423) requires that the pH of all discharges, except for those of once through cooling water, shall be in the range of 6.0 – 9.0 SU. The Massachusetts SWQS (314 CMR 4.05(4)(a)(3)) require that for Class SA waters, the pH of the receiving water shall be in the range of 6.5 through 8.5 standard units and not more than 0.2 standard units outside of the natural background range.

To be consistent with the State WQS, the draft permit limits pH to the range of 6.5 to 8.5 standard units and not more than 0.2 standard units outside of the natural background range. The draft permit requires weekly monitoring of the discharge.

6.1.3 Total Residual Oxidants (TRO)

The current permit restricts biocide use at the facility to chlorine only. The current permit also requires that the chlorination cycle for the circulating cooling water systems shall not exceed two (2) hours in any one day for one cooling water point source unless the discharger demonstrates to the EPA and the State that discharge for more than two hours is required for macroinvertebrate control. In the current permit, the TRO concentration was limited to 0.1 mg/l as a monthly average and daily maximum in the discharge to Cape Cod Bay. Since the intake water contains bromides (i.e., saline water), the sampling parameter is expressed as TRO instead of total residual chlorine (TRC), in accordance with the Steam Electric Power Generating Point Source Category effluent guidelines (see 40 C.F.R. § 423.11).

The Steam Electric ELGs at 40 C.F.R. § 423.13 require that for any plant with a total rated electric generating capacity of 25 megawatts or greater, the quantity of pollutants discharged in once through cooling water from each discharge point shall not exceed 0.2 mg/L of total residual chlorine (TRC) as a maximum. The term total residual chlorine (or total residual oxidants for intake water with bromides) means the value obtained using the amperometric method for total residual chlorine described in 40 C.F.R. Part 136. Additionally, 40 C.F.R. § 423.13(b)(2) states that "total residual chlorine may not be discharged from any single generating unit for more than two hours per day unless the discharger demonstrates to the permitting authority that discharge for more than two hours is required for macroinvertebrate control. Simultaneous multi-unit chlorination is permitted." As discussed above, however, the current permit imposes more stringent TRO limits - 0.1 mg/L as both a monthly average and daily maximum. Review of DMR data reveals that this daily maximum TRO limit has been exceeded on 3 occasions during the monitoring period, with a maximum concentration of 0.19 mg/L TRO. However, the monthly average limit has not been exceeded on any occasion, ranging between 0 and 0.07 mg/l.

Consistent with 40 C.F.R. Part 423, the draft permit maintains the two (2) hour daily maximum dosing requirement noted above.

In this draft permit, EPA must consider the applicable water quality criteria in setting TRO limits for this outfall. For the purposes of this permit, all TRO discharges are believed to be predominantly comprised of TRC, therefore, the limits based on the TRC criteria will be expressed as TRO limits. TRO limits would typically be calculated by multiplying the water quality criteria by the dilution available to the discharge. To EPA's knowledge, there has not been any prior hydrodynamic modeling conducted that would provide an estimate of dilution for the discharge from the discharge canal. The fact sheet to the 1991 permit notes in the section discussing the boron limits:

"The boron discharge is further diluted by the passive entrainment of the jet from the cooling water canal into Cape Cod Bay. Nominally such shoreline discharges entrain about 5 times the jet flow rate in the receiving water."

The source of this statement could not be found and it is not clear if this is the dilution that would be available to pollutants in the discharge canal once they are discharged to Cape Cod Bay. The chronic and acute, marine water quality criteria for TRC are 7.5 ug/l and 13 ug/l, respectively.

Therefore, this draft permit establishes TRO limits of 7.5 and 13 ug/l, as a monthly average and daily maximum, respectively. EPA will consider any comments during the public comment period regarding the applicability of any particular dilution that should be used to calculate a less stringent TRO limit for Outfall 001.

Post-shutdown, the permittee will be prohibited from chlorinating the water that is withdrawn with the CW pump to support shutdown operations. Therefore, the permit has included a prohibition on the chlorination of this intake water in Part I.B.1 and has removed the TRO monitoring requirement and limits for this outfall post-shutdown.

Post-shutdown, the only source of TRO, aside from that naturally occurring in sea water, will be the chlorinated water from the SW system at Outfall 010. The 1991 permit limited TRO at Outfall 010 at a monthly average of 0.5 mg/l and a daily maximum of 1.0 mg/l. For the 1991 permit, the permittee demonstrated that, with these limits set at Outfall 010, the concentration of TRO after mixing in the discharge canal with the flows from Outfall 001 would be below the limit of 0.10 mg/l set at Outfall 001. However, the condenser cooling water flow on which this demonstration for TRO limits was based, will be terminated, with the exception of flows from one of the two CW pumps which may be operated up to 5% of the time. As described in Section 6.6.5 below, criteria based limits for TRO have been established at Outfall 010 post-shutdown.

6.1.4 Temperature & Temperature Rise

The current permit requires a daily maximum effluent limitation for temperature of 102°F, monitored continuously. The current permit also requires that the temperature rise, or delta T, not exceed 32°F. These temperature limits were based on the CWA § 316(a) variance that was granted in the current permit. Review of DMR data reveals that the daily maximum effluent temperature has ranged from 69 – 101.6 °F and the effluent limit has not been exceeded on any occasion during the monitoring period. The DMR data also reveal that the maximum rise in temperature was 31.6°F on two occasions and that the temperature rise limit has not been exceeded during the monitoring period.

The draft permit includes a maximum daily temperature limit of 102°F and maximum daily rise in temperature (delta T) limit of 32°F. These temperature limits and the associated § 316(a) variance are explained in detail in Section 7.0, below, and in Attachments B and C. The permittee requests that “Sample Type” for thermal parameters be changed to “Resistance Temperature Detector” (RTD), which is a type of electronic temperature monitoring device. This type of device is acceptable for temperature monitoring and the sample type of “recorder” on the permit limits page is an appropriate description for this device.

Post-shutdown, since the water withdrawn with the CW pump will no longer be used for condenser cooling, but to support other operations, the draft permit limits the effluent temperature to a maximum daily limit of 85°F and a monthly average of 80°F, which are the temperature limits consistent with the MA SQWS for Class SA waters. *See* 314 CMR 4.05(4)(a)(2)(a). The permittee has estimated the delta T of this effluent will be up to 3°F above the intake temperature, presumably due to fact that even after the shutdown there will be some ongoing equipment cooling discharges associated with the SSW system. (Joe Egan email of

10/28/15, AR#519). Although not specified in the email, it is assumed that this delta T is associated with the remaining cooling water flows within the SW system post-shutdown. Therefore, it is necessary to establish temperature limits for Outfall 010, which will be the sole continuous remaining discharge in the discharge canal post-shutdown Although the MA SWQS generally limit any delta T to 1.5 °F, they also provide that temperature effluent limitations established pursuant to a § 316(a) variance "are in compliance with" MA SWQS. *Id.* Since the EPA concludes in Section 7.3 below that a continued § 316(a) variance for temperature allowing a delta T of 32°F during normal (pre-shutdown) operations will assure the protection and propagation of a balanced, indigenous population (BIP) of shellfish, fish and wildlife in and on the body of water into which the discharge is made, EPA concludes that a delta T of 3°F will likewise assure the protection and propagation of the BIP after shutdown, since the majority of the thermal component of the condenser cooling discharge will have been eliminated. Accordingly, the draft permit includes a maximum delta T of 3°F post-shutdown.

6.1.5 Oil and Grease

The current permit does not include O&G limits or monitoring at Outfall 001, and EPA is not aware of any existing O&G data for Outfall 001. Nor do the Steam Electric ELGs establish O&G limits for the discharge from Outfall 001 (*i.e.*, once-through cooling water). See 40 C.F.R. Part 423. The current permit does, however, include O&G limits for Outfalls 004 and 005, as discussed below in Section 6.4, and the draft permit proposes new technology-based limits for O&G at Outfalls 010, 011, and 014 based on the Steam Electric ELGs, as discussed below in Sections 6.6 and 6.7. All of these discharges commingle with the discharge from Outfall 001 prior to sampling for Outfall 001, which is conducted, as noted earlier, below the footbridge over the discharge canal. In order to ascertain O&G levels in the combined flows in the discharge canal, the draft permit establishes a monitoring requirement for O&G at Outfall 001, which will apply during both pre- and post-shutdown operations. The draft permit specifies a test method to be used to analyze for O&G and the minimum level (ML) of detection for this method of 5 mg/l.

6.1.6 Addition of biodegradable material

Due to occasional condenser leaks, the current permit provided that the addition of "a reasonable quantity of biodegradable and non-toxic material may be used to the extent necessary to find and/or seal the leak." The current permit further required the permittee to report the duration and estimated amounts of such material used.

The facility currently uses wood flour (sawdust) to find and/or seal condenser leaks and the draft permit includes a condition allowing the use of sawdust to seal condenser leaks to the extent necessary. The permittee shall report the type and approximate amount of material used on the DMR cover letter. The permittee shall be limited to using only sawdust or similar wood-based products for this purpose. If the permittee determines that another substance is required for this purpose, it shall request and receive approval from EPA prior to using such substance.

6.2 Outfall 002

Thermal backwashes are necessary to control biological growth (biofouling) in the intake structures. Outfall 002 consists of thermal backwash water, which is heated water taken from the CW system. Outfall 002 flows back through the intake structure to the intake channel (also called the intake embayment). Chlorination is not conducted during backwashes, which cannot be performed at full power. The CW system (condenser) backwashes occur 4-5 times per year and consists of a pair of backwashes (one for each CW pump bay), lasting approximately 60 minutes for each bay; during 45 minutes of which the permittee raises the reactor power level so that the water temperature reaches at least 105°F.

6.2.1 Flow

The current permit includes a daily maximum flow limit of 255 MGD, specified as "estimated when in use." This flow is based on the capacity of one of the CW pumps (155,500 gpm). The permittee backwashes one intake bay at a time, for a duration of about one hour each. The current permit also requires that the discharge shall not be more frequent than three hours a day twice a week for those periods when required to operate the plant most efficiently. The draft permit continues to limit thermal backwashes to once per week and for a maximum of three (3) hours for both intake bays. Although the typical backwash for each intake bay is completed within one (1) hour, under certain conditions, this time would need to be increased, so the three (3) hour maximum for the backwashing of both intake bays allows for such conditions.

The current permit notes that in addition to the thermal backwashes performed 4-5 times per year, non-thermal backwashes are performed 3-4 times per year. Although the current permit does not require monitoring of non-thermal backwashes, the draft permit requires monitoring of all backwashes through Outfall 002, whether they are thermal or non-thermal.

In a September 4, 2014 email from Joe Egan of PNPS to George Papadopoulos of EPA, the permittee proposed to reduce the maximum daily flow limit to 28 MGD, as opposed to the prior limit of 255 MGD, which was based on the flow rate of one circulating water pump. The draft permit includes a maximum daily flow limit of 28 MGD, as requested by the permittee. This permit limit is equivalent to the use of one CW pump (at 155,500 gpm) for a maximum of 3 hours per day.

Post-shutdown, the permittee has noted that it will no longer conduct thermal backwashes, but may need to conduct non-thermal backwashes. (Joe Egan – phone call of 12/21/15). Therefore, as shown in Part I.B.3 of the permit, there continue to be limits on the frequency and flows of such backwashes, as well as a limited pH range. This Part also prohibits the use of thermal backwashes after shutdown.

6.2.2 pH

The current permit requires that the pH of the discharge shall not vary by more than 0.5 standard units from that of the intake water.

The Steam Electric Power ELGs (40 C.F.R. Part 423) requires that the pH of all discharges, except for those of once through cooling water, shall be in the range of 6.0 – 9.0 SU. The Massachusetts SWQS (314 CMR 4.05(4)(a)(3)), however, require that, for Class SA waters, the pH of the receiving water shall be in the range of 6.5 through 8.5 standard units and not more than 0.2 standard units outside of the natural background range. The draft permit limits pH to the range of 6.5 to 8.5 standard units and not more than 0.2 standard units outside of the natural background range to be consistent with the State WQS.

6.2.3 Total Residual Oxidants (TRO)

The CW system is typically chlorinated 2 hours per day; however, during thermal backwash chlorination of the CW system is not conducted. The draft permit requires monitoring of TRO once during each backwash to ensure the discharge does not contain any detectable TRO, as there may be some residual TRO in the cooling water system. Post-shutdown, since the intake water from the CW pump will no longer be chlorinated, there will not be expected to be any TRC contributing to TRO in the discharge. Therefore, there will no longer be any monitoring required for TRO post-shutdown.

6.2.4 Temperature

The current permit requires a daily maximum temperature limit of 120°F, measured continuously during each thermal backwash procedure. During the monitoring period, this limit has not been exceeded, with a high temperature of 114.9°F. In a September 4, 2014 email from Joe Egan of PNPS to George Papadopoulos of EPA, the permittee proposed to reduce the daily maximum temperature limit for Outfall 002 from 120°F to 115°F. The draft permit includes the more stringent maximum discharge temperature of 115°F, as requested by the permittee. Since this temperature is higher than that allowed by the MA SWQS, a variance from the MA SWQS has been granted as discussed in Section 7.3 below.

The permittee requests that “Sample Type” for thermal parameters be changed to “Resistance Temperature Detector” (RTD). As noted in Section 6.1.4. above, this type of sample is acceptable for temperature, therefore the draft permit shall require a “recorder” sample type, which is the generic term used for electronic device monitoring.

Post-shutdown, since the permittee is prohibited from conducting thermal backwashes and no heat will be added to the water for non-thermal backwashes, the effluent temperature limit has been eliminated.

6.3 Outfalls 003 and 012

The source of the screen wash water (Outfall 003) is service water (SW) which has been dechlorinated, and possibly fire water in emergency conditions, which is not dechlorinated. Under normal operating conditions, the majority of this screen wash water is discharged to Outfall 003 to the intake embayment via a sluiceway added in 1980, but some also discharges to the discharge canal. During storm conditions, the majority of screen wash water is discharged to the discharge canal, mainly to prevent re-impingement of seaweed. The outfall to the discharge canal, which was previously not identified as a separate outfall, has been designated as Outfall 012 in the draft permit. (See Figure 7, also noted earlier in Section 2.4)

The current permit allows sampling at a representative point of the screen wash water flow. The draft permit specifies that screen wash water be sampled from the fish return sluiceway at Outfall 003, since this is where the majority of this flow is discharged. The draft permit also requires that the permittee document when routing of screen wash water to the discharge canal (Outfall 012) occurs along with the reason for such occurrence.

The permittee has requested that dechlorination be discontinued when screen wash water is discharged to Outfall 012. The permittee reasoned that during storm conditions when both circulating (seawater) pumps are in operation, dechlorination of screen wash water sent to the discharge canal via Outfall 012 could be discontinued due to increased discharge canal dilution, assuring that residual oxidants released to Cape Cod Bay are within permit limits. However, EPA does not agree, as it is expected that chlorinated screen wash water would be detrimental to the organisms washed from the screen that may survive during transit back to the receiving water. Although the mix of fragile vs. non-fragile species varies over time, there are periods when more non-fragile species are washed off the screens and survive the return to the receiving water. Therefore, the draft permit requires that all screen wash water be dechlorinated prior to use, with the exception of fire water that is used under emergency conditions.

Post-shutdown, the permittee believes that Outfall 012 will be the default flow path for the traveling screen washwaters. (Joe Egan email of 10/28/15). Therefore, Part I.B.4 of the permit allows this water to only be discharged to Outfall 012, including sampling from the fish return sluiceway at Outfall 012, with the same conditions as during normal operations as described below.

6.3.1 Flow

The current permit (as modified) requires both a monthly average and daily maximum flow limitation of 4.1 MGD for Outfall 003. In the 1992 permit modification, the permitted flow for Outfall 003 was raised to 4.1 MGD to account for the possible amount of 0.9 MGD of screen wash water that would come from potable Station Fire water. This water shall be used only under emergency conditions when traveling screen operation is impeded by the accumulation of algae or other biological material and when approved by the NRC.

Review of DMR data reveals that these limits have not been exceeded on any occasion, as neither monthly average nor daily maximum flow has exceeded 4.1 MGD. This flow limit of 4.1 MGD is based on the capacity of the booster pumps on 2 of the 5 service water bay pumps (1,100 gpm each for 24 hours per day, or 3.2 MGD) as well as 0.9 MGD for emergency fire water (at 500 gpm), which equals 4.1 MGD. The draft permit continues this flow limitation.

In its 1999 letter (Administrative Record (AR) #81), the permittee requested that flow be a monitor only parameter for this outfall, noting that this flow is intermittent. Although the total daily flow of 4.1 MGD may not be exceeded, this flow rate may be experienced if the permittee uses the fire water for screen wash water. Therefore, this limit has been maintained in the draft permit.

6.3.2 pH

The current permit requires that the pH of this discharge shall not vary more than 0.5 s.u. from the intake.

The Steam Electric Power ELGs (40 C.F.R. Part 423) require that the pH of all discharges, except once through cooling water, shall be in the range of 6.0 – 9.0 SU. The Massachusetts Water Quality Standards (WQS) (314 CMR 4.05(4)(a)(3)) require that for Class SA waters, the pH of the receiving water shall be in the range of 6.5 through 8.5 standard units and not more than 0.2 standard units outside of the natural background range. The draft permit limits pH to a range of 6.5 to 8.5 standard units and not more than 0.2 standard units outside of the natural background range to be consistent with the State WQS.

6.3.3 Total Residual Oxidants (TRO)

The current permit, as modified, requires that the screen wash water, with the exception of Station Fire water, shall be dechlorinated when in use and that the wash water shall contain no detectable TRO. The current permit does not, however, require that the permittee monitor TRO. To ensure that the screen wash water does not contain detectable levels of TRO, the draft permit requires monitoring of TRO once per month.

6.3.4 Temperature

The current permit requires that the temperature of the discharge shall at no time exceed the temperature of the intake water used for this discharge. The permittee has requested removal of this condition, since the process of screen washing does not add heat to the wash water. By removing the condition entirely, however, the draft permit would be less stringent than the current permit, which would not be consistent with anti-backsliding requirements at CWA § 402(o), 33 U.S.C. § 1342(o), and 40 C.F.R. § 122.44(*l*)(1). Part I.A.3.a. of the draft permit requires that the water used for screenwashing shall not have been used for any cooling purpose at the facility.

6.4 Stormwater Outfalls (004, 005, 006, 007, and 013)

Outfalls 004, 005, 006, and 007 discharge untreated stormwater. In addition to stormwater, Outfall 005 also discharges a portion of the flows from Outfall 011 (and rarely, emergency discharge from the heating boiler blowdown via a floor drain), and Outfall 006 discharges water from fire water storage tanks (municipal water). Outfalls 004 and 005 discharge to the discharge canal and Outfalls 006 and 007 discharge to the intake embayment. As described in Section 6.7 below, the permittee is rerouting a portion of the Outfall 011 flows directly to the discharge canal at times, thereby bypassing Outfall 005 as its connection point to the discharge canal.

The 1991 permit required monitoring of these four (4) outfalls twice per year and during significant storm events, a term which was not defined in the 1991 permit. The last few years of DMR indicate very limited sampling from these outfalls.

During the 1995 permit renewal application process, a miscellaneous storm drain located at the boat launch area between storm drain outfalls 006 and 007 was identified. It drains a small portion of the facility which is similar in characteristics to the drainage areas for Outfalls 004, 005, 006, and 007, consisting mainly of roadways and other impervious surfaces. Since that notification, the permittee has installed additional security fencing and a concrete wall around portions of the perimeter of the property, including the point beyond where this storm drain discharge occurs through a conduit. The permittee reported that, at this point, the stormwater infiltrates in sandy soil prior to the intake embayment. The permittee also noted that sampling of stormwater through this storm drain is not feasible, due to its location between two security fences. (email from Joe Egan to George Papadopoulos of 2/10/16, AR#516). The permittee believes that this miscellaneous storm drain does not discharge directly to the intake embayment and that, even prior to the installation of the fencing and concrete wall, this outfall was only expected to discharge to the intake embayment in the event of extreme weather conditions. The draft permit recognizes and authorizes the outfall of this storm drain, designating it as Outfall 013, but establishes no monitoring requirements for this location, since the outfall is inaccessible, is not expected to discharge directly to Cape Cod Bay except under extreme storm events, and drains a relatively small area similar in character to the drainage area for Outfall 006.

The draft permit requires monthly sampling for the four stormwater outfalls. Sampling requirements have been more clearly defined in the footnotes of Part I.C.1 of the draft permit. The permittee has stated that some of its stormwater outfalls are difficult to access for monitoring purposes and that it is often unclear whether a particular storm event triggers the current monitoring requirement. (email from Joe Egan to George Papadopoulos of 8/8/14, AR# 517). Therefore, the draft permit allows for sampling of these outfalls to be conducted at the first accessible upstream manhole hydraulically connected to each stormwater outfall, if the discharge outfall at end-of-pipe is not accessible. Due to the limited stormwater sampling conducted pursuant to the current permit, the draft permit has increased the monitoring frequency for these outfalls from two per year to monthly and has provided a definition of storm events that trigger sampling requirements and a description of when stormwater sampling during such events must occur, so as to assure that more storms are eligible to be sampled.

EPA reviewed the 2015 Multi-Sector General Permit's (MSGP) provisions for "Industrial Sector O, Steam Electric Generating Facilities" to determine whether there are any applicable monitoring requirements or other conditions for these stormwater discharges. The only applicable condition is a benchmark monitoring concentration of 1.0 mg/l for total iron. *See* MSGP, Part 8.O.7, *available at* http://go.usa.gov/cEMaQ. In the MSGP, pollutant benchmark concentrations are applicable to certain sectors or subsectors. Benchmark monitoring data are primarily used to determine the overall effectiveness of the control measures (BMPs) and to assist facilities in determining when additional corrective action(s) may be necessary to comply with the conditions of the MSGP. *See* MSGP, Part 6.2.1.

During the permit term, PNPS informed the Region that stormwater discharged from these outfalls includes stormwater that has accumulated in various electrical vaults on the property and that is periodically pumped out to the closest stormwater outfall in order to assure proper working condition of electrical cables and associated equipment in the vaults. The permittee indicated that the NRC requires the inspection of these vaults on a regular basis to assure that electrical equipment and wires are not submerged in water for extended periods of time. *See* United States Nuclear Regulatory Comm'n, *NRC Information Notice 2010-26: Submerged Electrical Cables* (Dec. 2, 2010). Consequently, facility personnel must routinely inspect these vaults, especially after storm events. PNPS identifies 25 electrical vaults on the property where it performs such pumping, nine (9) of which are outfitted with automated pumps, which are activated when waters reach a pre-determined level.

In order to assess the constituents of the water in these vaults, EPA sent PNPS a CWA Section 308 letter on March 24, 2015 requiring water sampling from seven (7) of the electrical vaults on the property for a variety of pollutants that could possibly be found. The results of this sampling, which were submitted with a letter of June 30, 2015 by PNPS, found that the sampled pollutants were either often not detected or detected at low levels. TSS was detected in two (2) of the vaults at 4.4 and 4.8 mg/l. Cyanide was detected in one vault at an estimated concentration of 5.3 ug/l. Total phenols and phthalates were detected in four (4) vaults and polychlorinated biphenyls (PCBs) were detected in one vault. Among the metals sampling, antimony, iron, copper, zinc, lead, nickel, cadmium, and hexavalent chromium were detected in 1 or more vaults. When comparing these results to the marine water quality criteria, it was found that the lead samples exceeded the chronic criterion of 8.1 ug/l on five (5) occasions, the chronic and acute criteria for copper of 3.1 ug/l and 4.8 ug/l, respectively, were exceeded three (3) times each, and the chronic and acute criteria for zinc of 81 ug/l and 90 ug/l, respectively, were also exceeded three (3) times each.

Based on the results of this sampling, the draft permit establishes regular monitoring requirements to assess the need for effluent limitations. Although some of the parameter values were above water quality criteria levels, this does not take into account the dilution that would be present when these discharges mix with the cooling water flows and other stormwater flows as they get discharged to Cape Cod Bay. In the draft permit, quarterly monitoring is required for water that has collected in five (5) separate electrical vaults, which are spread throughout the property and considered representative of the discharges from the twenty five (25) electrical vaults. Since each of these 5 vaults discharge to a nearby, permitted stormwater outfall, they have been designated as internal outfalls and numbered 004A, 005A, 005B, 007A and 007B, reflecting the stormwater outfall to which they are discharged. This sampling is required quarterly and does not need to be conducted during wet weather, since the addition of the water from the vaults can occur in wet or dry conditions. The parameters to be sampled include TSS, total phenols, total PCBs, total phthalates, total cadmium, total copper, total iron, total lead, total zinc, and pH. This parameter listing reflects those that were detected in at least one (1) of the vaults.

In addition, the draft permit establishes a one-time sampling requirement for all of the electrical vaults which were not sampled for the March 2015 Section 308(a) letter. These samples shall be analyzed for the same parameters which were required by that letter and listed in Permit

Attachment C. EPA believes that a characterization of water collected in all of the vaults is warranted because these vaults are located throughout the property and the initial sampling showed the presence of several pollutants.

6.4.1 Flow

The current permit does not require reporting of flow from Outfalls 004, 005, 006, and 007. On its permit reapplication, the permittee reported the following flows through these storm water outfalls based on a gallons per minute (GPM) peak runoff rate for a ten (10) year storm of 1.5 inches per hour for one (1) hour: Outfall 004 = 2,379 GPM, Outfall 005 = 1,212 GPM, Outfall 006 = 812 GPM, and Outfall 007 = 5,819 GPM.

Although the 1991 permit listed flow as a parameter, it did not specify any monitoring frequency or limits for flow. The draft permit requires the permittee to estimate stormwater discharges from all outfalls associated with the storm events which are sampled.

The draft permit requires the permittee to estimate the discharge through Outfall 005 without the contribution of flow from Outfall 011, which is monitored separately. As noted in Section 6.7 below, the permittee has redirected Outfall 011 flows directly to the discharge canal. The draft permit also requires the permittee to estimate the flow from Outfall 006 without the contribution of flow from the fire water storage tanks. For a month when there is flow from the fire water storage tanks to Outfall 006, the permittee shall estimate this flow and report it in an attachment to the DMR.

6.4.2 Total Suspended Solids (TSS)

Massachusetts WQS at 314 CMR 4.05(4)(a)(5) require that waters "shall be free from floating, suspended and settleable solids in concentrations or combinations that would impair any use assigned to this class, that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom." The current permit includes monthly average and daily maximum TSS limits of 30 mg/l and 100 mg/l, respectively, at Outfalls 004, 005, 006, and 007, measured twice per year. These limits were based on BPJ. Review of DMR data reveals that these limits have been exceeded on a few occasions.

Due to the lack of recent stormwater sampling data, EPA looked back to the period from 1998 to 2007, when more frequent stormwater sampling and analysis was conducted. At Outfall 004, the reported TSS concentration for this period ranged from 0.8 – 10.7 mg/l. At Outfall 005, the TSS concentration ranged from 1.0 – 133.3 mg/l; the monthly average concentration was exceeded on four occasions and the daily maximum concentration was exceeded once. At Outfall 006, the TSS concentration ranged from 0.8 – 30.4 mg/l; the monthly average concentration was exceeded on one occasion. At Outfall 007, the TSS concentration ranged from 1.3 – 100.3 mg/l, with three exceedances of the monthly average limit and one exceedance of the daily maximum limit.

To ensure that the narrative WQS for solids is maintained, the draft permit includes the TSS limits of 30 mg/l monthly average and 100 mg/l daily maximum from the current permit. Inclusion of these numeric, water quality-based limits is also consistent with anti-backsliding provisions of 40 C.F.R. § 122.44(*l*)(1). Due to the exceedences measured under the current permit and the lack of sampling data over roughly the last 10 years, the sampling frequency has been increased to quarterly, to more accurately characterize the discharges through these outfalls. Samples shall be taken during the first flush of wet weather, defined as during the first hour of the start a storm event greater than 0.1 inches in magnitude that occurs at least 24 hours from the previously measurable (greater than 0.1inch rain fall) storm event. If this is not feasible, then sampling shall be conducted as soon as possible after the first hour and the permittee shall provide a brief explanation of why a first flush sample was not taken. The permittee has noted that some required stormwater sampling over the last few years was not conducted due to the difficulty in accessing stormwater outfalls (email from Joe Egan to George P of 8/8/14). Therefore, the draft permit allows for sampling to be conducted in a manhole hydraulically connected to a particular stormwater outfall, if feasible and in particular if more easily accessible than the actual outfall during a storm event.

6.4.3 Oil and Grease (O&G)

The current permit includes a daily maximum O&G limitation of 15 mg/l, measured twice per year, at Outfalls 004, 005, 006, and 007.

Massachusetts WQS at 314 CMR 4.05(4)(a)(7) provide that SA waters "shall be free from oil and grease and petrochemicals," which EPA and MassDEP interpret as requiring no detection of oil and grease in SA waters. DMR data indicate, however, that O&G has ranged from non-detect (ND) – 6.5 mg/l at Outfall 004, from ND – 10.0 mg/l at Outfall 005, from ND – 5.3 mg/l at Outfall 006, and from ND – 13.0 mg/l at Outfall 007 during the monitoring period. All four of these stormwater outfalls discharge directly to SA waters of Cape Cod Bay and prior monitoring data reveal that O&G is or may be discharged at levels that will cause, have the reasonable potential to cause, or contribute to an excursion above the water quality standard, which, as noted above, provides that SA waters "shall be free from oil and grease and petrochemicals." Therefore, the draft permit establishes a daily maximum O&G limitation of non-detect for Outfalls 004, 005, 006 and 007. The draft permit specifies a test method that shall be used to analyze for O&G, and the minimum level (ML) of detection for this method of 5 mg/l will be the level at which compliance with this limit is determined. Essentially, to be in compliance with this limit, samples must be non-detect for O&G using the test method specified in the draft permit. In addition, the draft permit has established an O&G monitoring requirement at Outfall 001 which is monitored below the foot bridge over the discharge canal, to assure that O&G is not detected at the point of discharge to Cape Cod Bay. These conditions will ensure that WQS in the receiving water are satisfied.

Samples must be taken during the first flush of wet weather, as defined above and in the permit. In addition to the numeric maximum daily limits for O&G, the Storm Water Pollution Prevention Plan (SWPPP) includes best management practices (BMPs) to address potential contributions of O&G (see discussion in Section 9, below). In its SWPPP, the permittee must describe measures it will take to assure that any sources of oil and grease in all areas contributing to these outfalls are identified and minimized.

6.4.4 pH

The current permit requires that the pH shall not be less than 6.0 standard units nor greater than 8.5 standard units or not more than 0.2 standard units outside the naturally occurring range. This permit requirement did not require monitoring and reporting of the effluent pH, therefore no pH data is available. The current permit limit range is slightly less stringent than the Massachusetts WQS, 314 CMR 4.05(4)(a)(3), which require that for Class SA waters, the pH of the receiving water shall be in the range of 6.5 through 8.5 standard units and not more than 0.2 standard units outside of the natural background range.

The draft permit limits pH to a range of 6.0 to 8.5 standard units (SU) and not more than 0.2 SU outside of the natural background range for Outfalls 004, 005, 006, and 007. Although the lower end of the pH range is below that of the MA WQS limit of 6.5 s.u., the dilution available to these discharges is such that the range of 6.5 to 8.5 s.u. is expected to be met instream. Inclusion of these limits is consistent with anti-backsliding provisions at 40 C.F.R. 122.44(*l*)(1). Samples shall be taken during the first flush of wet weather, as defined above and in the permit.

6.5 Outfall 008

The modification to the current permit, which was effective in August of 1994, authorized the discharge of untreated sea foam suppression water from Outfall 008. Entergy informed EPA that sea foam suppression water was not used during the current permit period and will not be used in the future. (PNPS Trip Report, 1/24/2013, AR# 518). Accordingly, discharge of sea foam suppression water and use of Outfall 008 is not authorized by the draft permit.

6.6 Outfall 010

Outfall 010 discharges plant service non-contact cooling water [Salt Service Water (SSW) System] which undergoes continuous chlorination with sodium hypochlorite. Water for the SSW system is withdrawn from Cape Cod Bay through the CWIS. Service water is the ultimate heat sink for critical nuclear cooling systems within the plant, including the turbine building closed-cycle cooling water (TBCCW) system and the reactor building closed-cycle cooling water (RBCCW) system. Both the SSW and RBCCW systems are safety related and are subject to U.S. NRC regulatory requirements. The discharge through Outfall 010 is classified as a low volume waste source pursuant to 40 C.F.R. § 423.11.

Outfall 010 is sampled downstream of the heat exchangers, via grab sample valves. Outfall 010, discharges into the discharge canal and combines with once-through cooling water from the main condensers (Outfall 001). The SSW system is not chlorinated during refueling outages because the CW pumps are shut down and there is not adequate dilution to allow continuous release of effluent water with detectable residual chlorine from the SSW system into Cape Cod Bay.

6.6.1 Flow

The current permit includes a monthly average flow limitation of 19.4 MGD, which may be estimated from pump capacity curves and approximate time of discharge. Review of DMR data reveals that the flow limitation has not been exceeded on any occasion, with the highest recorded flow of 14.5 MGD during the monitoring period. This flow limitation is based on 5 pumps operating at 2,700 gpm each, discharging continuously (24 hours/day). However, the permittee typically operates a maximum of 4 of the 5 pumps at a time under most conditions. The draft permit includes a monthly average flow limitation of 19.4 MGD and a daily maximum flow of 19.4 MGD, reflecting the actual capacity of the 5 SSW pumps.

The current permit requires that the discharge through Outfall 010 be sampled "at the heat exchanger before this stream mixes with any other stream going to the discharge." According to the permittee, the current sampling location is via grab sample valves downstream of the heat exchangers but prior to being discharged to the discharge canal where it mixes with other flows. The draft permit requires that samples be taken at a representative location of the discharge exiting from the heat exchangers and prior to mixing with any other flows.

After shutdown, the flow limits for Outfall 010 shown in Part I.B.2 of the permit reflect the reduced use of intake water for the SSW. These limits, which will take effect no later than June 1, 2019, will be a monthly average limit of 7.8 MGD and a daily maximum limit 15.6 MGD. The monthly average limit is based on the permittee's expected use of up to two (2) SSW pumps for the majority of time post-shutdown for safety and reliability purposes. The daily maximum limit of 15.6 MGD represents the capacity for 4 of the 5 SSW pumps, which may be needed under some scenarios. (Joe Egan phone call of 12/21/15)

6.6.2 Total Suspended Solids (TSS)

The current permit does not include TSS requirements for this outfall. The discharge through Outfall 010, however, is classified as a low volume waste source pursuant to the ELGs, meaning that the technology-based limits for TSS in the ELGs are applicable to this discharge. Therefore, the draft permit has established the technology-based numeric limits for low volume waste in the ELGs at Outfall 010, including a daily maximum TSS concentration of 100 mg/l and a monthly average TSS concentration of 30 mg/l.

6.6.3 Oil and Grease (O&G)

The current permit does not include O&G requirements for this outfall. As stated above, since this discharge is classified as a low volume waste source pursuant to the ELGs, technology-based limits for O&G in the ELGs are applicable to this discharge. The draft permit applies the limits in the ELGs for low volume waste, including a daily maximum O&G concentration of 20 mg/l and a monthly average O&G concentration of 15 mg/l. As noted in Section 6.1.5 above, the draft permit also establishes a monitoring requirement for O&G at Outfall 001 for pre and post-shutdown conditions to provide data to enable the agencies to assess whether there are detectable levels of O&G at a point after which the discharges from all of the outfalls to the discharge canal have combined.

6.6.4 pH

The current permit does not include monitoring requirements for pH. The Steam Electric ELGs require that the pH of all discharges, except once through cooling water, shall be within the range of 6.0 – 9.0 SU. The Massachusetts Water Quality Standards (WQS) [314 CMR 4.05(4)(a)(3)] require that for Class SA waters, the pH of the receiving water shall be in the range of 6.5 through 8.5 standard units and not more than 0.2 standard units outside of the natural background range. The draft permit includes a technology-based numeric pH range of 6.0 to 9.0 standard units consistent with the Steam Electric ELG. This range is less stringent than the range required for discharges to Class SA waters of 6.5 to 8.5 s.u. However, as discussed in Section 6.1.2 above, the draft permit requires that the discharge at Outfall 001, which is sampled at a point after commingling with Outfall 010, among others, has the pH range required for Class SA waters, that is, 6.5 to 8.5 s.u.

6.6.5 Total Residual Oxidants (TRO)

The current permit allows use of continuous chlorination of SW system cooling water for macroinvertebrate control. The ELGs prohibit chlorination for more than two hours per day unless the permittee can demonstrate that such discharge is required for macroinvertebrate control. PNPS had previously demonstrated that macroinvertebrate fouling occurs in the SSW System and that continuous chlorination of the SSW system is required to be in conformance with the U.S. NRC Generic Letter 89-13. As detailed in the fact sheet of the 1991 permit, the permittee demonstrated that, with a daily maximum TRO concentration of 1.0 mg/l for the SSW system, the maximum TRO concentration after the SSW mixes with the condenser cooling water would be 0.04 mg/l at the end of the discharge canal. For these reasons, the draft permit authorizes continuous chlorination of the SSW system.

The current permit requires a monthly average and daily maximum TRO limitation of 0.5 mg/L and 1.0 mg/L, respectively, monitored continuously and prior to mixing with the condenser cooling water discharge through Outfall 001, or any other flows. The permittee has determined these levels are necessary for adequate macroinvertebrate control in its cooling equipment. The current permit also allows the permittee to submit manual grab samples taken four times per day in lieu of the continuous monitoring data if the continuous TRO monitoring equipment should become inoperative.

Review of DMR data reveals that daily maximum TRO, in the form of TRC, has been exceeded on five (5) occasions, with a highest recorded daily maximum TRO concentration of 2.4 mg/L. The monthly average TRO effluent limitation has not been exceeded on any occasion. The draft permit continues to require a monthly average TRO limit of 0.50 mg/l and a daily maximum limit of 1.0 mg/l at Outfall 010 until the shutdown occurs.

Post-shutdown, the condenser cooling water flow on which the original demonstration for these TRO limits was based will be terminated, with the exception of flows from one of the two CW pumps which may be operated up to 5% of the time The draft permit will set WQB limits for total residual oxidants (TRO) based on WQC for total residual chlorine (TRC) as explained in Section 6.1.3 above. The chronic and acute, marine water quality criteria for TRC are 7.5 ug/l and 13 ug/l, respectively. End-of-pipe TRC limits would typically be calculated by multiplying the water quality criteria by the dilution available to the discharge. To EPA's knowledge, there has not been any prior hydrodynamic modeling conducted that would provide an estimate of dilution for the discharge from the discharge canal. In addition, the permittee may choose to demonstrate to EPA and the MassDEP that discharge of TRC levels above criteria are required for macroinvertebrate control post-shutdown and shall include any dilution estimates based on an acceptable dilution model of Cape Cod Bay in the vicinity of the discharge. EPA and MassDEP would consider whether to establish less stringent limits for TRO based on review of any such demonstration.

6.6.6 Temperature

The current permit did not establish any temperature limits for Outfall 010. Effluent temperature and delta T limits that were established for Outfall 001, which comprised more than 95% of the flow in the discharge canal, the rest being the continuous flow from Outfall 010 in addition to other flows which were intermittent. As noted earlier, the condenser cooling water flow will terminate from the shutdown and beyond, with only one CW pump that must be operated for up to 5% of the time to support decommissioning activities. (See Joe Egan email of 10/28/15, AR#519) Therefore, it is necessary to establish temperature limits for Outfall 010, which will be the sole continuous remaining discharge in the discharge canal post-shutdown. Although some of the flows through the SW system are cooling water, the permittee believes that a delta T of no greater than 3°F would be expected. (See Joe Egan email of 10/28/15, AR #519). The draft permit has established effluent temperature limits at a maximum daily limit of 85°F and a monthly average of 80°F, which are the temperature limits consistent with the MA SQWS for Class SA waters. *See* 314 CMR 4.05(4)(a)(2)(a). In addition, there has been delta T limit of a maximum daily of 3°F, as discussed in Section 6.1.4 above.

6.7 Outfall 011 and new Outfall 014

Outfall 011 is an internal outfall which is sampled prior to commingling with any flow at Outfall 005, a storm drain, which ultimately is routed to the discharge canal. Discharges through Outfall 011 are intermittent, batch discharges directly from the "waste neutralizing sump" or from other source(s). Water released from Outfall 011 may be radiologically contaminated, in which case it would be coming from the waste neutralizing sump. Otherwise, it would originate from what is characterized as a "clean" system (e.g., demineralized water, service water, or station heating water).

The station heating system utilizes demineralized water that is discharged during heating system outages, which occur 1-2 times per year. Tolyltriazole and sodium nitrite are added as corrosion inhibitors to the TBCCW, RBCCW, and station heating systems.

The discharge from the demineralizer system consists of reject water, which is purified city water which does not meet the requirements of the condenser makeup water. This water is pumped from the demineralizer to the demineralizer storage tank, which is used as makeup water for several plant systems (condensate/feedwater, closed cooling water, station cooling water, station heating system, etc.) as dictated by inventory requirements.

Discharges from the waste neutralizing sump consist of drainage from heat exchanger process water [turbine building closed-cycle cooling water (TBCCW) system and the reactor building closed-cycle cooling water (RBCCW) system], station heating system water, drainage from the floor drains in the boiler room (station heating water), various sumps throughout the building (service water system chlorinated salt water), and reject water from the emergency standby liquid control system. This reject water is from the demineralizer, with sodium pentaborate added and which does not meet the plant's technical specifications.

Due to detected levels of tritium in groundwater samples in the vicinity of Outfall 005, the permittee conducted an investigation to determine its source and concluded that water from the waste neutralizing sump that was being discharged through the storm drain at Outfall 005 was the likely source of this tritium. The permittee believes that the storm drain associated with Outfall 005 is not watertight and leaks water from the Outfall 011 discharges. In order to avoid groundwater contamination from this discharge through this storm drain, the permittee has rerouted the flow from the waste neutralizing sump only, directly to the discharge canal with a hose, thereby bypassing the storm drain associated with Outfall 005 (See Figure 4). Since this is a discrete outfall to the discharge canal, it has been designated in this permit as a new Outfall, #014. The other discharges from Outfall 011, including demineralized water, service water, and station heating water will not need to bypass the storm drain and will continue to be discharged through the storm drain at Outfall 005. (12/17/15 email from J. Egan to G. Papadopoulos)

The low level radioactive effluent associated with Outfalls 011 and 014 shall continue to meet all the Nuclear Regulatory Commission (NRC) requirements as specified in 10 C.F.R. Part 20. These limits are detailed in the PNPS Technical Specifications which define facility operational conditions. EPA and the NRC, in the past, have signed a Memorandum of Understanding (MOU) which specifies that EPA will be responsible for the water quality aspects of the discharge in concert with the State, and the NRC will be responsible for the levels of radioactivity in the discharge. Thus, the draft permit addresses only the chemical aspects of water quality and does not regulate radioactive materials encompassed within the Atomic Energy Act's definitions of source, byproduct, or special nuclear materials. *See Train v. Colorado Public Interest Research Group*, 426 U.S. 1, 25 (1976) (holding that "the 'pollutants' subject to regulation under the [CWA] do not include source, byproduct, and special nuclear material."). All NRC radioactive discharge requirements will continue to be in effect, as required, in 10 C.F.R. Part 20 and plant technical specifications.

The current permit (at Part I.A.1.n) allows discharge of sodium nitrite (corrosion inhibitor) from the closed loop cooling water systems and heating systems through Outfall 011 and new outfall 014. In its letter to EPA dated May 22, 1995, the permittee requested that Tolyltriazole (a corrosion inhibitor) be added to the station heating, RBCCW, and TBCCW systems. These flows discharge through Outfalls 011 and 014 only during scheduled plant outages.

The discharges through Outfalls 011 and 014 are classified as low volume waste sources pursuant to the Steam Electric ELGs at 40 C.F.R. §423.11. As noted above, Outfall 011 is an internal outfall, because the point of discharge to the receiving water is at Outfall 005. Applying limits at Outfall 011 is consistent with 40 C.F.R. § 122.45(h), which allows for such limits when the wastes associated with the internal outfall may be so diluted as to make monitoring at the point of discharge (Outfall 005) impracticable. In this case, certain pollutants expected to be present in the discharge from Outfall 011, including tolyltriazole, sodium nitrite, and boron, could, depending on the storm event, be so diluted by the stormwater discharge from Outfall 005 as to make monitoring at Outfall 005 impracticable. Moreover, the draft permit requires monitoring at Outfall 005 during the first flush of wet weather of triggering storm events, whereas discharges from Outfall 011 are generally independent of storm events.

6.7.1 Flow

The current permit requires monthly average and daily maximum flow limitations of 0.015 MGD and 0.06 MGD, respectively, for Outfall 011. Review of DMR data indicates that these effluent limitations have not been exceeded. The highest monthly average flow recorded was 0.0104 MGD and the highest daily maximum flow recorded was 0.0122 MGD.

The permittee requested removal of the flow limits at Outfall 011, however, the limits have been retained based on anti-backsliding requirements. The discharges through Outfalls 011 and 014 are expected to meet these flow limits, since they have been consistently met in the past under the current permit. Flow is required to be measured at these outfalls prior to combining with any other wastewater or with stormwater that drains to Outfall 005.

6.7.2 Total Suspended Solids (TSS)

The current permit requires monthly average and daily maximum TSS limitations of 30 mg/l and 100 mg/l, respectively. Review of DMR data from 2008 through 2014 indicates that these effluent limitations have not been exceeded, with a maximum concentration of 26.4 mg/l.

The discharges through Outfalls 011 and 014 include low volume waste sources pursuant to the Steam Electric ELGs 40 C.F.R. § 423.12, which requires effluent limitations for TSS of 100 mg/l as a maximum and 30 mg/l as an average. Therefore, the draft permit includes an average monthly TSS limit of 30 mg/L and a maximum daily TSS limit of 100 mg/L consistent with the ELGs requirement for low volume waste sources. The monitoring frequency at Outfall 011 remains at once per month but Outfall 014 is required to be sampled whenever it discharges because this discharge is expected to occur less frequently than Outfall 011.

6.7.3 Oil & Grease

The current permit does not include oil and grease (O&G) limitations at Outfall 011. However, since this discharge is classified as a low volume waste source, it must meet effluent limitations for O&G of 20 mg/l as a maximum and 15 mg/l as an average, pursuant to 40 C.F.R. § 423.12.

Therefore, the draft permit establishes a maximum daily O&G limit of 20 mg/l and an average monthly limit of 15 mg/l at Outfall 011 (monthly), as well as Outfall 014 (quarterly, when discharging).

6.7.4 pH

The current permit requires that the discharge through Outfall 011 shall not be less than 6.1 standard units nor greater than 8.4 standards units. The current permit did not specify any monitoring frequency or reporting requirements for effluent pH for this outfall, therefore no pH data are available.

The current permit limit is slightly more stringent than the NELG requirement for low volume wastes (40 C.F.R. § 423.12) that require the pH of all discharges, except once through cooling water, shall be within the range of 6.0 – 9.0 SU. The State WQS (314 CMR 4.05(4)(a)(3)) require that for Class SA waters, the pH of the receiving water shall be in the range of 6.5 through 8.5 standard units and not more than 0.2 standard units outside of the natural background range. A water quality-based pH limitation would be more stringent than the technology-based effluent limitation. In this case, however, Outfall 011 is an internal, low volume waste stream that combines with stormwater at Outfall 005 prior to reaching the receiving water through the discharge canal. The only exception is water from the waste neutralization sump, which as noted above, is discharged directly to the discharge canal through new Outfall 014. The draft permit establishes a water quality-based pH limitation at Outfall 001 downstream of where Outfalls 005 and 011 merge and prior to discharging to Cape Cod Bay that will ensure the effluent meets WQS. Therefore, the draft permit maintains the limit for pH ranging from 6.1 to 8.4 at these outfalls. This permit limit range is slightly less stringent than the WQS (but which will be met prior to discharging to the receiving water) but more stringent than the technology-based limits in the Steam Electric ELGs. EPA is carrying forward the pH limit from the current permit consistent with the anti-backsliding regulations at 40 C.F.R. § 122.44(*l*)(1) which require a re-issued permit to establish limits at least as stringent as the current permit with limited exceptions, none of which apply to the pH limit in this case.

6.7.5 Sodium nitrite

PNPS uses sodium nitrite as a corrosion inhibitor in its TBCCW, RBCCW, and station heating systems. The current permit (at Part I.A.1.n) limited the discharge of sodium nitrite as it mixed with the Outfall 001 effluent in the discharge channel, to a concentration of 2.0 mg/L, by calculation. These discharges are generally associated with periods of maintenance, modifications, or equipment repair.

The permittee is required to monitor the discharge through Outfalls 011 (monthly) and 014 (quarterly, when discharging) for sodium nitrite and provide the calculated concentration in the discharge canal upon mixing with the cooling water discharges of Outfalls 001 and 010, as described below, to assure that the sodium nitrite limit of 2.0 mg/l is not exceeded. To calculate the estimated concentrations of sodium nitrite in the discharge canal, the permittee shall divide the concentration of this parameter in the Outfall 011 internal discharge by the dilution factor derived by dividing the flow rate of the cooling water flow being used from the combination of CW and SSW pumps that are operating at the time of the batch discharge of these waters by the flow rate of this discharge. These discharges may be made directly to the discharge canal.

EPA's Gold Book (Quality Criteria for Water, 1986: EPA Publication No. 440/5-86-001 dated May 1, 1986) does not establish any marine water quality criteria for sodium nitrite. Rather it notes that... "In oxygenated natural waters systems, nitrite is rapidly oxidized to nitrate." The Gold Book provides no marine organism toxicity data or stream criteria for nitrites, but does indicate that a nitrite nitrogen level at or below 5 mg/L should be protective of most warm water fish. Therefore, the current permit established a maximum daily concentration of 2.0 mg/L nitrite as calculated in the discharge canal, based on the reported rapid reaction of nitrite to nitrate in oxygenated waters and the protective level of 5.0 mg/L for warm water species.

6.7.6 Copper

EPA's National Recommended Water Quality Criteria for Saltwater include a CMC (acute) copper concentration of 4.8 ug/L and a CCC (chronic) copper concentration of 3.1 ug/L. The permit application submitted by the permittee indicated a copper concentration at Outfall 011 of 49.8 ug/L.

As noted, Outfalls 011 and 014 combine with the discharge from Outfall 001 in the discharge canal, where a significant amount of dilution is provided. Dilution provided from the Outfall 001 discharge is approximately 1:1,000 (using the lowest recorded monthly average flow of 65.6 MGD for Outfall 001 and the daily max flow limit at Outfall 011 of 0.06 MGD). Assuming this dilution, the concentration of copper in the discharge from Outfall 011 would be diluted from 49.8 ug/L to approximately 0.05 ug/L in the discharge canal. Post-shutdown, the worst case condition for low flow would be represented by the operation of one SSW pump. Under this scenario, the dilution available to this flow would be about 65:1, and the corresponding copper concentration would be 0.77 ug/l, assuming the same level of 49.8 ug/l at the internal location.

The estimated concentration at the discharge canal is not expected to approach the level that would cause or contribute to a WQS violation and this is based on one sampling result. Therefore, the draft permit does not require a limit or monitoring specific to copper. However, the draft permit does establish whole effluent toxicity (WET) testing requirements at Outfalls 011 and 014, described below, which includes monitoring for a suite of metals and will provide twice yearly effluent copper data.

6.7.7 Tolyltriazole

In a letter to EPA dated May 22, 1995 (AR #164), the permittee requested the authorization to use tolyltriazole (a corrosion inhibitor) as an additive to its station heating, RBCCW, and TBCCW systems. By letter of June 30, 1995 (AR #154), EPA approved the use of tolyltriazole. Flow from Outfall 011 and 014 containing tolyltriazole would typically occur only during scheduled plant outages. Initial conditioning of the cooling systems would require a maximum tolyltriazole concentration of 20 mg/l, after which concentrations would be maintained at 2.0

mg/l. The maximum concentration would be in the neutralization sump. With one SW pump operating, a worst case condition, corresponding to a flow of 2700 gpm (3.88 MGD), the tolyltriazole concentration would be expected to be about 1.48 mg/l in the discharge canal. Below are calculations of estimated tolyltriazole concentration in the discharge canal under two scenarios using the maximum flow rate of 200 gpm out of the neutralization sump:

Dilution with 1 SW pump operating:

$$\frac{2700 \text{ gpm}}{200 \text{ gpm}} = 13.5$$

Dilution with 1 SW pump and 1 CW pump operating:

$$\frac{155{,}000 \text{ gpm} + 2700 \text{ gpm}}{200 \text{ gpm}} = 790$$

Maximum Tolyltriazole concentration after mixing in discharge canal under both scenarios:

20 mg/l tolyltriazole / 13.5 = **1.48 mg/l** 20 mg/l / 790 = **0.025 mg/l**

Therefore, the concentration of tolyltriazole under the worst case condition of one SW pump operating of 1.48 mg/l would be below the acute and chronic toxicity levels of this chemical, which is a 96 hour LC_{50} for rainbow trout of 23.7 mg/l and a 21 day LC_{50} for *Daphnia magna* of 5.8 mg/l. Based on a more typical operating scenario of one SW pump and one CW pump operating, the discharge concentration of tolyltriazole at Outfall 001 would be expected to be about 0.025 mg/l.

The draft permit includes a maximum daily limit of 1.48 mg/l of tolyltriazole at Outfalls 011 and 014. Consideration has been given to the use of multiple chemicals that combine in the effluent from these outfalls, resulting in the establishment of WET testing requirements as described below.

6.7.8 Boron

The standby liquid control (SLC) wastewater which drains to Outfall 014 via the neutralizing sump consists of reject water from the SLC system. This low volume wastewater is characterized as demineralizer water with sodium pentaborate added, containing approximately 8% boron, and is therefore discharged as reject water.

Sodium pentaborate is commonly used and discharged from most nuclear power plants in the United States. The wastewater source is boronated water used in the reactor's main coolant system. Boron in the form of highly soluble boric acid or sodium pentaborate is added to the water surrounding the active fuel elements for neutron moderation. This boronated water and the movable control rods are used to maintain a constant power output between refueling operations. In practice, the boronated water is steadily reduced in boron content from a maximum concentration of 16,500 mg/l, after refueling, in order to maintain a suitable neutron flux.

According to EPA's Gold Book, boron is an essential element for growth of plants but there is no evidence that it is required by animals. The maximum concentration found in 1,546 samples of river and lake waters from various parts of the United States was 5.0 mg/L; the mean value was 0.1 mg/L (Kopp and Kroner, 1967). Groundwaters could contain substantially higher concentrations in certain locations. The concentration in seawater was reported as 4.5 mg/L in the form of borate (NAS, 1974). Naturally occurring concentrations of boron should have no effects on aquatic life.

According to Ambient Water Quality Guidelines for Boron, 1992, Province of British Columbia, Canada (S.A. Moss, N.K. Nagpal):

> Many jurisdictions have not set boron guidelines for the protection of marine aquatic life. According to the EPA (1988), Guam, the Mariana Islands and Trust Territories have set criteria for the protection of marine aquatic life at 5.0 mg/L. Puerto Rico has set the guideline at 4.8 mg/L for coastal waters for use in propagation, maintenance and preservation of desirable marine species.
>
> Taylor et al. (1985) studied the effects of boron on *Limanda limanda* (Dab) and found a 24h-LC_{50} concentration of 88.3 mg B/L. Thompson et al. (1976) performed static renewal studies using seawater and sodium metaborate on underyearling and alevin coho salmon (*Oncorhynchus kisutch*) (1.8-3.8 g in weight). This study was performed on the west coast of British Columbia. They found the 96h-LC_{50} was 40.0 mg B/L and the 283h-LC_{50} was 12.2 mg/L. Hamilton and Buhl (1990) conducted static acute toxicity tests on coho salmon in brackish water using boric acid to find the 24h-LC_{50} at greater than 1,000 mg B/L and the 96h-LC_{50} at 600 mg B/L. They found similar results when tests on chinook salmon (*O. tshawytscha*) were performed. Studies performed on coho salmon by British Columbia MELP found a 96h-LC_{50} of 122.6 mg/L (MELP, 1996).
>
> It was recommended that the maximum concentration of boron for the protection of marine aquatic life should not exceed 1.2 mg B/L. This guideline was based on study by Thompson noted above that found the most sensitive species was coho salmon (*Oncorhynchus kisutch*), with a 283h-LC_{50} of 12.2 mg B/L. A safety factor of 0.1 was used to derive the guideline (1.2 mg/l) in the marine environment.

Marine waters normally contain a natural background concentration of boron of about 4.6 mg/l. The current permit limits the concentration of boron in the discharge to the discharge canal to 1.0 mg/l above the natural background concentration, to be shown by calculation. According to the permittee, sodium pentaborate may be discharged in 20,000 gallon batches at a maximum concentration of 16,500 mg/l calculated as boron. The boron concentration shall not exceed 1.0 mg/l, by calculation, above background in the discharge from the discharge canal, with the assumption that background concentration is 4.6 mg/l. Therefore, the actual effluent limit will be 5.6 mg/l. Sufficient water from a combination of CW and SW pumps must be available during each sodium pentaborate release to ensure adequate dilution prior to discharge. Each release of boron will be reported in the appropriate DMR providing the concentration of boron in the tank before release, and the calculated boron concentration in the discharge canal before mixing with Cape Cod Bay water. In addition, at the time of discharge, the permittee must sample the ambient water and analyze it for boron to confirm that the background levels are approximately 4.6 mg/l.

6.7.9 Whole Effluent Toxicity (WET) Testing

EPA's Technical Support Document for Water Quality-Based Toxics Control, March 1991, EPA/505/2-90-001, recommends using an "integrated strategy" containing both pollutant-specific (chemical) approaches and whole effluent (biological) toxicity approaches to better control toxics in effluent discharges. Pollutant-specific approaches, such as those in EPA's Gold Book (ambient water quality criteria) and state regulations, address individual pollutants, whereas whole effluent toxicity (WET) approaches evaluate, in effect, interactions between pollutants, i.e., the "additive," "antagonistic" and/or "synergistic" effects of combinations of pollutants. In addition, WET analyses can reveal the presence of an unknown toxic pollutant. Region I adopted this "integrated strategy" on July 1, 1991, for use in permit development.

Section 101(a)(3) of the CWA states a nation goal of prohibiting the discharge of toxic pollutants in toxic amounts. The Massachusetts SWQS, in effect, prohibit such discharges, by stating that "all surface waters shall be free from pollutants in concentrations or combinations that are toxic to humans, aquatic life or wildlife." 314 CMR 4.05(5)(e). The NPDES regulations at 40 C.F.R. § 122.44(d)(1)(v) require whole effluent toxicity (WET) limits in a permit when the permitting authority determines that a discharge causes, has the "reasonable potential" to cause, or contributes to an instream excursion above the State's narrative criterion for toxicity.

Sections 402(a)(2) and 308(a) of the CWA authorize EPA to establish toxicity testing requirements and toxicity-based permit limits in NPDES permits. Section 308 specifically states that biological monitoring methods may be required when needed to carry out the objectives of the Act. Under certain narrative State water quality standards and Sections 301, 303, and 402 of the CWA, EPA and the States may establish toxicity-based limits to implement the narrative "no toxics in toxic amounts" criterion.

The regulations at 40 C.F.R. § 122.44(d)(ii) state that:

> [w]hen determining whether a discharge causes, has the reasonable potential to cause, or contributes to an in-stream excursion above a narrative or numeric criteria within a State water quality standard, the permitting authority shall use procedures which account for existing controls on point and nonpoint sources of pollution, the variability of the pollutant or pollutant parameter in the effluent, the sensitivity of the species to toxicity testing (when evaluating whole effluent toxicity), and where appropriate, the dilution of the effluent in the receiving water.

The complexity of the wastewater from various sources associated with Outfalls 011 and 014 is such that whole effluent toxicity testing is required to identify, evaluate and address any potential water quality impacts. There are limited data on the individual chemical characteristics of waste streams discharging to internal Outfalls 011 and 014. These discharges are likely to be variable in quality and could potentially contain metals and other pollutants that individually could be toxic to aquatic life. However, it is not possible based on current information to determine whether or not the combination of these pollutants, and their subsequent dilution with other internal streams, would result in toxic effects upon discharge. WET testing is conducted to assess whether an effluent contains a combination of pollutants which produces toxic effects. WET testing and WET limits are used in conjunction with pollutant specific effluent limits to control the discharge of toxic pollutants.

EPA has included a WET testing requirement in the Draft Permit for Outfalls 011 and 014, in addition to the chemical-specific limitations described above, to assess the effects of the combination of pollutants on aquatic life. This approach is consistent with that recommended in *Technical Support Document for Water Quality-based Toxics Control*, March 1991, EPA/505/2-90-001, p. 60. The permittee shall report the results of acute WET tests twice per year using the Mysid shrimp, *Americamysis bahia* and the Inland Silverside *Menidia beryllina*. A 24-hour composite sample is the required "sample type" for WET testing. Pursuant to EPA Region 1 policy and MassDEP's Implementation Policy for the Control of Toxic Pollutants in Surface Waters (February 23, 1990), discharges having a dilution ratio of greater than 100:1 require acute toxicity testing two times per year. With two or more SSW pumps operating, the dilution factor is about 130 for this discharge.

If the WET tests indicate toxicity, the Regional Administrator and the Commissioner may decide to modify the permit. Any such modifications may include the addition of WET limits and/or additional pollutant limits to adequately protect receiving water quality during the remainder of the permit term. WET test results under the new permit will be considered "new information not available at the time of permit development." Therefore, the permitting authority would be allowed to use this information as a potential basis for modifying the existing permit. *See* 40 C.F.R. § 122.62(a)(2).

6.8 Additional Permit Conditions

6.8.1 Radiological Wastewater ("radwaste") Effluents

The discharge of radiological waste water ("Radwaste Effluents") directly into the discharge canal occurs via a diffuser pipe submerged at the upstream (proximal) end of the canal, adjacent to the discharge structure. It consists of demineralized water contaminated with radioactive species [plant makeup water (contact cooling water)] which is normally recycled within the radwaste processing system. In the event of a discharge, it is sampled, analyzed and pumped to the diffuser pipe in the discharge canal. Radioactive materials that fall within the Atomic Energy Act's definitions of source, byproduct, or special nuclear materials are not subject to regulation under the CWA. *Train v. Colorado Public Interest Research Group*, 426 U.S. 1, 25 (1976); *see also* 40 C.F.R. § 122.2 (defining "pollutant"). Thus, the NRC, not EPA, regulates this discharge, which typically occurs 1-2 times per year, usually during refueling outages.

6.8.2 Groundwater

Recent studies regarding groundwater onsite have indicated low levels of tritium ranging from 1,000-3,100 picocuries/liter (pCi/L). EPA's drinking water standard for tritium is 20,000 pCi/L – the average annual amount assumed to produce a dose of 4 mrem/year. From 2007 to 2013, PNPS worked with the Massachusetts Department of Public Health (DPH) to resolve the issue, citing weekly phone calls and quarterly meetings to determine the source of contamination. The permittee has determined that the storm line draining to Outfall 005 likely is not watertight and is a source of ongoing contamination of the groundwater from the demineralizer waste associated with internal Outfall 011. See discussion for Outfalls 011 and 014 in Section 6.7 above for the remedy that the permittee is proposing to implement.

6.8.3 Gas Bubble Disease

Two occurrences of fish mortality during the spring of 1973 and 1975 prompted a study in 1986 of "gas bubble disease" (see AR#419 and discussion of available literature and PNPS studies in Attachment C to this fact sheet pp. 30-33). As a result, the current permit included a provisions at Parts I.A.2.e and I.A.2.f meant to address fish mortality caused by gas bubble disease. In its supplemental permit application letter of 12/1/99 (AR #81), the permittee has requested that the conditions in the current permit pertaining to the barrier net at the end of the discharge canal (Part I.A.2.e.) and dissolved nitrogen saturation level (Part I.A.2.f.) be deleted from the draft permit, because gas bubble disease has only been documented on two separate occasions in the 1970's. EPA has reviewed the dissolved gas saturation measurements made from 2003 to 2012. Although limited, the data indicates that dissolved nitrogen has exceeded 115% (the value representing a critical threshold for adult menhaden; see Clay, et al., 1976) once in June 2005 and once in September 2009, both collected during low tide when contact with the bottom limits the extent of the plume outside of the discharge canal.

Under the current permit, PNPS employed a fish barrier until 1995 to prevent fish from entering the discharge canal. Specifically, the barrier was intended to protect Atlantic menhaden, which are particularly vulnerable to mortality from supersaturation of dissolved nitrogen in the discharge and which experienced the mortality events in the early 1970's. Use of the barrier net was discontinued in 1995 because there had been "no evidence of any significant thermal discharge related incidents for the past several years such as Menhaden being attracted to the thermal plume, collecting outside the net, and/or attempting to gain entry into the canal itself." November 23, 1994 letter from EPA to E.T. Boulette of PNPS (AR #351).

The lack of thermal discharge related mortality events and recent dissolved gas saturation data demonstrate that gas bubble disease is unlikely to occur at the PNPS discharge and the permit conditions specific to these events are no longer necessary. Furthermore, PNPS will cease generating electricity no later than June 1, 2019, at which time the heated discharge from the main condenser will be terminated and the rise in temperature at the discharge from Outfall 001 will be a maximum of 3°F, compared to the current permit limit of 32°F. The draft permit does not include permit conditions requiring a barrier net or a maximum average dissolved nitrogen saturation level.

7.0 ANALYSIS OF THERMAL DISCHARGE LIMITS FOR OUTFALL 001

As discussed above, in developing thermal discharge limits for this permit, EPA and MassDEP must consider applicable technology-based requirements, water quality-based requirements, and the applicant's CWA § 316(a) demonstration submitted in support of its request for a § 316(a) variance. Specifically, the permittee requested an extension of its § 316(a) variance in its supplemental application letter (AR #292) that was submitted on October 25, 1995 and with its 316 demonstration report submitted in March of 2000 (AR# 233).

7.1 Technology-Based Requirements

Turning first to technology standards, the statute classifies heat as a "nonconventional" pollutant subject to BAT standards. *See* 33 U.S.C. §§ 1311(b)(2)(A) and (F), 1311(g)(4), 1314(a)(4), 1362(6). As noted above, the ELGs for the Steam Electric Power Generating Point Source Category, which are found at 40 C.F.R. Part 423, apply to PNPS because this facility meets the ELG's definition of a steam electric power plant. This definition covers facilities that, among other things, utilize a nuclear fuel in conjunction with a thermal cycle employing the steam water system as the thermodynamic medium. Since the Steam Electric ELGs do not include categorical standards for thermal discharge, the permit writer is authorized under Section 402(a)(1)(B) of the CWA and 40 C.F.R § 125.3 to establish technology-based thermal discharge limits by applying the BAT standard on a case-by-case, BPJ basis.

With regard to technologies for reducing thermal discharges, EPA is aware that closed-cycle cooling towers, if available for use at the site, would substantially reduce thermal discharges from a facility like PNPS. Therefore, thermal discharge limits based on this technology would be substantially more stringent than the limits based on the open-cycle cooling system that characterizes PNPS' present operation. EPA has considered closed-cycle cooling in the Assessment of Cooling Water Intake Structure Technologies and Determination of Best Technology Available (Attachment D).

In setting a BAT effluent limit on a BPJ basis, EPA considers the relative capability of available technological alternatives and seeks to identify the best performing technology for reducing pollutant discharges (*i.e.*, for approaching or achieving the national goal of eliminating the discharge of pollutants). In addition, before determining the BAT, EPA also considers the following factors: (1) the age of the equipment and facilities involved; (2) the process employed; (3) the engineering aspects of the application of various control techniques; (4) process changes; (5) the cost of achieving such effluent reduction; and (6) non-water quality environmental impacts (including energy requirements); as well as the appropriate technology for the category or class of point sources of which the applicant is a member based upon all available information; and any unique factors relating to the applicant. 33 U.S.C. § 1314(b)(2)(B); 40 C.F.R. § 125.3(c)(2), (d)(3).

"Open-cycle" (or "once-through") cooling systems typically produce the highest levels of thermal discharges (and water withdrawals), as compared to closed-cycle or partially closed-cycle systems. PNPS currently operates with an open-cycle cooling system and, as a result, the entire volume of the facility's cooling water (and thus the entire amount of waste heat) is discharged to the receiving water. "Closed-cycle" cooling systems reduce thermal discharges (and cooling water withdrawals). In a closed-cycle system, cooling water is used to condense the steam, but rather than discharge the heated water, a cooling system is used to remove most of the waste heat from the cooling water – typically dissipating the heat to the atmosphere through a cooling tower of some type – so that the water can be reused for additional cooling.

Given that PNPS is an existing facility that would require retrofitting to achieve technologically-driven improvements, EPA has looked to the existing steam electric facilities that have achieved the greatest reductions in thermal discharges through technological retrofits. As a general matter, the best performing facilities in terms of reducing thermal discharges at existing open-cycle cooling power plants are those facilities that have converted from open-cycle cooling to closed-cycle cooling using some type of "wet" cooling tower technology. Converting to closed-cycle cooling can reduce heat load to the receiving water by 95% or more. EPA's research has identified a number of facilities that have made this type of technological improvement. *See* Draft Permit Determinations Document for Brayton Point Station NPDES Permit, #MA0003654, at pp. 7-37 to 7-38; Responses to Comments for Brayton Point Station NPDES Permit, at p. IV-115.

As part of its determination of the BTA for PNPS's CWISs under CWA § 316(b), EPA evaluated alternative cooling system technologies in light of their feasibility and the various factors listed above (e.g., cost, engineering considerations). *See* Attachment D. EPA relies upon and incorporates by reference that analysis here. EPA determined that closed-cycle cooling was not the best technology available for minimizing entrainment at PNPS, because the permittee has determined that, no later than June 1, 2019, it will cease generating electricity and, therefore, withdrawing and discharging once-through cooling water for the main condenser. EPA concludes in Attachment D that a closed-cycle cooling system could not be installed and operational prior to the planned termination of electricity generation and the associated once-through cooling water discharges for the main condenser. When PNPS ceases generating electricity, however, it will achieve a 96% reduction in flow, which exceeds the flow reductions that could have been achieved by retrofitting the existing system with closed-cycle cooling.

In addition to reducing flow, the elimination of withdrawals to cool the main condenser will achieve a roughly 91% reduction in the maximum delta T of the discharge. By comparison, retrofitting PNPS for closed-cycle cooling would reduce the maximum delta T of the discharge by a similar percentage. As discussed in Attachment D, these reductions in volume and temperature via closed-cycle cooling would come at a significant cost to install a technology that could be obsolete even before it is completed, given the permittee's announcement to cut its withdrawals drastically by June 2019 and to begin decommissioning in preparation for closing the facility completely. Thus, in light of Entergy's decision to close PNPS no later than June 1, 2019, EPA concludes that retrofitting PNPS for closed-cycle cooling would not be the BAT for thermal discharges. EPA considers several other technologies in Attachment D and their impacts on entrainment and impingement, but none of these would appreciably lower the delta T or the absolute temperature of the discharge. (VFDs, for one, would likely raise the temperature of the discharge even further).

For these reasons, EPA has determined that, in light of the impending closure of the facility, continuing to operate the plant with the existing technology and controls in the near term and then eliminating water withdrawals for the main condenser and reducing cooling water and other miscellaneous water withdrawals on or before June 1, 2019, resulting in a 96% reduction in flow, would be the BAT for the reduction of thermal discharges at the facility. The draft permit includes conditions and requirements consistent with prohibiting the discharge of thermal effluent from the main condenser once the facility ceases generating electricity. In the interim, EPA has concluded that a less stringent set of limits – namely, the thermal discharge limits in the existing permit – would satisfy CWA § 316(a) and support the renewal of PNPS' existing § 316(a) variance.

7.2 Water Quality-Based Requirements

Water quality-based requirements would be based on the Massachusetts SWQS's numeric and narrative temperature criteria, consideration of designated and existing uses, and the State's antidegradation and mixing zone policies. The state's SWQS classify Cape Cod Bay as a Class SA water and, accordingly, prohibit discharges from causing ambient water temperatures to exceed 85°F (29.4°C) or a maximum daily mean of 80°F (26.7°C), and the rise in temperature due to a discharge shall not exceed 1.5°F (0.8°C). *See* 314 CMR 4.05(4)(a)(2)(a). The SWQS further provide that "there shall be no [temperature] change from natural background that would impair any uses assigned to this class including those conditions necessary to protect normal species diversity, successful migration, reproductive functions or growth of aquatic organisms." *Id.* 4.05(4)(a)(2)(b). In addition, 314 CMR 4.05(4)(a)(2)(c) states that "alternative effluent limitations established in connection with a variance for a thermal discharge issued under 33 U.S.C. § 1251 (FWPCA, § 316(a)) and 314 CMR 3.00 are in compliance with 314 CMR 4.00. As required by 33 U.S.C. § 1251 (FWPCA, § 316(a)) and 314 CMR 3.00, for permit and variance renewal, the applicant must demonstrate that alternative effluent limitations continue to comply with the variance standard for thermal discharges."

At the current level of operation, PNPS's thermal discharge cannot always meet the numeric temperature criteria of the MA SWQS throughout the receiving water (see MIT modeling – 2000 316 demonstration, AR#233).

The data and analysis to support these determinations are presented in Attachment C: Assessment of Impacts to Marine Organisms from Thermal Discharge and Thermal Backwash. Although PNPS's thermal discharge would not satisfy the above-discussed temperature criteria of the Massachusetts SWQS, the state's SWQS also provide that thermal effluent limits established pursuant to a CWA § 316(a) variance will satisfy SWQS. Also see the discussion in Section 5.4 of this fact sheet. Thus, as explained below, EPA's decision to grant a thermal discharge variance from technology- and water quality-based standards authorized under CWA § 316(a) variance is deemed to satisfy the SWQS. *See* 314 CMR 4.05(4)(a)(2)(c) (for Class SA waters).

7.3 CWA § 316(a) Variance-Based Limits

As described above, discharges of heat must satisfy both technology-based standards and any more stringent water quality-based requirements that may apply. According to CWA §316(a) and 33 USC §1326(a), however, thermal discharge effluent limits in permits may be less stringent than those required by technology-based and water quality-based requirements, if the discharger demonstrates that such limits meeting those requirements would be more stringent than necessary to assure the protection and propagation of a balanced, indigenous population (BIP) of shellfish, fish, and wildlife in and on the water body receiving the thermal discharge. EPA regulations define the term “balanced, indigenous population”—and its synonym, “balanced, indigenous community”—in the following way:

> . . . a biotic community typically characterized by diversity, the capacity to sustain itself through cyclic seasonal changes, presence of necessary food chain species and by a lack of domination by pollution tolerant species. Such a community may include historically non-native species introduced in connection with a program of wildlife management and species whose presence or abundance results from substantial, irreversible environmental modifications. Normally, however, such a community will not include species whose presence or abundance is attributable to the introduction of pollutants that will be eliminated by compliance by all sources with section 301(b)(2) of the act; and may not include species whose presence or abundance is attributable to alternative effluent limitations imposed to section 316(a).

40 C.F.R. § 125.71(c).

The demonstration “must show that the alternative effluent limitation desired by the discharger, considering the cumulative impact of its thermal discharge together with all other significant impacts on the species affected, will assure the protection and propagation of the BIP.” *Id.* § 125.73(a); *see also* 33 U.S.C. § 1326(a).

As part of the permit renewal process, the permittee must reapply for the § 316(a) variance. A permittee can make a case for a variance retrospectively, by showing that monitoring data collected during plant operation show no evidence of appreciable harm to the BIP attributable to the thermal discharge. 40 C.F.R. § 125.73(c). Permittees may also present a prospective analysis. *Id.* This approach generally requires extensive modeling of the thermal plume and is usually undertaken when a facility is requesting a change to its operation and its thermal limits. Regardless of the method chosen, the demonstration must show that the requested variance, “considering the cumulative impact of [the permittee’s] thermal discharge together with all other significant impacts on the species affected, will assure the protection and propagation of a [BIP].” *Id.* § 125.73(a). PNPS has opted for a retrospective analysis, with some data collection to confirm prior modeling efforts.

The § 316(a) variance in the current PNPS NPDES permit allows the station to have a maximum daily discharge temperature of 102^o F with a delta T (change in temperature from intake to discharge) of 32^o F. These discharge limits are required to be met in the discharge canal prior to release into Cape Cod Bay. These limits were proposed based on the consideration of the operational characteristics of the reactor unit. In addition, this draft permit has established an effluent temperature limits for thermal backwashes at Outfall 002 of 115^o F as discussed in Section 6.2.4 above, which replaces the 120 ^{o} F limit in the 1991 permit.

For its evaluation of PNPS’s § 316(a) demonstration, EPA considered the suite of available information including 1) PNPS’ § 316(a) demonstration materials submitted in March of 2000, specifically Sections 5.3.1 to 5.3.7 – thermal impacts to “representative important species” (“RIS”); 2) 1974 investigations conducted by MIT (Pagenkopf et al.,1974); 3) an investigation by EG&G, in 1995, and (4) information on the assemblage of fish and invertebrate species in the affected area of the Cape Cod Bay and their thermal sensitivities.

EPA's evaluation of the § 316(a) variance for PNPS is provided in Attachments B and C. EPA and MassDEP considered the temperature effects and tolerances on representative important species (RIS) and other biological data that have been collected and evaluated. EPA concludes that the thermal plume from PNPS is relatively small compared to the receiving water, dissipates rapidly, and is predominantly a surface plume that moves with the tides and the wind. Minor impacts to the macroalgal community have been documented that can be attributed to the thermal plume, but this area is only roughly one acre in size. Thus, from a retrospective analysis, the past forty (40) years of operation of PNPS—during which the thermal component of the discharge has remained the same—have been protective of the balanced indigenous population of fish, shellfish and wildlife, in the context of § 316(a). Based on this information, EPA concludes that no appreciable harm has resulted from the current variance-based thermal limits in the PNPS discharge permit and that the continuation of the variance-based limits will assure the protection and propagation of a balanced, indigenous community of shellfish, fish and wildlife.

Although the thermal backwash temperature limit is higher than the Outfall 001 effluent temperature of 102^o F, the thermal backwashes occur less than ten times per year, are for a short duration of typically one to two hours, and occur one intake bay at a time, representing about 50% of the typical condenser cooling water flow. On Page 33 of Fact Sheet Attachment C, MassDEP considered the thermal backwash and its potential effects to aquatic life and concluded that these backwash events are not a cause for appreciable harm to the fish populations in the environs of the intake. Therefore, the continuation of the lower, variance-based thermal limit for the thermal backwash discharges will also assure the protection and propagation of a balanced, indigenous community of shellfish, fish and wildlife.

In Part I.A.1.g of the current permit, there were additional delta T limits which applied over sixty (60) minute periods during steady state and load cycling operations. These delta T limits have been carried over into the draft permit at Part I.A.11 and apply through the date of shutdown of electricity generation.

8.0 SECTION 316(b): DETERMINATION OF BEST TECHNOLOGY AVAILABLE (BTA) FOR COOLING WATER INTAKE STRUCTURES (CWIS)

With any NPDES permit issuance or reissuance, EPA is required to evaluate or re-evaluate compliance with applicable standards, including the technology standard specified in Section 316(b) of the CWA for cooling water intake structures (CWIS). Section 316(b) requires that:

> [a]ny standard established pursuant to section 301 or section 306 of this Act and applicable to a point source shall require that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact.

33 U.S.C. § 1326(b). To satisfy § 316(b), the location, design, construction, and capacity of the facility's CWIS(s) must reflect "the best technology available for minimizing adverse

environmental impacts" ("BTA"). The operation of CWISs can cause or contribute to a variety of adverse environmental effects, such as killing or injuring fish larvae and eggs entrained in the water withdrawn from a water body and sent through the facility's cooling system, or by killing or injuring fish and other organisms by impinging them against the intake structure's screens. CWA § 316(b) applies to facilities with point source discharges authorized by a NPDES permit that also withdraw water from waters of the United States through a CWIS for cooling purposes. CWA § 316(b) applies to this permit due to the operation of a CWIS withdrawing water from Cape Cod Bay and used for cooling at the Pilgrim Nuclear Power Station (PNPS).

On August 15, 2014, EPA published the Final Rule establishing requirements for existing facilities under § 316(b) of the CWA. *See* 79 Fed. Reg. 48,300 (Aug. 15, 2014) ("Final 316(b) Rule for Existing Facilities" or "Final Rule").[6] The Final Rule's requirements reflect the BTA for minimizing adverse environmental impact, applicable to the location, design, construction, and capacity of cooling water intake structures for existing power generating facilities and existing manufacturing and industrial facilities. The Final Rule applies to all existing power generating facilities and existing manufacturing and industrial facilities that have the design capacity to withdraw more than 2 MGD of cooling water from waters of the United States and use at least twenty-five (25) percent of the water they withdraw exclusively for cooling purposes. The Final Rule, which became effective on October 14, 2014, applies to this permit because PNPS is an existing power generating facility that withdraws more than 2 MGD from waters of the United States and uses at least 25 percent of that withdrawal exclusively for cooling purposes.

In the Final Rule, EPA also sought to address ongoing permitting proceedings like the reissuance of the PNPS NPDES permit. Specifically, EPA recognizes that, in some cases, a facility may already be in the middle of a permit proceeding at the time the new regulations were promulgated. *See* 40 C.F.R. § 125.98(g). The Final Rule makes clear that for an ongoing proceeding, when sufficient information has already been collected, the permitting authority may proceed to a site-specific BTA determination for entrainment and impingement mortality. It is evident that EPA does not intend that the ongoing permit proceeding must backtrack and go through the full information gathering and submission process set out by the Final Rule where sufficient information has been submitted upon which to base a site-specific BTA determination. *See also* 79 Fed. Reg. at 48,358 ("… in the case of permit proceedings begun prior to the effective date of today's rule, and issued prior to July 14, 2018, the Director should proceed. See §§ 125.95(a)(2) and 125.98(g)."). The Final Rule also states that the permitting authority may base its site-specific BTA determination for entrainment on some or all of the factors specified in 40 C.F.R. §§ 125.98(f)(2) and (3).

PNPS was first issued a NPDES permit in 1975 and has been collecting and submitting information to EPA and MassDEP about its CWIS for more than 30 years. Region 1 was working on the permit prior to promulgation of the Final 316(b) Rule for Existing Facilities and had gathered substantial additional information from the permittee as required under its current, administratively-continued permit through the use of information request letters (sent pursuant to CWA § 308(a)) and site visits. In this case, the Region has determined that the information

[6] EPA notes that following its promulgation, multiple petitions challenging the Final 316(b) for Existing Facilities have been filed in federal court. Nonetheless, the rule is in effect as of this writing.

already submitted by the Facility is sufficient. The BTA determination for controlling impingement mortality and entrainment at PNPS has been developed on a site-specific basis, consistent with EPA's Final 316(b) Rule for Existing Facilities and under the ongoing permit proceeding provision at 40 C.F.R. § 125.98(g). In addition, EPA has considered any conditions necessary to meet Massachusetts surface water quality standards at 314 CMR 4.00 as they apply to the effects of CWISs on the State's waters. This determination is set forth in Attachment D, *Assessment of Cooling Water Intake Structure (CWIS) Technologies and Determination of Best Available Technology (BTA) under Section 316(b)*, to this fact sheet. The draft permit at Part I.C requires the facility to implement the following changes to the current CWISs to reflect the BTA to minimize the adverse environmental impacts associated with impingement and entrainment:

1. Upon termination of generation of electricity and no later than June 1, 2019 the permittee shall:

    a. Operate the traveling screens with a maximum through-screen intake velocity no greater than 0.5 feet per second. Limited exceedances of the maximum through-screen velocity are authorized for the purposes of maintaining the CWIS and when the circulating water pumps are required to withdraw water to support decommissioning activities not to exceed five (5) percent of the time on a monthly basis.

    b. Monitor the through-screen velocity at the screen at a minimum frequency of daily. Alternatively, the permittee shall calculate through-screen velocity using water flow, depth, and screen open area. For this purpose, the maximum intake velocity shall be calculated during minimum ambient source water surface elevations and periods of maximum head loss across the screens. The average monthly and maximum daily through-screen intake velocity shall be reported each month on the DMR. See Part I.B.1. of the draft permit.

    c. Cease cooling water withdrawals for the main condenser and reduce total cooling water withdrawals to an average monthly rate of 7.8 MGD. Cooling water withdrawals at the salt service water pumps shall be limited to a maximum daily flow of 15.6 MGD.

    d. Withdrawal of seawater using a single circulating water pump not to exceed five (5) percent of the time on a monthly basis is authorized to support decommissioning activities.

    e. Continuously rotate the traveling screens when operating the circulating water pumps.

2. From the effective date of the permit until termination of generation of electricity, no later than June 1, 2019, the permittee shall continuously rotate the traveling screens.

3. Any change in the location, design, or capacity of any CWIS except as expressed in the above requirements must be approved in advance and in writing by the EPA and MassDEP.

EPA has determined on a site-specific, BPJ basis that the requirements in Part I.F of the draft permit will ensure that the facility's CWIS reflects the BTA for this specific facility and will minimize entrainment and impingement of all life stages of fish. Attachment B to the draft permit ("Biological Monitoring Plan") requires monitoring impingement and entrainment at the CWIS and in Cape Cod Bay to confirm EPA's evaluation of the likely environmental impact on the aquatic community resulting from the operation of the CWIS through June 1, 2019, at which time the facility will shutdown and water withdrawals through the CWIS will be substantially reduced. Part I.F of the draft permit and the Biological Monitoring Plan also include reduced biological monitoring requirements to ensure that impingement and entrainment are minimized during decommissioning activities.

9.0 STORM WATER POLLUTION PREVENTION PLAN (SWPPP)

PNPS stores and handles numerous chemicals on its property which could result in the discharge of pollutants to Cape Cod Bay either directly or indirectly through storm water runoff. Operations include the following activities from which there is, or could be, site runoff: materials handling and storage; chemical handling and storage; fuel handling and storage. To control these and other activities and operations, which could contribute pollutants to waters of the United States, potentially violating the MA SWQS, the Draft Permit requires that the permittee implement and maintain a SWPPP containing best management practices (BMPs) appropriate for this facility See Sections 304(e) and 402(a)(1)(B) of the CWA.

The goal of the SWPPP is to reduce or prevent the discharge of pollutants through the storm water drainage system. The SWPPP requirements in the draft permit are intended to provide a systematic approach by which the permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) it uses to achieve compliance with the conditions of the permit. The SWPPP shall be prepared in accordance with good engineering practices and identify potential sources of pollutants which may reasonably be expected to affect the quality of storm water discharges associated with industrial activity at the facility. The SWPPP supports the permit's numerical effluent limitations and is an enforceable element of the permit.

Implementation of the SWPPP involves the following four main steps:

1) Forming a team of qualified facility personnel who will be responsible for developing and updating the SWPPP and assisting the plant manager in its implementation;
2) Assessing potential storm water pollution sources;
3) Selecting and implementing appropriate management practices and controls for these potential pollution sources; and
4) Periodically re-evaluating the SWPPP effectiveness at preventing storm water contamination and complying with the various terms and conditions of the permit.

To minimize preparation time, the permittee's SWPPP may reflect pertinent requirements from other environmental management or pollution control plans, such as, for example, a Spill Prevention Control and Countermeasure (SPCC) plan under Section 311 of the CWA and 40 C.F.R. Part 112 or a Corporate Management Practices plan. The permittee may incorporate any part of such a plan into the SWPPP by reference, but any provision from another plan that is being incorporated by reference into the SWPPP must be attached to the SWPPP so that it is immediately available for review and inspection by EPA and MassDEP personnel. Although relevant portions of other environmental plans, as appropriate, can be built into the SWPPP, ultimately however, it is important to note that the SWPPP must be a comprehensive, stand-alone document. Thus, to repeat, any provision from another plan that is being incorporated by reference into the SWPPP must be physically attached to the SWPPP.

A copy of the most recent SWPPP shall be kept at the facility and be available for inspection by EPA and MassDEP. The draft permit requires the permittee to develop and implement a SWPPP no later than one hundred and eighty (180) days after the permit's effective date. The SWPPP supports the permit's numerical effluent limitations and the SWPPP will be equally as enforceable as those numerical limits and other requirements of the permit. See Part I.H. of the draft permit.

The permit requires that the permittee incorporate into its SWPPP all specific pollution control activities and other requirements found in the 2015 Multi-Sector General Permit's (MSGP) provisions for "Industrial Sector O, Steam Electric Generating Facilities." *See* MSGP, Part 8.0.7, *available at* http://go.usa.gov/cEMaQ.

The SWPPP specifically requires the permittee to address the storm water that accumulates in various electrical vaults on the property as explained in Section 6.4 above.

10.0 BIOLOGICAL MONITORING PROGRAM

The draft permit includes a continuation of some of the biological monitoring which has been conducted by the permittee during this permit term. In the 1991 permit, there was a Marine Ecology Monitoring program that was established as described in Attachment A to the permit. The draft permit includes requirements for impingement and entrainment monitoring as well as periodic fish trawling in the vicinity of the discharge for as long as the facility continues to generate electricity with the associated once-through cooling water withdrawals for the main condenser. The specific methodologies for the biological monitoring requirements are based on the existing methodology employed by PNPS and described in its annual monitoring reports. The Biological Monitoring Plan is included as Attachment B of the draft permit.

11.0 ENDANGERED SPECIES ACT (ESA)

Section 7(a) of the Endangered Species Act of 1973, as amended (ESA), grants authority to and imposes requirements upon Federal agencies regarding the conservation of endangered and threatened species of fish, wildlife, or plants ("listed species"), and the habitat of such species that has been designated as critical ("critical habitat"). The ESA requires Federal agencies, in consultation with and with the assistance of the Secretary of Interior, to insure that any action that they authorize, fund, or carry out, in the United States or upon the high seas, is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. The United States Fish and Wildlife Service (USFWS) typically administers Section 7 consultations for birds and terrestrial and freshwater aquatic species, while the National Marine Fisheries Service (NMFS) administers Section 7 consultations for marine species and anadromous fish.

As described in this fact sheet, EPA is proposing to reissue the NPDES permit for PNPS authorizing the withdrawal of once-through cooling water and the discharge of process water and storm water through multiple outfalls. PNPS currently operates a single reactor unit with a boiling water reactor and turbine generator. Seawater is withdrawn from Cape Cod Bay through an intake embayment formed by two breakwaters. Seawater, primarily used for condenser cooling water, is pumped from the cooling water intake structure (CWIS) by two circulating water pumps and five salt service water pumps at a maximum volume of 447 MGD. Once-through condenser cooling water (Outfall 001), combined with plant service cooling water (Outfall 010) are discharged to Cape Cod Bay via the discharge canal. In addition, PNPS discharges effluent for thermal backwash, intake screen wash water, neutralizing sump waste commingled with demineralizer reject water, station heating water, and storm water, through various outfalls on an intermittent basis. A more detailed description of each of these waste streams and outfalls is provided in Section 2.0 of this fact sheet. A more detailed description of the receiving water is provided in Section 3.0 of this fact sheet.

NMFS, in consultation with the NRC, completed an assessment of the potential effects of the ongoing operation of PNPS on listed species as part of the renewal of the facility's operating license in 2012. *See* May 17, 2012 letter from Daniel S. Morris (NMFS) to Andrew S. Imboden (NRC) (AR# 465) ("2012 ESA Consultation letter"). In its letter, NMFS concludes that effects of the continued operation of PNPS to listed species will be insignificant and discountable, and that the renewal of PNPS' operating license is not likely to adversely affect any listed species under NMFS jurisdiction and will have no effect on right whale critical habitat. In other words, effects would not be meaningfully measured or detected ("insignificant"), or effects would be extremely unlikely to occur ("discountable").[7] NMFS specified that re-initiation of this consultation would likely be necessary when EPA reissues a revised NPDES permit for this facility.

On October 13, 2015, Entergy announced that PNPS will cease generation of electricity at the facility no later than June 1, 2019. Based on a recent press release, EPA expects that operation of the facility to support electrical generation will continue until May 31, 2019. Beginning June 1, 2019, EPA expects that seawater withdrawal and effluent discharge will be dramatically altered as a function of entering the decommissioning phase. To the best of its ability based on available

[7] According to USFWS and NMFS, a "not likely to adversely affect" conclusion is appropriate when effects on listed species are expected to be discountable, insignificant, or completely beneficial. Beneficial effects are "contemporaneous positive effects without any adverse effects," insignificant effects "relate to the size of the impact and should never reach the scale where takes occurs," and discountable effects are "those extremely unlikely to occur." Glossary of Terms used in Section 7 Consultations in the joint USFWS and NMFS *Endangered Species (Section 7) Consultation Handbook* (March 1998).
http://www.fws.gov/endangered/esa-library/pdf/esa_section7_handbook.pdf

information, EPA has taken this into account and has tailored the permit to reflect post-shutdown operations and discharges as appropriate. However, since the permittee cannot fully anticipate all changes in permitted flows that will take place post-shutdown, this permit may be modified post-shutdown if warranted by any new or increased discharges.

The draft permit establishes technology- and water quality-based effluent limitations and conditions designed to ensure the protection of designated uses of Cape Cod Bay, including as an excellent habitat for fish, other aquatic life and wildlife, including for their reproduction, migration, growth and other critical functions consistent with the Massachusetts surface water quality standards at 314 CMR 4.05(4)(a). In this section, EPA identifies listed species that may be present in the vicinity of PNPS and evaluates the potential impacts of the action on listed species as authorized under the draft permit. EPA agrees with NMFS' 2012 evaluation of the potential impacts to ESA listed species and the conclusion that continued operation of PNPS is not likely to adversely affect any listed species. The conditions of the draft permit are as stringent as or more stringent than the conditions evaluated in the 2012 consultation. In particular, the permit conditions that take effect upon termination of electrical generation at PNPS are substantially more stringent, and will result in fewer effects on listed species, than the conditions assessed during the 2012 consultation.

11.1 Listed Species in the Vicinity of the Federal Action

As the federal agency charged with authorizing the discharges from this facility, EPA has reviewed available habitat information developed by USFWS and NMFS (collectively, "the Services") to see if one or more of the federal endangered or threatened species of fish, wildlife, or plants may be present within the influence of the discharge. The following federally listed species may potentially inhabit (seasonally) Cape Cod Bay in the area of the facility discharge:

Common Name	Species Name	Status
Atlantic Sturgeon	*Acipenser oxyrinchus oxyrinchus*	Threatened
North Atlantic Right Whale	*Eubalaena glacialis*	Endangered
Humpback Whale	*Megaptera novaeangliae*	Endangered
Fin Whale	*Balaenoptera physalus*	Endangered
Kemp's Ridley Sea Turtle	*Lepidochelys kempii*	Endangered
Leatherback Sea Turtle	*Dermochelys coriacea*	Endangered
Loggerhead Sea Turtle	*Caretta caretta*	Threatened
Green Sea Turtle	*Chelonia mydas*	Threatened*

*Population of Green Sea Turtle present in action area listed as threatened. Breeding populations in Florida and Mexico's Pacific Coast listed as Endangered.

Atlantic Sturgeon

The Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) is a species of sturgeon distributed along the eastern coast of North America from Hamilton Inlet, Labrador, Canada to Cape Canaveral, Florida, USA. NMFS has delineated U.S. populations of Atlantic sturgeon into five distinct population segments (DPSs): the Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs. *See* 77 Fed. Reg. 5880 (Feb. 6, 2012); 77 Fed. Reg. 5914 (Feb. 6, 2012). NMFS has listed the Gulf of Maine DPS of Atlantic sturgeon as a threatened species and extended the prohibitions under section 9(a)(1) of the ESA to this DPS. *See* 78 Fed. Reg. 69,310 (Nov. 19, 2013). The primary factors responsible for the decline of the Gulf of Maine DPS include the destruction, modification, or curtailment of habitat due to poor water quality, dredging and the presence of dams; overutilization due to unintended catch of Atlantic sturgeon in fisheries; lack of regulatory mechanisms for protecting the fish; and other natural or manmade factors including loss of fish through vessel strikes. *See* 77 Fed. Reg. at 5905.

After emigration from the natal estuary, subadults and adults travel within the marine environment, typically in nearshore waters less than 50 meters in depth characterized by gravel and sand substrate, including Massachusetts Bay (Stein *et al.* 2004). According to the *Status Review of Atlantic Sturgeon*, Atlantic Sturgeon Status Review Team Report to National Marine Fisheries Service, Northeast Regional Office (Feb. 23, 2007 p. 61):

> Stein et al. (2004b) examined bycatch of Atlantic sturgeon using the NMFS sea sampling/observer 1989-2000 database. The bycatch study identified that the majority of recaptures occurred in five distinct coastal locations (Massachusetts Bay, Rhode Island, New Jersey, Delaware, and North Carolina) in isobaths ranging from 10 to 50 m, although sampling was not randomly distributed…Fisheries conducted within rivers and estuaries may intercept any life stage, while fisheries conducted in the nearshore and ocean may intercept migrating juveniles and adults.

Based on the Status Review document and the information summarized by NMFS in its 2012 consultation, subadult and adult Atlantic sturgeon may be present in nearshore habitat in Cape Cod Bay. As NMFS provides, the Kennebec and Hudson rivers are the closest rivers to Pilgrim in which Atlantic sturgeon are known to spawn. Given the distance from those rivers to Cape Cod Bay, early life stages (eggs, larvae, and juvenile) of Atlantic sturgeon are not likely to occur in the action area.

<u>North Atlantic Right Whale</u>

The Northern right whale (*Eubalaena glacialis*) was listed as endangered in 1970 prior to the passage of the ESA. In 2006, the North Atlantic, North Pacific, and southern right whale were listed as three separate endangered species under the ESA based on their unique lineages. *See* 71 Fed. Reg. 77,704 (Dec. 27, 2006); 73 Fed. Reg. 12,024 (Mar. 6, 2008). The North Atlantic right whale primarily occurs in coastal or shelf waters with calving and nursery areas off the Southeastern U.S. and summer feeding grounds extending from New England waters north to the Bay of Fundy and Scotian Shelf (NMFS 2005). The distribution of right whales seems linked to the distribution of their principal zooplankton prey, calanoid copepods (Baumgartner and Mate 2005; Waring et al. 2012). The largest threat to recovery of the population is ship collisions and entanglements. Other threats include habitat degradation, noise, contaminants, and climate and ecosystem change (NMFS 2005).

New England waters include important foraging habitat for right whales and individuals have been sighted off Massachusetts in most months (Watkins and Schevill 1982, Winn et al. 1986, Hamilton and Mayo 1990). Peak occurrence falls between February and May, particularly in Cape Cod and Massachusetts bays (Hamilton and Mayo 1990, Payne et al. 1990). In recent years, however, right whales have been sighted on Jeffreys and Cashes Ledges, Stellwagen Bank, and Jordan Basin during December to February (Khan et al. 2011 and 2012). On multiple days in December 2008, congregations of more than 40 individual right whales were observed in the Jordan Basin area of the Gulf of Maine, leading researchers to believe this may be a wintering ground (NOAA 2008). Calving is known to occur in the winter months in coastal waters off of Georgia and Florida (Kraus et al. 1986). Right whale sightings from May 1997 to the present have been mapped (http://www.nefsc.noaa.gov/psb/surveys/). Since the last consultation in May 2012, there have been multiple sightings of right whales in the action area (particularly spring of 2013 and 2015), including sighting of a mother and calf pair sighted near the northern embayment wall in January 2013 and south of the facility in April 2013. In addition, a large aggregation of North Atlantic right whales spotted in western Cape Cod Bay (near PNPS) in early April of 2013 prompted MassDMF to issue an advisory for vessel operators to proceed with caution when traveling in that area (Attachment C to this fact sheet, p.9).

Humpback whale

The Humpback Whale (*Megaptera novaeangliae*) has been listed as endangered under the ESA since its passage in 1973. Humpback whales inhabit all major ocean basins from the equator to subpolar latitudes. With the exception of the northern Indian Ocean population, they generally follow a predictable migratory pattern in both southern and northern hemispheres, feeding during the summer in the higher near-polar latitudes and migrating to lower latitudes in the winter where calving and breeding take place (Perry et al. 1999). During the summer months, humpback whales foraging in the Gulf of Maine visit Stellwagen Bank and the waters of Massachusetts and Cape Cod bays. Small numbers of individuals may be present in this area, including the waters of Stellwagen Bank, year-round. They feed on small schooling fishes, particularly sand lance and Atlantic herring, targeting fish schools and filtering large amounts of water for their associated prey. Humpback whales may also feed on euphausiids (krill) as well as on capelin (Waring et al. 2010; Stevick et al. 2006). In winter, whales from waters off New England, Canada, Greenland, Iceland, and Norway migrate to mate and calve primarily in the West Indies, where spatial and genetic mixing among these groups occurs (Waring et al. 2014). Acoustic recordings made on Stellwagen Bank National Marine Sanctuary in 2006 and 2008 detected humpback song in almost all months, including throughout the winter (Vu et al. 2012). Changes in humpback whale distribution in the Gulf of Maine have been found to be associated with changes in herring, mackerel, and sand lance abundance associated with local fishing pressures (Stevick et al. 2006; Waring et al. 2014). Shifts in relative finfish species abundance correspond to changes in observed humpback whale movements (Stevick et al. 2006). According NFMS, the majority of humpback whale sightings are in the eastern portion of Cape Cod Bay with few sightings in the action area.

As with other large whales, the major known sources of anthropogenic mortality and injury of humpback whales occur from fishing gear entanglements and ship strikes. Humpback whales, like other baleen whales, may also be adversely affected by habitat degradation, habitat exclusion, acoustic trauma, harassment, or reduction in prey resources resulting from a variety of activities including fisheries operations, vessel traffic, and coastal development.

Fin Whale

The fin whale (*Balaenoptera physalus*) has been listed as endangered under the ESA since its passage in 1973. The fin whale is widely distributed in the North Atlantic and occurs from the Gulf of Mexico and Mediterranean Sea northward to the edges of the Arctic ice pack (NMFS 2010). Off the eastern U.S., fin whales are centered along the 100 m isobaths but with sightings well spread out over shallower and deeper water, including submarine canyons along the shelf break (Kenney and Winn 1987; Hain et al. 1992). Hain et al. (1992) identified Jeffrey's Ledge as a primary feeding area. Fin whales prey on both pelagic crustaceans and schooling fish (NMFS 2010). The overall distribution may be based on prey availability, as this species preys opportunistically on both invertebrates and fish (Watkins et al. 1984).

Like right and humpback whales, fin whales are believed to use North Atlantic waters primarily for feeding, and more southern waters for calving. This species is commonly found from Cape Hatteras northward. During the 1978-1982 aerial surveys, fin whales accounted for 24% of all cetaceans and 46% of all large cetaceans sighted over the continental shelf between Cape Hatteras and Nova Scotia (Waring et al. 2014). Underwater listening systems have also demonstrated that the fin whale is the most acoustically common whale species heard in the North Atlantic (Clark 1995). The single most important area for this species appeared to be from the Great South Channel, along the 50 meter isobath past Cape Cod, over Stellwagen Bank, and past Cape Ann to Jeffreys Ledge (Hain et al.1992).

The major known sources of anthropogenic mortality and injury of fin whales include entanglement in commercial fishing gear and ship strikes. Pollutants do not appear to be a major direct threat to fin whale populations, although the loss of prey base due to pollution and climate change could potentially impact populations (NMFS 2010).

Sea Turtles

The Loggerhead Sea Turtle (*Caretta caretta*) was listed as endangered through its range on July 28, 1978. Loggerhead turtles inhabit the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans. Nesting occurs from Texas to Virginia; eggs and hatchlings are not likely to occur in the action area (NMFS and USFWS 2008). Post-hatchling loggerhead enter neritic waters along the continental shelf and before transitioning to the oceanic zone, where juveniles are found particularly around the Azores and Maderia in the North Atlantic (Bolten 2003). Following the oceanic stage, juvenile loggerheads transition to the neritic zone where they are common along the eastern U.S. seaboard in continental shelf waters from Cape Cod Bay, MA to the Gulf of Mexico feeding primarily on benthic invertebrates. Adult, non-nesting loggerheads prefer shallow water habitats and are common in large, open bays (e.g., Florida Bay and Chesapeake Bay) and offshore waters from New York through the Gulf of Mexico (Schroeder et al. 2003). Major threats to loggerhead turtles include commercial fishery bycatch, legal and illegal harvest, habitat degradation (especially of nesting beaches), and predation by native and exotic species (NMFS and USFWS 2008).

The Leatherback Sea Turtle (*Dermochelys coriacea*) has been listed as endangered through its range since the passage of the ESA in 1973. Adult leatherbacks are highly migratory and are believed to be the most pelagic of all sea turtles. There is little information about the habitat requirements and distribution of adult leatherbacks beyond limited knowledge of nesting beaches, including those in the Gulf of Mexico and U.S. Caribbean islands (e.g., the U.S. Virgin Islands and Puerto Rico) (NMFS and USFWS 1992). Eggs and hatchlings are not likely to occur in the action area. Periodic sightings of leatherbacks have occurred in New England waters, particularly around Cape Cod during summer months (NMFS and USFWS 1992). One study tracking the movements of leatherback turtles captured off the coast of Cape Cod indicated that several of the tagged individuals remained near the Northeast U.S. continental shelf (and in Massachusetts Bay) during summer and fall before migrating to tropical or sub-tropical habitat (Dodge et al. 2014).

The Green Sea Turtle (*Chelonia mydas*) was listed as endangered for coastal breeding colonies in Florida and Mexico's Pacific coast and threatened through the rest of its range in 1978. The green turtle occurs in tropical and sub-tropical waters worldwide; in Atlantic waters green turtles are found around the U.S. Virgin Islands, Puerto Rico, and the continental U.S. from Texas to Massachusetts. Primary nesting beaches occur in east central and southeast Florida, and in smaller numbers in Puerto Rico and the U.S. Virgin Islands. Eggs and hatchlings are not likely to occur in the action area. After transitioning from pelagic habitat to shallow, benthic feeding grounds, herbivorous juvenile and adult green turtles forage in pastures of seagrasses and/or algae but can also be found over coral reefs, warm reefs, and rocky bottoms (NMFS and USFWS 1991). Primary threats include degradation of nesting habitat, dredging and coastal development, pollution, seagrass bed degradation, entanglement in commercial fishing gear, and fishery bycatch (NMFS and USFWS 1991).

The Kemp's Ridley Sea Turtle (*Lepidochelys kempii*) has been listed as endangered through its range since the passage of the ESA in 1973. The species has a relatively limited distribution with nesting beaches primarily located in the western Gulf of Mexico; eggs and hatchlings are not likely to occur in the action area. Once hatchlings emerge, they swim offshore into deeper waters where some juveniles may be transported to the Northwest Atlantic by the Gulf Stream (NMFS et al. 2011). Juveniles in the Northwest Atlantic transition into shallow coastal habitats (including bays and sounds) extending from Florida to New England (Morreale et al. 2007). Both adult and juvenile Kemp's ridley turtle may use New England waters from June through October as seasonal feeding grounds with crabs as its primary prey (NFMS et al. 2011). Migration from coastal foraging areas to overwintering sites is likely triggered by temperature declines. By late fall, most are found south of Chesapeake Bay towards North Carolina (NMFS et al. 2011). Major threats to the recovery of the Kemp's Ridley sea turtle include the degradation of nesting habitat and commercial fishery bycatch (NMFS et al. 2011).

<u>Northern Right Whale Critical Habitat</u>

Critical habitat for right whales was initially designated for most of Cape Cod Bay (CCB), Great South Channel (GSC), and coastal Florida and Georgia (outside of the action area). The habitat features identified in this designation include copepods (prey), and oceanographic conditions created by a combination of temperature and depth that are conducive for foraging, calving and nursing. *See* 59 Fed. Reg. 28,805 (June 3, 1994). In its 2012 ESA Consultation, NMFS determined that, within critical habitat, the thermal plume is no longer detectable and that any pollutants discharged from PNPS would be fully mixed and no longer detectable from background levels. Therefore, there would be no direct effects to critical habitat. See 2012 ESA Consultation letter, 30.

The NMFS has recently replaced the 1994 critical habitat designation for the population of right whales in the North Atlantic. *See* 81 Fed. Reg. 4,838 (Jan. 27, 2016) The critical habitat, which contains physical and biological features of foraging habitat that are essential to the conservation of the North Atlantic right whale, encompasses a large area within the Gulf of Maine and Georges Bank region, including Cape Cod Bay and Massachusetts Bay and deep underwater basins (Wilkinson, Georges, and Jordan Basins). The area incorporates state waters and "includes the large embayments of Cape Cod Bay and Massachusetts Bay but does not include inshore areas, bays, harbors, and inlets." 81 Fed. Reg. 4,862. The newly expanded designated critical habitat does not include the inshore location of PNPS' CWIS and outfalls, due to the absence or rarity of foraging right whales and the likelihood that dense aggregations of preferred prey are not present in these areas, even as NMFS recognizes that there has been an increase in the concentration of right whales in Western Cape Cod Bay in recent years. NMFS received a comment requesting special management considerations of impacts associated with coastally-located industrial electric generators (including PNPS) during the comment period for the proposed critical habitat. NMFS responded that, while some copepods are likely lost to entrainment at PNPS, "the essential feature of dense aggregations of late stage *C. finmarchicus* does not require special management considerations or protection due to entrainment by the PNPS…" 81 Fed Reg. 4,855-56. EPA has considered direct and indirect effects to North Atlantic right whales below.

11.2 Effect of the Federal Action on Listed Species

Effects of this action on listed species of whales and turtles and their critical habitat primarily include impingement and entrainment of potential prey and effects to habitat, including the discharge of heated effluent. Effects of this action on Atlantic sturgeon include impingement, the discharge of heated effluent, and may also include direct impacts of the discharge of pollutants from PNPS. To date there has been no reported take of Atlantic sturgeon or sea turtles from impingement at PNPS.

11.2.1 Heated Thermal Discharge

EPA characterizes the potential impacts of the heated effluent discharged from PNPS in detail in Attachments B ("Outline of §316(a) Determination Decision Criteria") and C ("MassDEP Assessment of Impacts to Marine Organisms from the Pilgrim Nuclear Thermal Discharge and Thermal Backwash"). Based on this analysis, EPA determined that the temperature limits in the current permit are protective of the balanced, indigenous population and has granted PNPS a variance from technology- and water quality-based temperature limits. Under the draft permit, PNPS may discharge up to 447 MGD of non-contact condenser cooling water heated to a maximum daily temperature of 102°F and a maximum rise in temperature of 32°F from Outfall 001 to Cape Cod Bay. The draft permit also authorizes the discharge of heated backwash water from Outfall 002 to the intake bay and out to the embayment. Thermal backwashes are intermittent.

Attachment C to this Fact Sheet characterizes the thermal plume, which changes throughout the tidal cycle and with ambient temperature. The analysis provided in Attachment C is consistent with the evaluation of the thermal plume in the 2012 ESA Consultation Letter (p. 17). At high tide, the plume is confined to the surface layer (to a depth ranging from 3 to 8 feet below the surface) and spreads from the point of release. Studies on the shape and dimensions of the plume suggest that, under worst case conditions, the area where water temperatures are at least 1°C (1.8°F) above ambient could extend to 3,000 acres, or about 0.8% of the surface area of Cape Cod Bay. In November, when ambient temperatures are cooler, the extent of the plume at temperatures at least 3°C (5.4°F) above ambient is 56 acres; the plume extends to 138 acres in July when ambient temperatures are higher.

At low tide, elevated temperatures are present near the discharge canal and the plume contacts the bottom. The maximum areal extent of the plume at temperatures greater than 1°C (1.8°F) above ambient is 1.2 acres. The maximum linear extent of the 1°C isotherm in contact with the bottom is about 170 m (560 ft) and the bottom area with the maximum recorded rise in temperature (9°C or 16.2°F) was limited to less than 0.13 acres.

EPA concludes that the thermal plume from PNPS is relatively small compared to the receiving water and dissipates rapidly. It is predominantly a surface plume that moves with the tides and the wind. Minor impacts to the macroalgal community have been documented that can be attributed to the thermal plume, but this area is only roughly one acre in size. Thus, from a retrospective analysis, the past forty (40) years of operation of PNPS—during which the thermal component of the discharge has remained the same—has been protective of the balanced indigenous population of fish, shellfish and wildlife, including species listed under the ESA, in the context of § 316(a).

In addition, NMFS, in its 2012 ESA Consultation for the relicensing of PNPS, likewise concluded that, even during the warmest months of the year, the surface and bottom area of the plume is small and that threatened and endangered species of whales are expected to be able to swim around or under the plume throughout the year. As a result, any avoidance of the relatively small plume would not result in the disruption or delay in any essential behaviors that these species may be carrying out in the action area, including foraging, migrating, or resting. *See* 2012 ESA Consultation letter, 18-19. The dimensions of the plume do not extend into designated critical habitat for North Atlantic right whale, therefore, there will be no direct effects to critical habitat. Similarly, threatened and endangered species of sea turtles present in the action area would also be able to avoid the plume by swimming around or under it and the plume will not disrupt or delay any essential behaviors, including foraging, migrating, or resting. NMFS also considered the potential for the risk of cold-stunning of sea turtles, in which turtles attracted by the plume remain in the action area so long that they risk becoming incapacitated when the contact colder ambient temperatures outside the plume. *Id*. at 20. NMFS concluded that the thermal plume is limited sufficiently spatially and temporally that it is extremely unlikely that sea turtles would seek out and use the plume as refuge from falling temperatures such that it would increase vulnerability to cold stunning. *Id*.

NMFS also considered if the thermal plume would be likely to affect Atlantic sturgeon in the action area. At high tide, when the thermal plume is confined to the surface, the normal behavior of Atlantic sturgeon as benthic-oriented fish is likely to limit exposure to the plume and fish that may be near the surface are likely to be able to avoid the relatively small area where ambient temperature are warmest (11.25 acres). At low tide, Atlantic sturgeon are likely to be able to avoid bottom waters with elevated temperatures by swimming around it. NMFS also determined that it is extremely unlikely that Atlantic sturgeon would be exposed to temperatures that could result in mortality (33.7°C or greater) because fish would exhibit avoidance behavior at temperatures of 28°C and would avoid the small area where temperatures are greater than tolerable. NMFS concluded that there would be no avoidance-related effects to Atlantic sturgeon from the thermal plume, and that it is unlikely that the thermal plume would preclude any essential behaviors of Atlantic sturgeon present in the action area, including foraging, migrating, and resting or that the fitness of any individual will be affected. *See* 2012 ESA Consultation letter, 21-22.

Finally, NMFS considered any impacts to listed species as a result of the effect of the thermal plume on the preferred prey species of threatened and endangered species. NMFS concluded that benthic invertebrates, the preferred prey of sea turtles and Atlantic sturgeon, would be displaced from a small area and would likely be able to avoid temperatures that would result in injury or mortality. Effects to foraging sea turtles and Atlantic sturgeon would be insignificant and limited to the distribution of prey away from the thermal plume. *See* 2012 ESA Consultation letter, 23. Similarly, prey species for humpback and fin whales, including Atlantic herring, sand lance, Pollock, and mackerel, would be displaced from a small area and would not be injured or killed due to exposure to intolerable temperatures. As a result, effects to foraging humpback and fin whales would be insignificant and limited to the distribution of prey away from the thermal plume. *Id*. Finally, NMFS concluded that copepods, the preferred prey of North Atlantic right whales, would be able to avoid the small area in which temperatures would be intolerable, rather than be injured or killed and, as a result, effects to foraging right whales would be extremely unlikely. *Id*. at 24. Similarly, effects to designated critical habitat for North Atlantic right whales resulting from thermal effects on prey species are also extremely unlikely.

Based on the detailed analysis in the 2012 ESA consultation, NMFS concludes that the thermal plume is not likely to adversely impact threatened and endangered species in the action area. The temperature limits in the draft permit that apply during the period when PNPS will generate electricity are consistent with the conditions evaluated in the 2012 ESA consultation. EPA agrees that, under these conditions, the thermal plume is not likely to adversely impact threatened and endangered species in the action area.

Based on Entergy's proposal to terminate the generation of electricity at PNPS by June 1, 2019, the draft permit requires the permittee to cease discharging non-contact cooling water for the main condenser by this date. Elimination of this discharge will effectively eliminate the primary source of heated effluent from the facility. Without the need for condenser cooling water, both the maximum temperature and rise in temperature will be substantially reduced. The draft permit authorizes the discharge of up to 224 MGD (at an average monthly volume of 11.2 MGD) of cooling water to support decommissioning activities at a maximum temperature of 85°F, a monthly average temperature of 80°F, and a maximum rise in temperature of 3°F upon terminating electrical generation at PNPS. The maximum daily temperature of 85°F and monthly average temperature of 80°F are consistent with the water quality standards for Class SA waters at 314 CMR 4.05(4)(a)(2)(a). Based on the 2012 ESA Consultation and information reviewed and assessed in development of the draft permit, the effects of heated effluent from the continued operation of PNPS at the current temperature on listed species are likely to be insignificant. The substantial reduction in both maximum daily temperature and rise in temperature as a result of terminating electrical generation will further reduce any potential impacts to listed species from the discharge of heated effluent.

11.2.2 Operation of a Cooling Water Intake Structure

EPA characterizes the potential impacts of entrainment and impingement mortality from PNPS' CWIS in detail in Attachment D, Section 3.0 ("Biological Impact of Cooling Water Intake Structures"). Based on sampling conducted by the facility since 1980, EPA estimates that, on average, PNPS entrains about 2.8 billion eggs and 354 million larvae annually, and impinges about 42,800 fish annually. According to NMFS, because early life stages of listed species are either not present or too large to be entrained, and sub-adult and adults are likely strong enough swimmers to avoid becoming impinged, impingement or entrainment of any whales, sea turtles, or Atlantic sturgeon is extremely unlikely to occur. *See* 2012 NMFS ESA Consultation letter, 7-9. In 40 years of biological monitoring, PNPS has not observed the impingement or entrainment of any listed species. Any potential impacts to ESA listed species would be indirect, resulting from the impingement and entrainment of prey species.

In its 2012 ESA consultation with NRC, NMFS assessed the potential impacts of impingement and entrainment of prey on listed species as a result of the continued operation of PNPS. At the current levels of cooling water withdrawal and intake velocity, NMFS expects that reductions in prey on listed species as a result of PNPS' CWIS will be insignificant. Specifically, NMFS found that, while entrainment likely results in the loss of some copepods that would otherwise be available as forage for right whales, the reduction would be undetectable from natural variability and any effects to foraging right whales insignificant. *See* 2012 ESA Consultation letter, 12. Similarly, effects to designated critical habitat for North Atlantic right whales resulting from loss of prey are also insignificant. NMFS also expects that the effect of impingement and entrainment losses of Atlantic mackerel, Atlantic herring, and sand lance on foraging whales would be insignificant. *Id*. at 13. Finally, NMFS expects that the effects of the loss of benthic invertebrates as available forage for sea turtles and Atlantic sturgeon would be insignificant. *Id*. at 15. EPA is aware of no new information since 2012 that would alter these conclusions.

Based on Entergy's proposal to terminate the generation of electricity at PNPS by June 1, 2019, the draft permit requires the permittee to cease seawater withdrawals for the main condenser by this date. Elimination of seawater withdrawals for electrical generation will result in an average flow reduction of 96% beginning no later than June 1, 2019. By eliminating seawater withdrawals for the main condenser, PNPS will achieve an actual through-screen intake velocity of no more than 0.5 fps. This lower intake velocity would be even more protective by ensuring that listed species are not impinged and by allowing most prey species to avoid impingement. Together, EPA has determined that a 96% reduction in flow and 0.5 fps actual through-screen velocity are the "best technology available" to minimize the adverse environmental impacts from impingement and entrainment. This determination is explained in more detail in Sections 6.0 and 7.0 of Attachment D ("Assessment of Cooling Water Intake Structure Technologies and Determination of Best Technology Available Under CWA § 316(b)").

The draft permit requires a 96% reduction in cooling water withdrawals from Cape Cod Bay and prohibits cooling water withdrawals for the main condenser effective upon terminating electrical generation at the plant and no later the June 1, 2019. This reduction in cooling water will effectively reduce entrainment by 96%. In addition, the draft permit requires PNPS to achieve a through-screen velocity no greater than 0.5 fps at the traveling screens. Based on the 2012 ESA Consultation and information reviewed and assessed in development of the draft permit, the effects of the continued operation of PNPS at the current levels of seawater withdrawal and intake velocity on listed species are likely to be insignificant. The substantial reduction in both cooling water withdrawals and intake velocity as a result of terminating electrical generation will further reduce any potential impacts to listed species from entrainment and impingement.

11.3 Finding

It is EPA's opinion that the operation of this facility, as governed by this permit action, is not likely to adversely affect the listed species or any of their critical habitat occurring in the vicinity of the receiving water for the reasons discussed in the Attachments B, C, and D and the 2012 ESA Consultation letter and as summarized above.

Based on the analysis of potential impacts presented here, impacts to listed species from the withdrawal and discharge of cooling, process, and storm water at PNPS will be insignificant or discountable. EPA has made the preliminary determination that the renewal of the PNPS permit may affect, but is not likely to adversely affect, any species listed as threatened or endangered by NMFS or any designated critical habitat. This finding is consistent with the conclusion NMFS reached in 2012 during consultation with the NRC for relicensing PNPS. Because the draft permit includes effluent limitations and conditions that are as stringent as or more stringent than the conditions assessed in the 2102 consultation, the effects of the draft permit on threatened and endangered species and critical habitat, as described above, have already been considered and EPA has determined that re-initiation of consultation is not necessary at this time. EPA is seeking concurrence from NMFS regarding this determination through the information presented in this fact sheet.

Re-initiation of consultation will take place: (a) if new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered in the consultation; (b) if the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the consultation; or (c) if a new species is listed or critical habitat is designated that may be affected by the identified action.

During the public comment period, EPA has provided a copy of the draft permit and fact sheet to both NMFS and USFWS.

12.0 ESSENTIAL FISH HABITAT (EFH) ASSESSMENT

Pursuant to section 305(b)(2) of the 1996 Amendments, PL 104-297, to the Magnuson-Stevens Fishery Conservation and Management Act, 16 U.S.C. § 1801 et seq. (1998), EPA is required to consult with the National Marine Fisheries Services (NMFS) if EPA's action or proposed actions that it funds, permits, or undertakes, may adversely affect "essential fish habitat," *see also id.* § 1855(b)(2); 50 C.F.R. § 600.920(a)(1), which is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity," 16 U.S.C. § 1802 (10). "Adverse effect means any impact that reduces quality and/or quantity of EFH." 50 C.F.R. § 600.910(a). Adverse effects may include direct (e.g., contamination or physical disruption), indirect (e.g., loss of prey, reduction in species' fecundity), site-specific, or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions. *Id.*

EFH is only designated for species for which federal fisheries management plans exist. 16 U.S.C. § 1855(b)(1)(A). EFH designations for New England were approved by the U.S. Department of Commerce on March 3, 1999. The following is a list of the EFH species and applicable life stage(s) for Cape Cod Bay including waters from Plymouth Harbor south to Lookout Point in Plymouth, MA:

Species	Eggs	Larvae	Juveniles	Adults
Atlantic cod *(Gadus morhua)*	X	X	X	X
haddock *(Melanogrammus aeglefinus)*	X	X		
pollock *(Pollachius virens)*		X	X	X
whiting *(Merluccius bilinearis)*	X	X	X	X
offshore hake *(Merluccius albidus)*				
red hake *(Urophycis chuss)*	X	X	X	X
white hake *(Urophycis tenuis)*	X	X	X	X
redfish *(Sebastes fasciatus)*	n/a			
witch flounder *(Glyptocephalus cynoglossus)*				
winter flounder *(Pseudopleuronectes americanus)*	X	X	X	X
yellowtail flounder *(Limanda ferruginea)*	X	X	X	X
windowpane flounder *(Scophthalmus aquosus)*	X	X	X	X
American plaice *(Hippoglossoides platessoides)*	X	X	X	X
ocean pout *(Macrozoarces americanus)*	X	X	X	X

Atlantic halibut *(Hippoglossus hippoglossus)*	X	X	X	X
Atlantic sea scallop *(Placopecten magellanicus)*	X	X	X	X
Atlantic sea herring *(Clupea harengus)*	X	X	X	X
monkfish *(Lophius americanus)*	X	X		
bluefish *(Pomatomus saltatrix)*			X	X
long finned squid *(Loligo pealeii)*	n/a	n/a	X	X
short finned squid *(Illex illecebrosus)*	n/a	n/a	X	X
Atlantic butterfish *(Peprilus triacanthus)*	X	X	X	X
Atlantic mackerel *(Scomber scombrus)*	X	X	X	X
summer flounder *(Paralichthys dentatus)*				X
scup *(Stenotomus chrysops)*	n/a	n/a	X	X
black sea bass *(Centropristis striata)*	n/a			
surf clam *(Spisula solidissima)*	n/a	n/a	X	X
ocean quahog *(Artica islandica)*	n/a	n/a		
spiny dogfish *(Squalus acanthias)*	n/a	n/a	X	
tilefish *(Lopholatilus chamaeleonticeps)*				
bluefin tuna *(Thunnus thynnus)*			X	X

12.1 Description of Federal Action

As described in this fact sheet, EPA is proposing to reissue the NPDES permit for PNPS authorizing the withdrawal of once-through cooling water and the discharge of process water and stormwater through multiple outfalls. PNPS currently operates a single reactor unit with a boiling water reactor and turbine generator. Seawater is withdrawn from Cape Cod Bay through an intake embayment formed by two breakwaters. Seawater, primarily used for condenser cooling water, is pumped from the cooling water intake structure (CWIS) by two circulating water pumps and five salt service water pumps at a maximum volume of 467 MGD. Once-through condenser cooling water (Outfall 001) is combined with plant service cooling water (Outfall 010) and discharged to Cape Cod Bay via the discharge canal. In addition, PNPS discharges effluent for thermal backwash, intake screen wash water, neutralizing sump waste commingled with demineralizer reject water, station heating water, and stormwater, through various outfalls on an intermittent basis. A more detailed description of each of these waste streams and outfalls is provided in Section 2.0 of this fact sheet.

On October 13, 2015, Entergy announced that PNPS will cease generation of electricity at the facility no later than June 1, 2019. EPA expects that operation of the facility to support electrical generation will continue until May 31, 2019. Beginning June 1, 2019, seawater withdrawal and effluent discharge will be dramatically altered as a function of entering the decommissioning phase. To the best of its ability based on available information, EPA has taken this into account and has tailored the permit to reflect post-shutdown operations and discharges as appropriate. However, since the permittee cannot fully anticipate all changes in permitted flows that will take place post-shutdown, this permit may be modified post-shutdown if warranted by any new or increased discharges.

The draft permit establishes technology- and water quality-based effluent limitations and conditions designed to ensure the protection of designated uses of Cape Cod Bay, including as an excellent habitat for fish, other aquatic life and wildlife, including for their reproduction, migration, growth and other critical functions consistent with the Massachusetts surface water quality standards at 314 CMR 4.05(4)(a).

12.2 Analysis of Potential Effects on EFH

The primary effects of PNPS on EFH and the managed species are related to the discharge of heated water, and the impacts of entrainment and impingement associated with the CWIS, either directly or indirectly (e.g., entrainment of prey species).

12.2.1 Impacts from Seawater Withdrawals at the CWIS

EPA characterized the potential impacts of entrainment and impingement mortality from PNPS' CWIS in detail in Attachment D, Section 3.0 ("Biological Impact of Cooling Water Intake Structures"). EPA briefly summarizes the impacts here. Based on sampling conducted by the facility since 1980, EPA estimates that, on average, PNPS entrains about 2.8 billion eggs and 354 million larvae annually, and impinges about 42,800 fish annually. PNPS has reported entrainment of early life stages of 17 EFH species and impingement of 20 EFH species. Additionally, entrainment likely impacts an unknown number of phytoplankton and zooplankton, as well as tens of thousands of macroinvertebrates (e.g., worms, shrimp, and crabs) that may be important prey for EFH species.

PNPS calculated equivalent adults for a subset of species using species- and life-stage specific survival rates from the scientific literature and the number of eggs and larvae entrained. Not all EFH species were included in this analysis because the species- and life-stage survival data are not available for every species. For those EFH species for which adequate data are available, the permittee estimates that entrainment likely results in the average annual loss of more than 17,000 age-3 winter flounder, 12,800 age-1 Atlantic herring, 1,800 age-2 Atlantic cod, and 1,400 age-3 Atlantic mackerel. Cumulatively over the life of the facility, impingement and entrainment at PNPS have likely resulted in the loss of millions of adult fish designated as EFH species.

Based on Entergy's proposal to terminate the generation of electricity at PNPS by June 1, 2019, the draft permit requires the permittee to cease seawater withdrawals for the main condenser by this date. Elimination of seawater withdrawals for electrical generation will result in an average flow reduction of 96% beginning no later than June 1, 2019. By eliminating seawater withdrawals for the main condenser, PNPS will achieve an actual through-screen intake velocity of no more than 0.5 fps. Together, EPA has determined that a 96% reduction in flow and 0.5 fps actual through-screen velocity are the "best technology available" to minimize the adverse environmental impacts from impingement and entrainment. This determination is explained in more detail in Sections 6.0 and 7.0 of Attachment D ("Assessment of Cooling Water Intake Structure Technologies and Determination of Best Technology Available Under CWA § 316(b)"). EPA believes that this flow reduction will effectively minimize any potential impacts from impingement and entrainment on species with designated EFH in Cape Cod Bay.

12.2.2 Impacts from Effluent Discharges

Discharge of heated effluent can have both lethal and sublethal effects on organisms in the vicinity of the thermal plume. Lethal thermal shock is most likely to occur closest to the discharge source. Sublethal effects may include reduced egg hatching success, larval developmental inhibition, or a change in the composition of the biotic community. Environmental responses to thermal effluent include avoidance of biota, scouring of vegetation and, in some cases, attraction to the thermal plume is possible.

The draft permit includes a maximum effluent temperature limit of 102°F and maximum rise in temperature of 32°F at Outfall 001 (heated non-contact cooling water from the main condenser), which is consistent with the limits in the current permit. The company's thermal discharge and its effects on ocean temperatures were modeled by Pagenkopf and others from MIT (Pagenkopf, *et al*., 1974; 1976). Field characterizations of the plume were also conducted by MIT in the early 1970's in part to validate the model. Additional field studies to characterize ocean-bottom plume dimensions were conducted by EG&G (1995). A detailed description of the thermal plume and its effects on aquatic organisms, including species for which EFH has been designated, are provided in Attachments B and C of this fact sheet.

The PNPS thermal discharge is released to Cape Cod Bay. The near-field shape of the plume and its degree of contact with the bottom are constantly changing throughout the tidal cycle. At stages near low-tide, the plume has its greatest effect on the bottom, but due to the slope of the bottom adjacent to the facility, the large tidal range (about 10'), and other variables, the most extensive measured plume effects (heat and velocity) to the bottom have been limited to about an acre or less, although, in theory, plume effects to the bottom could be greater. Due to its buoyancy, the bulk of the plume rises to the surface and its horizontal spread increases with distance from the point of release. In tidal periods around and including low tide, the plume can interact directly with the bottom to a distance of about 700 ft. (but changes with the degree of tidal fluctuation which varies over the course of each month and seasonally). As the tide progresses from low to high and the height of the water column increases, the plume lifts from the bottom but spreads to a much greater extent in the far-field. Because the shape of the plume is constantly changing throughout the day, from day to day and throughout the seasons, there is little consistency to the location of the impact of the far-field plume on water temperatures. Far-field delta temperatures of 1°C from background are typically found in only the top 3-8 feet of the water column. Heat in the plume is extracted both by surrounding water and by the atmosphere. The rate of release of plume heat to the atmosphere is greatly affected by wind velocity, the difference between ambient air temperature and water temperature, humidity, tidal stage (which affects the horizontal and vertical shape of the plume) and other factors.

EPA and MassDEP have concluded that the current permit limits will assure the protection and propagation of the balanced, indigenous population and that there are likely to be no adverse effects from the thermal plume on benthic flora, benthic fauna, and pelagic fish, including species for which EFH has been designated. See Section 7 and Attachments B and C of this fact sheet for further discussion of the potential impacts of the thermal plume. Moreover, upon termination of the generation of electricity at PNPS (no later than June 1, 2019), PNPS will no longer discharge non-contact cooling water from the main condenser after terminating electrical generation which will eliminate the primary source of heated effluent to Cape Cod Bay. As a result, PNPS will be able to meet more stringent temperature limits no later than June 1, 2019.

12.3 Conclusion

EPA has concluded that the limits and conditions in the draft permit minimize adverse effects to EFH for the following reasons:

- All permitted limits in the draft permit are as stringent as or more stringent than those in the current permit and consistent with Massachusetts surface water quality standards for the protection of fish and fish habitat.

- The draft permit prohibits the discharge of pollutants or combination of pollutants in toxic amounts.

- The draft permit includes numeric limitations for pH, oil and grease, total residual oxidants, tolyltriazole, sodium nitrate, and total suspended solids that are protective of state water quality standards.

- The thermal plume from PNPS is relatively small compared to the receiving water and dissipates rapidly. Over 40 years of biological monitoring data demonstrate that the variance-based limits will assure the protection and propagation of a balanced, indigenous community of shellfish, fish and wildlife.

- Following termination of electrical generation at PNPS, the facility will cease discharges of non-contact cooling water from the main condenser, which will drastically reduce the maximum effluent temperature and rise in temperature compared to the existing conditions.

- The draft permit establishes requirements related to the CWIS that reduce cooling water withdrawals from Cape Cod Bay by 96%, prohibit cooling water withdrawals for the main condenser, and require the facility to achieve a through-screen velocity no greater than 0.5 fps. These conditions become effective upon terminating electrical generation at the plant and no later the June 1, 2019 and are expected to reduce impingement and entrainment of all aquatic life by 96%. These conditions will also significantly reduce the temperature differential and extent of the thermal plume.

- To reduce impingement mortality, the draft permit requires PNPS to continuously rotate the traveling screens in the interim period from the effective date of the permit until termination of electrical generation.

It is the opinion of EPA that the conditions and limitations contained in the draft permit will adequately protect all aquatic life, including those with designated EFH in Cape Cod Bay, and that further mitigation is not warranted. If adverse impacts to EFH are detected as a result of this permit action, or if new information is received that changes the basis for our conclusion, NMFS will be notified and an EFH consultation will be initiated. NMFS has been notified of the permit action and has been provided with copies of the draft permit and fact sheet during the public comment period.

13.0 MONITORING AND REPORTING

The effluent monitoring requirements have been established to yield data representative of the discharge under authority of Section 308 (a) of the CWA in accordance with 40 C.F.R. §§ 122.41(j), 122.44 (*l*), 122.48.

The draft permit requires the permittee to report monitoring results obtained during each calendar month in the Discharge Monitoring Reports (DMRs) no later than the 15th day of the month following the completed reporting period.

The draft permit includes new provisions related to electronic DMR submittals to EPA and MassDEP. The draft permit requires that, no later than three (3) months after the effective date of the permit, the permittee submit all DMRs to EPA using NetDMR, unless the permittee is able to demonstrate a reasonable basis, such as technical or administrative infeasibility, that precludes the use of NetDMR for submitting DMRs and reports ("opt-out request").

In the interim (until three months from the effective date of the permit), the permittee may either submit monitoring data to EPA in hard copy form, or report electronically using NetDMR.

NetDMR is a national web-based tool for regulated Clean Water Act permittees to submit DMRs electronically via a secure Internet application to U.S. EPA through the Environmental Information Exchange Network. NetDMR allows participants to discontinue mailing in hard copy forms under 40 C.F.R. § 122.41 and § 403.12. NetDMR is accessed from the following url: http://www.epa.gov/netdmr. Further information about NetDMR can be found on the EPA Region 1 NetDMR website located at http://www.epa.gov/region1/npdes/netdmr/index.html.

EPA currently conducts free training on the use of NetDMR, and anticipates that the availability of this training will continue to assist permittees with the transition to use of NetDMR. To learn more about upcoming trainings, please visit the EPA Region 1 NetDMR website http://www.epa.gov/region1/npdes/netdmr/index.html.

The draft permit also includes an "opt-out" request process. Permittees who believe they cannot use NetDMR due to technical or administrative infeasibilities, or other logical reasons, must demonstrate the reasonable basis that precludes the use of NetDMR. These permittees must submit the justification, in writing, to EPA at least sixty (60) days prior to the date the facility would otherwise be required to begin using NetDMR. Opt-outs become effective upon the date of written approval by EPA and are valid for twelve (12) months from the date of EPA approval. The opt-outs expire at the end of this twelve (12) month period. Upon expiration, the permittee must submit DMRs to EPA using NetDMR, unless the permittee submits a renewed opt-out request sixty (60) days prior to expiration of its opt-out, and such a request is approved by EPA.

In most cases, reports required under the permit shall be submitted to EPA as an electronic attachment through NetDMR, subject to the same three (3) month time frame and opt-out provisions as identified for NetDMR. Certain exceptions are provided in the permit such as for the submittal of pre-treatment reports and for providing written notifications required under the Part II Standard Permit Conditions. Once a permittee begins submitting reports to EPA using NetDMR, it will no longer be required to submit hard copies of DMRs or other reports to EPA and will no longer be required to submit hard copies of DMRs to MassDEP. However, permittees must continue to send hard copies of reports other than DMRs to MassDEP until further notice from MassDEP.

Until electronic reporting using NetDMR begins, or for those permittees that receive written approval from EPA to continue to submit hard copies of DMRs, the draft permit requires that submittal of DMRs and other reports required by the permit continue in hard copy format. Hard copies of DMRs must be postmarked no later than the 15th day of the month following the completed reporting period.

14.0 State Certification Requirements

EPA may not issue a permit unless the Massachusetts Department of Environmental Protection (MassDEP) certifies that the effluent limitations included in the permit are stringent enough to assure that the discharge will not cause the receiving water to violate the Massachusetts Surface Water Quality Standards. The MassDEP has reviewed the draft permit and advised EPA that the limitations are adequate to protect water quality. EPA has requested permit certification by the State pursuant to 40 C.F.R. § 124.53 and expects the draft permit will be certified.

15.0 Public Comment Period, Public Hearing, and Procedures for Final Decision

All persons, including applicants, who believe any condition of the draft permit is inappropriate must raise all issues and submit all available arguments and all supporting material for their arguments in full by the close of the public comment period, to George Papadopoulos, U.S. EPA, Office of Ecosystem Protection, Industrial Permits Section, Mailcode OEP 06-1, 5 Post Office Square, Suite 100, Boston, Massachusetts 02109-3912.

Prior to such date, any person may submit a written request for a public hearing to consider the draft permit to EPA and the State Agency. Such requests shall state the nature of the issues proposed to be raised in the hearing. EPA will consider any request for a hearing and may decide to hold a public hearing if the criteria stated in 40 C.F.R. § 124.12 are satisfied. In reaching a final decision on the draft permit, the EPA will respond to all significant comments and make these responses available to the public at EPA's Boston office.

Following the close of the comment period and any public hearings that may be held, the EPA will issue a Final Permit decision and forward a copy of the final decision, including responses to any significant comments, to the applicant and each person who has submitted written comments or requested notice. Within 30 days following the notice of the Final Permit decision, any interested person may submit a petition for review of the permit to EPA's Environmental Appeals Board consistent with 40 C.F.R. § 124.19.

16.0 EPA & MASSDEP CONTACTS

Additional information concerning the draft permit may be obtained between the hours of 9:00 a.m. and 5:00 p.m., Monday through Friday, excluding holidays, from the EPA and MassDEP contacts below:

George Papadopoulos, Industrial Permits Section
5 Post Office Square - Suite 100 - Mailcode OEP 06-1
Boston, MA 02109-3912
Telephone: (617) 918-1579 FAX: (617) 918-0579

Cathy Vakalopoulos, Massachusetts Department of Environmental Protection
Bureau of Water Resources
1 Winter Street, Boston, Massachusetts 02108
catherine.vakalopoulos@state.ma.us
Telephone: (617) 348-4026; FAX: (617) 292-5696

May 18, 2016	Ken Moraff, Director
Date	Office of Ecosystem Protection
	U.S. Environmental Protection Agency

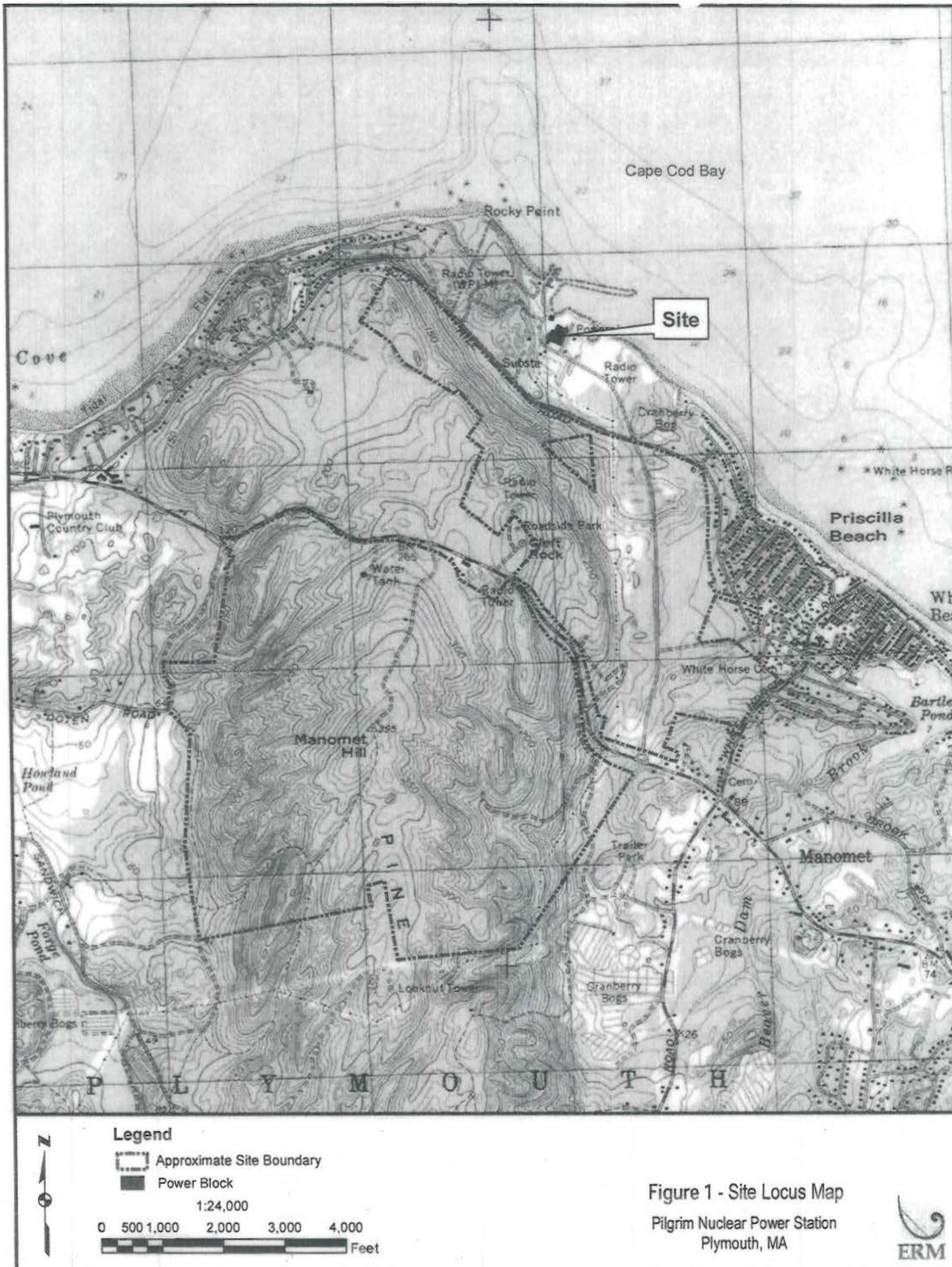

Figure 1 - Site Locus Map

Pilgrim Nuclear Power Station
Plymouth, MA

ERM

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Figure 2 – Regional Site Locus Map

Map of Massachusetts Bay, showing location of Pilgrim Nuclear Power Station (PNPS) on the western side of Cape Cod Bay.

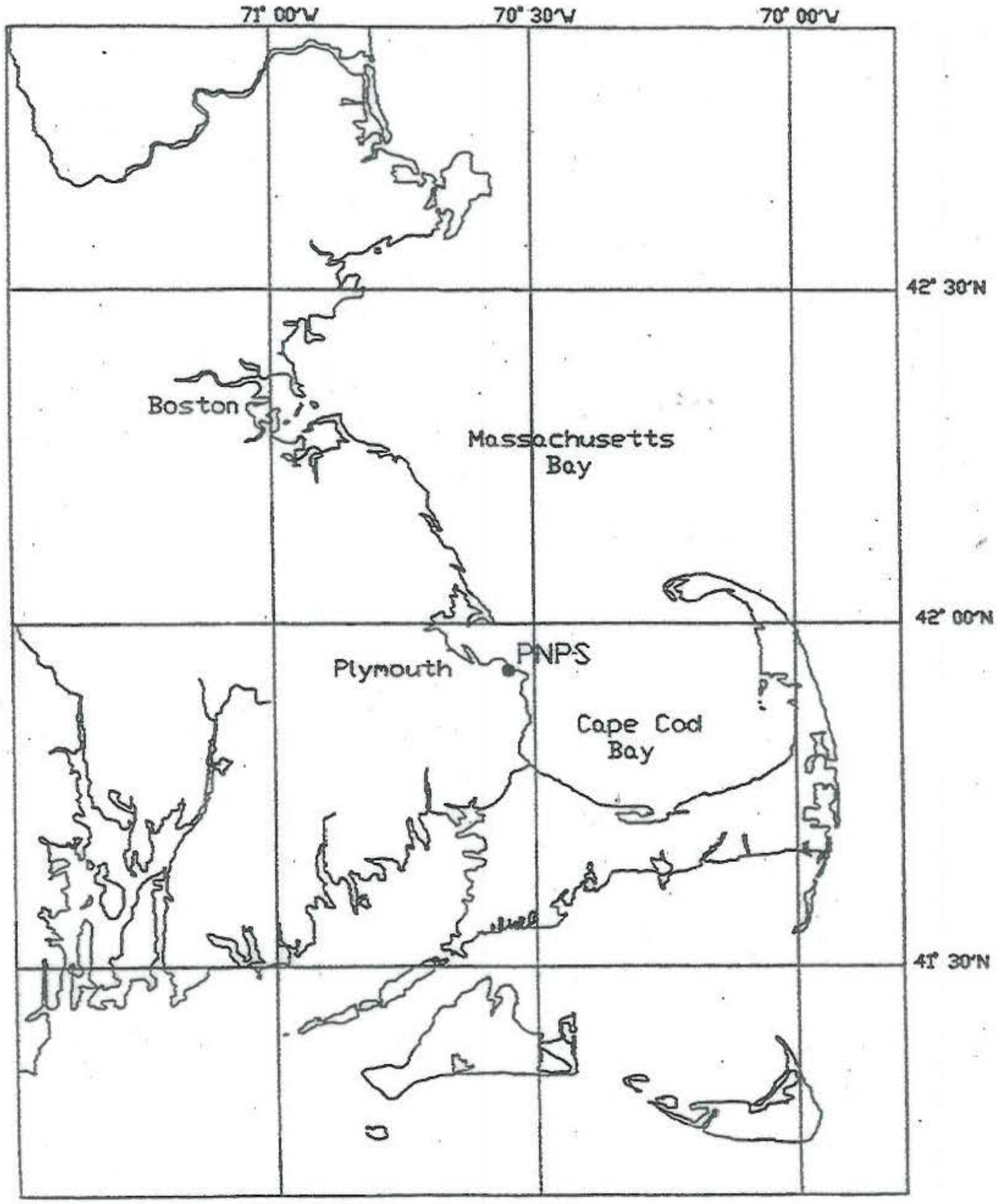


Figure 3 - Site Layout With Outfalls

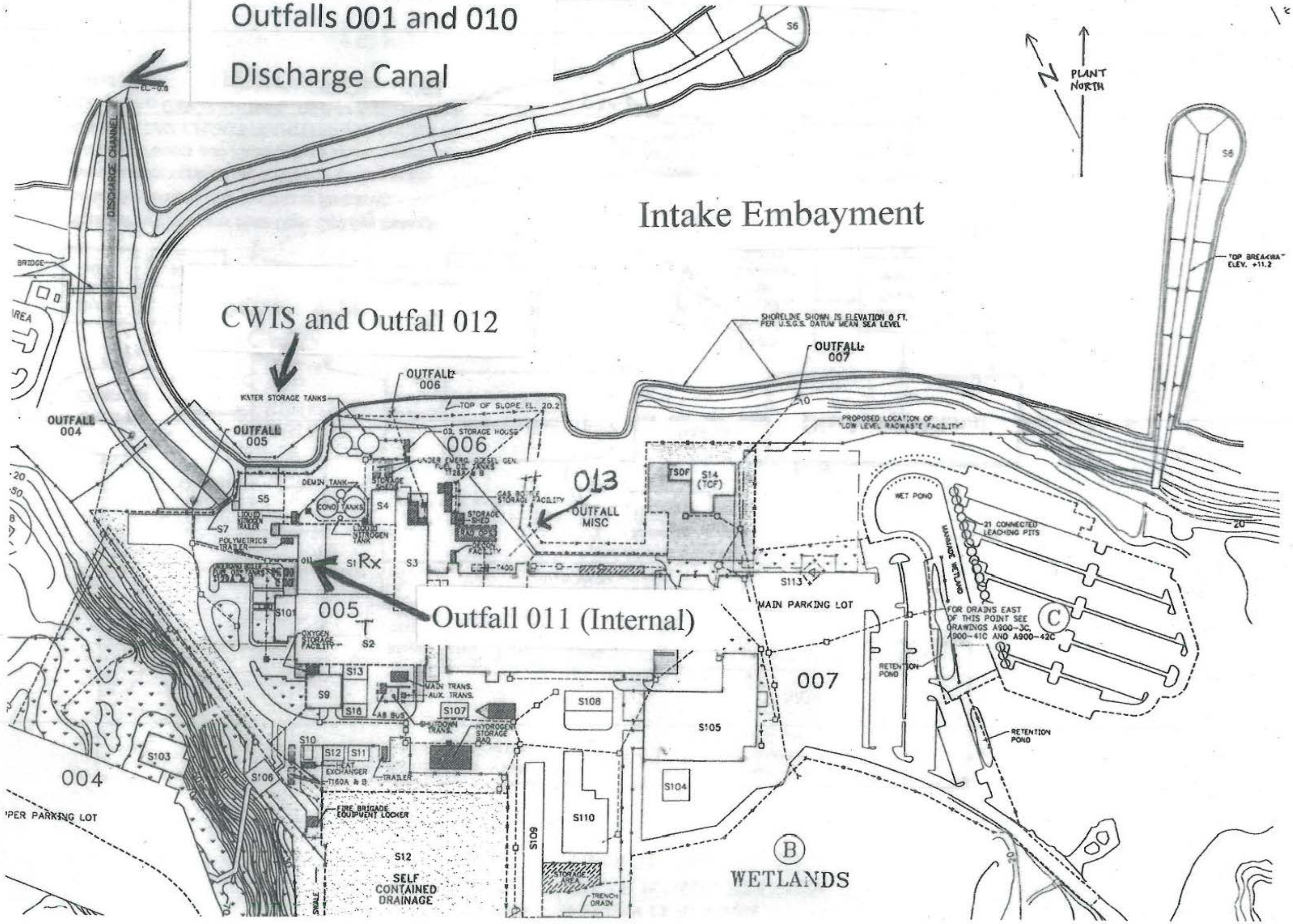
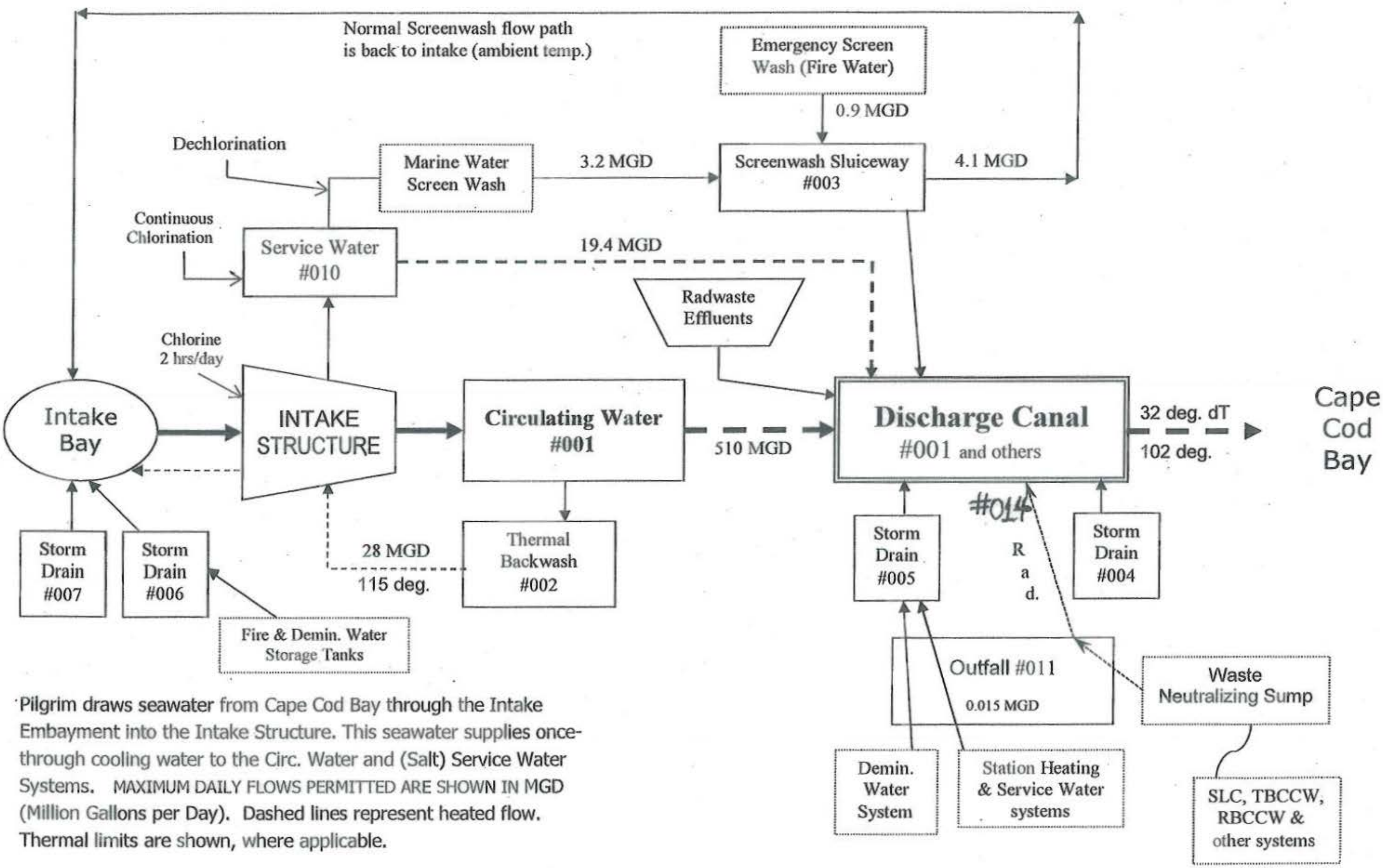


FIGURE 4

WATER FLOW DIAGRAM
PILGRIM NUCLEAR POWER STATION
PLYMOUTH, MA

This diagram shows the basic elements related to NPDES Permit outfalls for Pilgrim Station



Pilgrim draws seawater from Cape Cod Bay through the Intake Embayment into the Intake Structure. This seawater supplies once-through cooling water to the Circ. Water and (Salt) Service Water Systems. MAXIMUM DAILY FLOWS PERMITTED ARE SHOWN IN MGD (Million Gallons per Day). Dashed lines represent heated flow. Thermal limits are shown, where applicable.

Water-flow-diagram 2016

Figure 5

Cross Section and Plan Views of Cooling Water Intake Structure (CWIS)

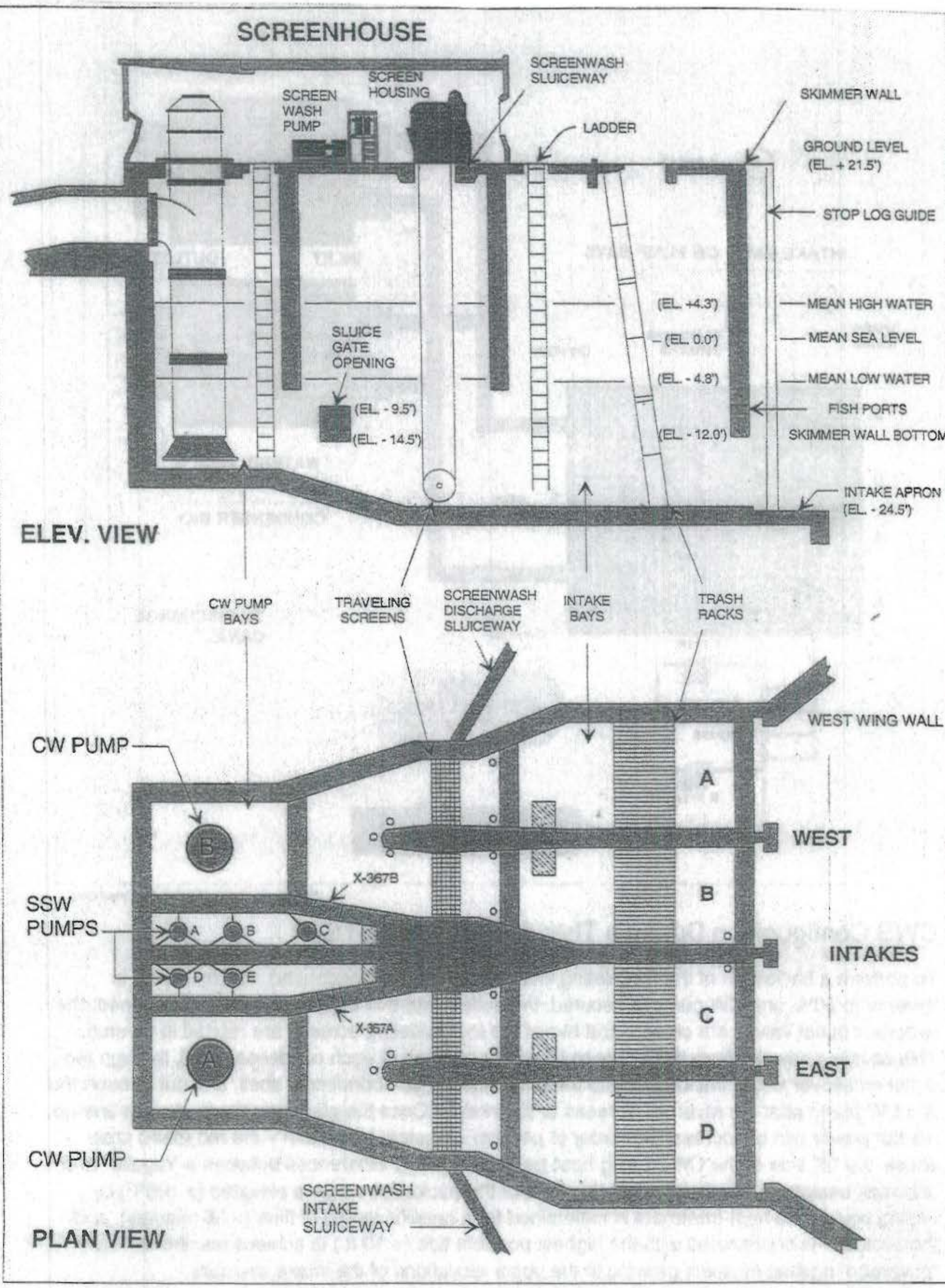
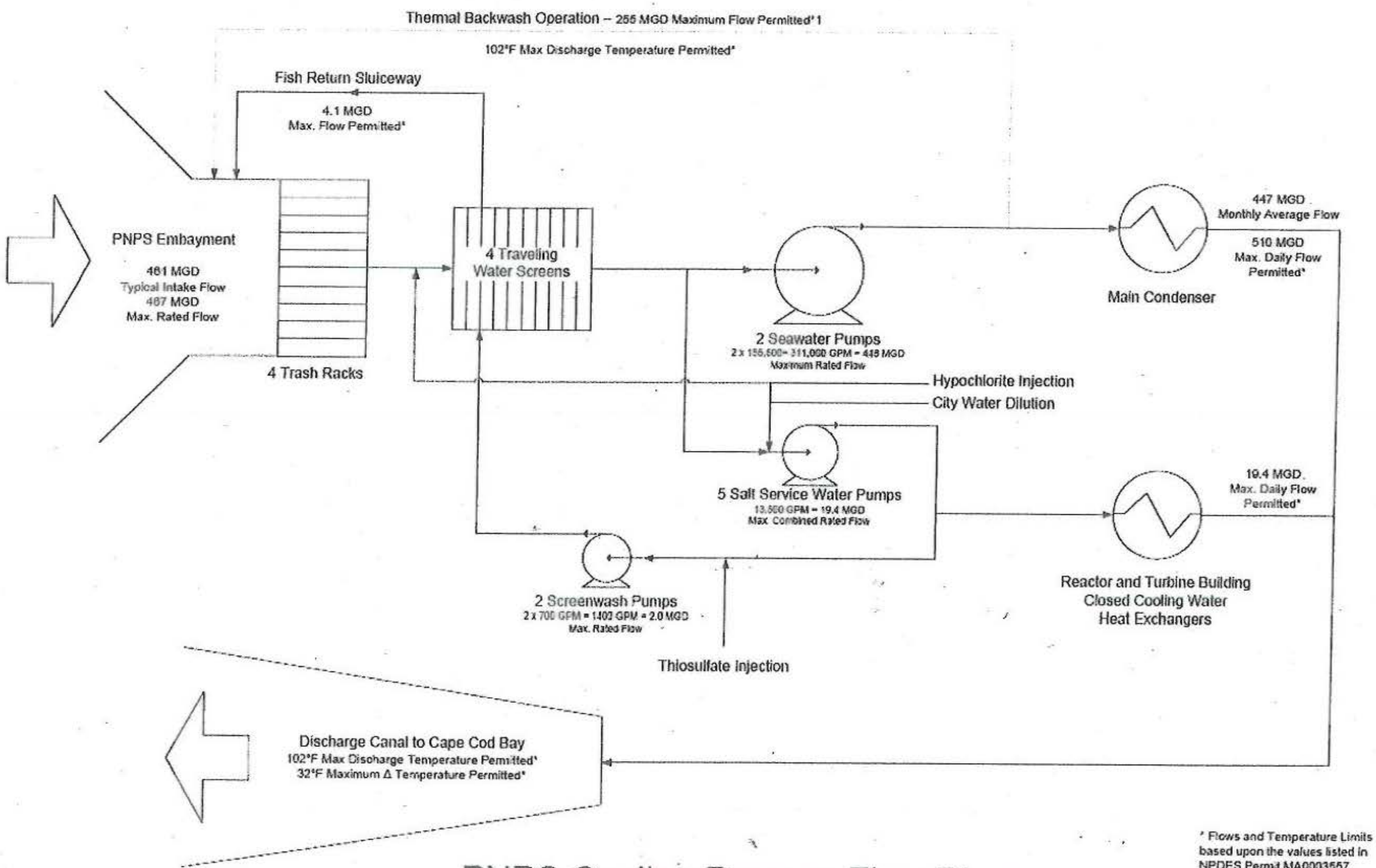


Figure: Intake Structure at Pilgrim Nuclear Power Station. *The top diagram is a cross sectional view of the intake, while the lower diagram is a plan view.*

Figure 6 - Cooling Process Flow Diagram



PNPS Cooling Process Flow Diagram

Figure 7 - Schematic of Fish Return System

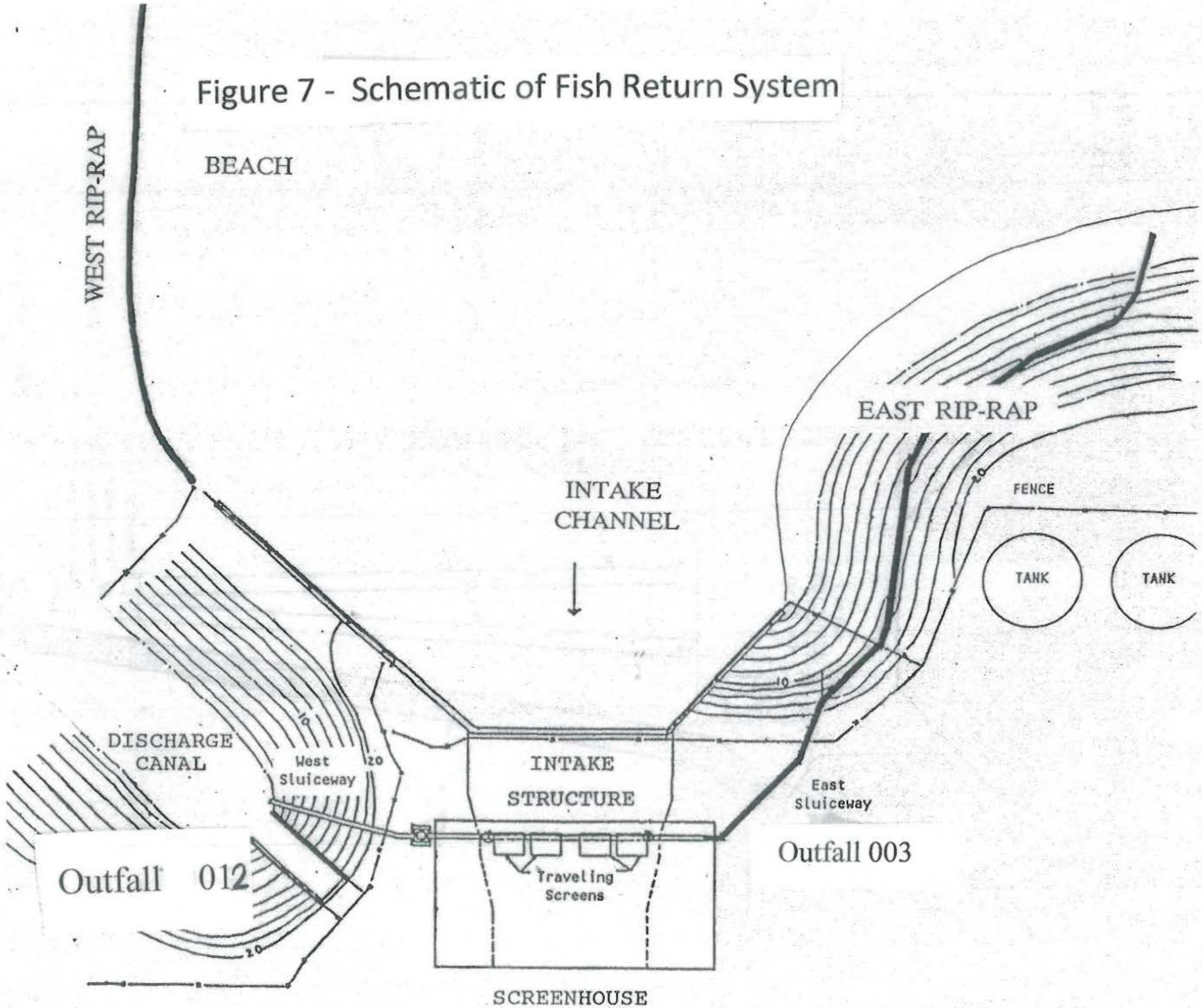
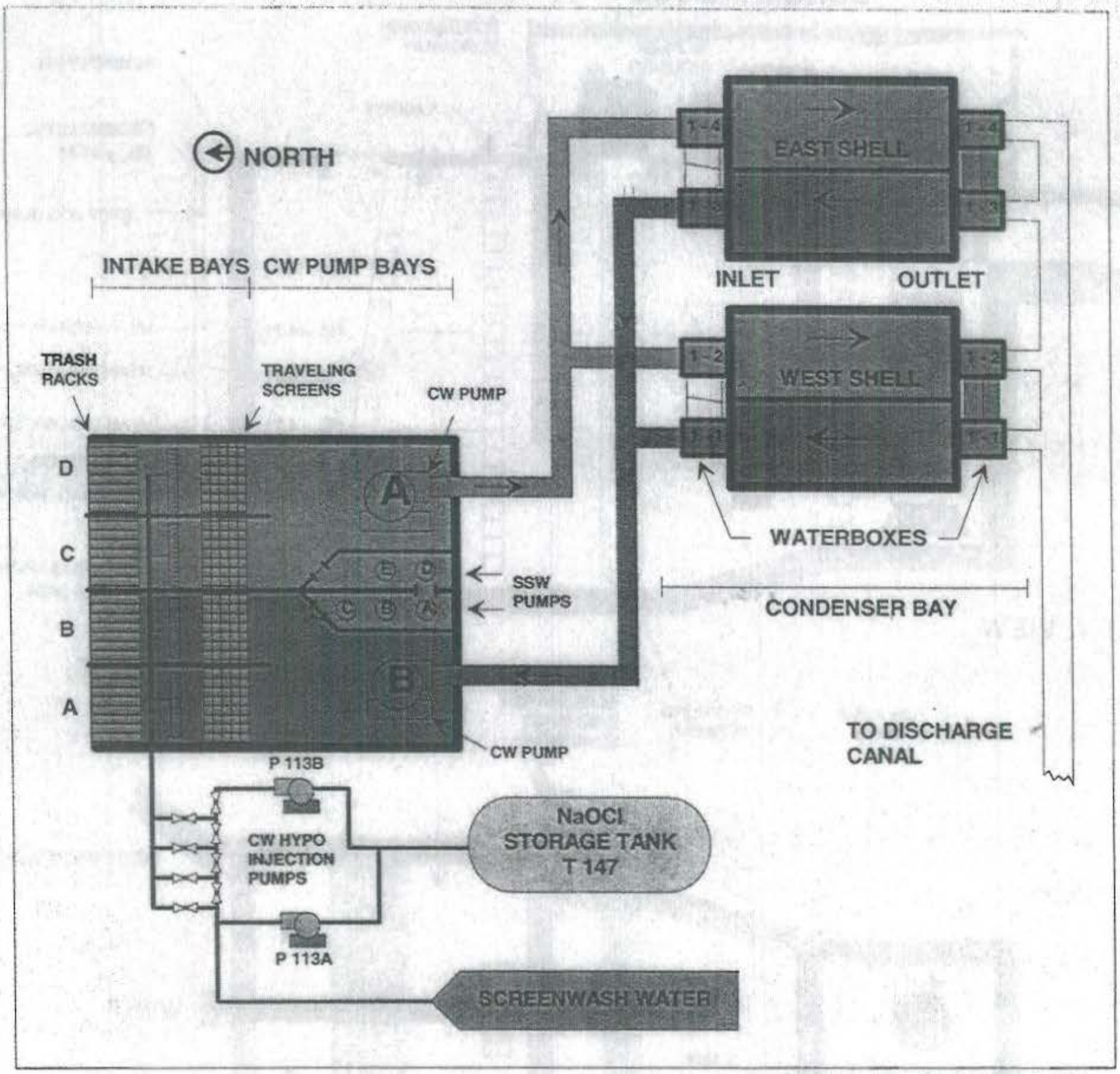


Figure 8 - Configuration of CWIS Thermal Backwash



Graphic courtesy of Marine Biocontrol Corp.

CWS Configuration During a Thermal Backwash (TBW)

To perform a backwash of the Circulating Water System (and condenser), reactor power is lowered to 50%, one CW pump is secured, the outlet waterbox crossover valves are opened, the waterbox outlet valves are closed, and two of the four traveling screens are rotated in reverse. This causes seawater from the intake to flow from one half of each condenser shell, through the outlet crossover valve, backwards into the other half of each condenser shell, and out through the idle CW pump past the reversed screens to the intake. Once the plant is in the backwash line-up, reactor power can be increased in order to perform a thermal backwash – the red (dark) area shows the "B" side of the CWS being heat-treated. The key differences between a "regular" and "thermal" backwash are that: the temperature of the backwash water is elevated (> 105°F) by raising power, the heat-treatment is maintained for a specific length of time (> 35 minutes), and the evolution is coordinated with the highest possible tide (> 10 ft.) to achieve maximum "coverage" against mussels growing in the upper elevations of the intake structure.

Attachment A: Discharge Monitoring Data

Pilgrim Nuclear Power Station - Outfall 001

Monitoring Period End Date	Flow		Total Residual Oxidants		Effluent Temperature	Delta T Intake – Effluent Temperature
	MGD	MGD	mg/l	mg/l	ºF	ºF
	Mon Avg	Daily Max	Mon Avg	Daily Max	Daily Max	Daily Max
Jan-08	446.4	446.4	0.04	0.07	77.2	28.7
Feb-08	446.4	446.4	0.04	0.06	72.5	28.7
Mar-08	446.4	446.4	0.04	0.06	73.5	28.7
Apr-08	427	446.4	0.04	0.08	80.1	29.8
May-08	445.5	446.1	0.05	0.08	84.3	28.5
Jun-08	444.3	446.4	0.06	0.08	94	28.6
Jul-09	446.4	446.4	0.06	0.08	90.9	27.9
Aug-08	444.3	446.4	0.04	0.08	99.2	27.9
Sep-08	446.4	446.4	0.05	0.08	99.4	28.2
Oct-08	444.2	446.4	0.05	0.08	90.3	28.1
Nov-08	446.4	446.4	0.05	0.07	82.2	27.9
Dec-08	441.9	446.4	0.05	0.07	78.7	29
Jan-09	446.4	446.4	0.03	0.06	69.9	29.1
Feb-09	446.4	446.4	0.05	0.08	70.9	28.8
Mar-09	446.4	446.4	0.05	0.08	74.2	28.7
Apr-09	262.2	446.4	0.04	0.05	77.4	28.3
May-09	243.1	446.4	0.03	0.05	85.1	28.6
Jun-09	446.4	446.4	0.03	0.06	92.9	28.1
Jul-09	444.2	446.4	0.03	0.08	95	29.1
Aug-09	444.2	446.4	0.05	0.09	97.1	28.9
Sep-09	446.4	446.4	0.05	0.09	95.6	27.6
Oct-09	444.1	446.4	0.04	0.09	88.3	28
Nov-09	446.4	446.4	0.05	0.09	83.9	27.6
Dec-09	446.4	446.4	0.05	0.09	82.4	27.9
Jan-10	446.4	446.4	0.05	0.08	71.7	28.3
Feb-10	446.4	446.4	0.05	0.08	71	28.4
Mar-10	445.8	446.4	0.05	0.08	76.3	28.3
Apr-10	446.4	446.4	0.04	0.07	81.2	28.4
May-10	444.2	446.4	0.04	0.08	88.3	28.6
Jun-10	446.4	446.4	0.04	0.08	91.8	27.5
Jul-10	444.2	446.4	0.04	0.09	99	28.2
Aug-10	443.3	446.4	0.04	0.09	97.1	27.8
Sep-10	446.4	446.4	0.04	0.09	100.3	28
Oct-10	444	446.4	0.05	0.09	95.3	28.1
Nov-10	445.8	446.4	0.05	0.09	88.7	31.6
Dec-10	444.8	446.4	0.04	0.08	77.2	29.1

Jan-11	446.4	446.4	0.04	0.05	69	28.1
Feb-11	445.8	446.4	0.05	0.06	69.6	27.5
Mar-11	446.4	446.4	0.04	0.06	72.8	27.6
Apr-11	276	446.4	0.03	0.03	72.2	24.1
May-11	343.7	446.4	0.04	0.06	87.3	29.5
Jun-11	446.4	446.4	0.04	0.08	97.7	30.5
Jul-11	444.1	446.4	0.05	0.09	101.2	29.8
Aug-11	446.4	446.4	0.03	0.08	98.6	30.5
Sep-11	444.2	446.4	0.04	0.09	94.5	30.2
Oct-11	446.4	446.4	0.05	0.08	93.6	31.5
Nov-11	441.1	446.4	0.05	0.08	87.7	30.7
Dec-11	434	446.4	0.06	0.14	82.5	30.3
Jan-12	446.4	446.4	0.06	0.09	73.3	30.3
Feb-12	442.9	446.4	0.03	0.06	73.7	29.9
Mar-12	446.4	446.4	0.04	0.06	77.2	30.4
Apr-12	446.4	446.4	0.04	0.06	83.7	30.5
May-12	444.3	446.4	0.03	0.06	90	30.7
Jun-12	444.4	446.4	0.02	0.04	95.7	30.5
Jul-12	446.4	446.4	0.02	0.08	98.2	29.9
Aug-12	444.3	446.4	0.04	0.09	99.3	29.8
Sep-12	446.4	446.4	0.03	0.19	96.5	30
Oct-12	446.4	446.4	0.03	0.07	88.3	30.1
Nov-12	443.1	446.4	0.04	0.08	86.8	30
Dec-12	446.4	446.4	0.03	0.05	78.5	29.8
Jan-13	446.4	446.4	0.04	0.07	72.5	29.4
Feb-13	385.7	446.4	0.07	0.16	73.8	28.9
Mar-13	446.4	446.4	0	0	73.1	27.5
Apr-13	217.7	446.4	0	0	76	26.3
May-13	287.9	446.4	0	0	71.2	15.8
Jun-13	443.1	446.4	0.02	0.05	93.9	31.1
Jul-13	446.4	446.4	0.02	0.04	101.6	31.6
Aug-13	444	446.4	0.02	0.08	98.6	31
Sep-13	445.8	446.4	0.02	0.04	92.9	29.9
Oct-13	426.7	446.4	0.02	0.04	95.1	29.9
Nov-13	443.7	446.4	0.04	0.07	86.7	30.3
Dec-13	446.4	446.4	0.05	0.07	76.1	30.7
Jan-14	446.4	446.4	0.05	0.08	76	31.6
Feb-14	446.4	446.4	0.04	0.05	70.9	30.6
Mar-14	443.4	446.4	0.03	0.05	75.5	30.6
Apr-14	446.4	446.4	0.03	0.07	79.4	31
May-14	445.8	446.4	0.03	0.06	88	30.8
Jun-14	444.1	446.4	0.03	0.06	95.7	30.2
Jul-14	446.4	446.4	0.03	0.05	94.7	30.4
Aug-14	439.3	446.4	0.03	0.06	99	30.3
Sep-14	446.4	446.4	0.02	0.07	99.5	30.4
Oct-14	443.9	446.4	0.03	0.05	95.2	30.4
Nov-14	446.4	446.4	0.04	0.06	89.6	29.8
Dec-14	444.7	446.4	0.04	0.06	80.4	30.8

Jan-15	389.6	446.4	0.03	0.04	73	30.4
Feb-15	428.6	446.4	0.07	0.08	71.7	30.3
Mar-15	446.4	446.4	0.03	0.05	72.1	30.4
Apr-15	282	446.4	0.03	0.05	76.9	30.8
May-15	221.7	446.4	0.02	0.02	83.1	29.5
Jun-15	444	446.4	0.04	0.07	91	30.9
Jul-15	446.4	446.4	0.03	0.05	95.8	30.5
Aug-15	444	446.4	0.03	0.05	101.4	30.6
Sep-15	446.4	446.4	0.03	0.05	99.2	30.4
Oct-15	444.1	446.4	0.03	0.04	95.6	30.3
Nov-15	446.4	446.4	0.04	0.07	91.1	30.6
Dec-15	443.7	446.4	0.04	0.05	83	29.9
Jan-16	446.4	446.4	0.02	0.02	76.2	30.1
Feb-16	438	446.4	0.03	0.05	77	
Mar-16	443.3	446.4	0.04	0.07	76.1	30.1

Outfall 001 Summary						
1991 Permit Limits	447	510	0.1	0.1	102	32
Minimum	217.7	446.1	0	0	69	15.8
Maximum	446.4	446.4	0.07	0.19	101.6	31.6
Average	433.4	446.4	0.038	0.068	85.5	29.3
# of violations	0	0	0	3	0	0
# of samples	99	99	99	99	99	98

Attachment A: Discharge Monitoring Data

Pilgrim Nuclear Power Station - Outfalls 002, 003, and 010

	Outfall 002		Outfall 003		Outfall 010		
Monitoring Period End Date	Flow, Daily Max	Eff. Temp.	Flow, Monthly Average	Flow, Daily Max	Flow, Monthly Avg	Total Residual Oxidants MA	DM
	MGD	°F	MGD	MGD	MGD	mg/l	mg/l
Jan-08			1.1	3.2	7.2	0.29	0.59
Feb-08			0.9	3.2	8.5	0.33	1.25
Mar-08			0.7	2.9	7.6	0.28	0.59
Apr-08			1	3.2	7.5	0.31	0.69
May-08	12.1	108.6	1.7	3.2	10.7	0.26	0.44
Jun-08	16.3	111.8	1	2.8	14.2	0.29	0.49
Jul-09			1.1	2.6	14.4	0.24	0.49
Aug-08	26.2	109.5	1.4	3.2	14.5	0.23	0.48
Sep-08			1.7	3.2	11.3	0.22	0.96
Oct-08	14.7	110.9	1.7	3.2	13.4	0.27	0.88
Nov-08			1.8	3.2	11.6	0.29	0.99
Dec-08			2.4	3.2	9.4	0.3	0.83
Jan-09			2.9	3.2	7.2	0.29	0.61
Feb-09			1.5	3.2	7.2	0.27	0.74
Mar-09			2.1	3.2	7.5	0.26	0.61
Apr-09			2	3.2	7.6	0.1	0.45
May-09			1.2	3.2	8	0.09	0.41
Jun-09			2.4	3.2	7.2	0.23	0.54
Jul-09	20.3	112.9	1.5	3.2	14.4	0.13	0.5
Aug-09	24.2	113.1	1.5	3.2	12.6	0.26	0.64
Sep-09			2.5	3.2	14.4	0.22	0.7
Oct-09	18.6	113.3	2.5	3.2	12.3	0.35	0.7
Nov-09			2.3	3.2	11.3	0.3	0.67
Dec-09			1.6	2.4	1.9	0.3	0.67
Jan-10			1.6	3.2	10.2	0.34	0.73
Feb-10			1.3	3.2	8	0.3	0.73
Mar-10			2	3.2	9.3	0.27	1.03
Apr-10			0.9	3.2	9.5	0.21	0.5
May-10	23.6	114.9	1.1	3.2	10.9	0.28	0.74
Jun-10			1	3.2	14.1	0.28	0.6
Jul-10	24.2	113.3	0.9	3.2	14.4	0.2	0.58
Aug-10	21.5	114	1.4	3.2	14.4	0.29	0.69
Sep-10			1.8	3.2	7.2	0.3	0.7
Oct-10	20.6	112.5	1.6	3.2	14.4	0.3	0.66
Nov-10			2.6	3.2	11.6	0.33	2.4
Dec-10			2.5	3.2	8.2	0.27	0.71

Jan-11			1.4	3.2	8.7	0.3	0.73
Feb-11			1.1	3.2	7.4	0.3	0.73
Mar-11			0.9	3.2	9.2	0.23	0.68
Apr-11			0.8	3.2	7.6	0.14	1.3
May-11			2	3.2	9.5	0.19	0.61
Jun-11			2.7	3.6	13.7	0.31	0.69
Jul-11	17.5	111.2	2.2	3.2	14.4	0.28	1.15
Aug-11			2.7	3.3	14.3	0.23	0.65
Sep-11	18	109.7	2.5	3.2	14.4	0.24	0.66
Oct-11			2.4	3.2	13.9	0.3	0.93
Nov-11	14.7	107.6	2.3	3.2	8.7	0.35	0.75
Dec-11			2.6	3.2	8.1	0.27	0.97
Jan-12			1.2	3.2	7.4	0.3	0.74
Feb-12	14.3	107.5	2	3.2	7.3	0.24	0.52
Mar-12			1.7	3.2	7.3	0.2	0.66
Apr-12			1.6	3.2	8.5	0.3	0.66
May-12	7.1	108	1.7	3.2	9.5	0.29	0.92
Jun-12	17.5	106.8	2.6	3.2	12.1	0.13	0.32
Jul-12			1.5	3.2	13.9	0.23	0.91
Aug-12	14.3	109	2	3.2	13.5	0.25	0.57
Sep-12			2.2	3.2	12.9	0.29	0.84
Oct-12			2.6	3.2	10.9	0.31	0.7
Nov-12	15	108.9	2.3	3.2	9	0.31	0.75
Dec-12			1.9	3.2	7.4	0.3	0.63
Jan-13			0.8	3.2	7.3	0.23	0.71
Feb-13			1.4	3.2	7.3	0.28	0.72
Mar-13			2.3	3.2	7.2	0.26	0.76
Apr-13			0.5	2.6	5.9	0.13	0.64
May-13			0.2	2.6	7.3	0.14	0.72
Jun-13	19.7	110.2	2.1	3.2	13.8	0.17	0.41
Jul-13			2	3.2	14.4	0.11	0.23
Aug-13	20.6	108.7	2.1	3.2	13.5	0.18	0.69
Sep-13			2.2	3.2	12.7	0.2	0.83
Oct-13	16.4	108.4	2.8	3.2	12.9	0.24	0.87
Nov-13	16.4	107.9	3.2	3.2	9.6	0.24	0.71
Dec-13			3	3.2	7.6	0.24	0.69
Jan-14			1.5	3.2	7.7	0.26	0.75
Feb-14			2.2	3.2	7.2	0.17	0.67
Mar-14	17.8	106	1.6	3.2	7.2	0.2	0.7
Apr-14			2.5	3.2	7.3	0.26	0.7
May-14			2.6	3.2	7.7	0.24	0.56
Jun-14	16.3	108.1	2.4	3.2	11.4	0.21	0.48
Jul-14			2.1	3.2	12.9	0.22	0.58
Aug-14	20.8	106.8	2.6	3.2	13.8	0.14	0.43
Sep-14			2.9	3.2	12.5	0.24	0.47
Oct-14	14.7	107.2	2.4	3.2			
Nov-14			1.6	3.2	8.6	0.26	0.55
Dec-14	16.3	110	1.9	3.2	8.7	0.26	0.6

Jan-15			1.1	3.2	7.9	0.24	0.57
Feb-15			2.6	3.2	6.9	0.11	0.48
Mar-15			1	3.2	7.2	0.28	0.52
Apr-15			0.4	3.2	7.2	0.13	0.54
May-15			0.8	1.6	8.8	0.1	0.92
Jun-15	19.2	107	1.8	3.2	10.8	0.17	0.53
Jul-15			2	3.2	14	0.23	0.43
Aug-15	17.4	107.1	2.1	3.2	14	0.2	0.55
Sep-15			2.3	3.2	14.4	0.25	0.55
Oct-15	15.5	108.6	2.9	3.2	12.2	0.27	0.74
Nov-15			2.3	3.2	10.7	0.26	0.6
Dec-15	16.9	109.6	2.6	3.2	10.4	0.25	0.71
Jan-16			2.2	3.2	7.7	0.29	0.71
Feb-16			2.1	3.2	7.4	0.24	0.55
Mar-16	14.1	106.3	2.2	3.2	7.3	0.28	0.81

Outfalls 002, 003, and 010 Summary							
	Outfall 002		**Outfall 003**		**Outfall 010**		
1991 Permit Limits	255	120	4.1	4.1	19.4	0.5	1.0
Minimum	7.1	106	0.2	1.6	1.9	0.09	0.23
Maximum	26.2	114.9	3.2	3.6	14.5	0.35	2.4
Average	17.6	109.7	1.86	3.1	10.1	0.25	0.70
# of violations	0	0	0	0	0	0	5
# of samples	33	33	99	99	99	99	99

Attachment A: Discharge Monitoring Data

Pilgrim Nuclear Power Station - Outfall 011

Monitoring Period End Date	Flow		Total Suspended Solids	
	Monthly Avg	Daily Max	Monthly Avg	Daily Max
	MGD	MGD	mg/l	mg/l
Jan-08				
Feb-08				
Mar-08				
Apr-08				
May-08	0.0053	0.0053	0.5	0.5
Jun-08	0.0063	0.0122	0.5	0.5
Jul-09	0.0002	0.0002	0.5	0.5
Aug-08				
Sep-08				
Oct-08				
Nov-08				
Dec-08				
Jan-09	0.0104	0.0104	20	20
Feb-09				
Mar-09				
Apr-09	0.0054	0.0054	7	7
May-09	0.0002	0.0002	11.3	11.3
Jun-09				
Jul-09				
Aug-09				
Sep-09				
Oct-09	0.0049	0.0075	0.5	0.5
Nov-09				
Dec-09				
Jan-10				
Feb-10	0.001	0.001	21.5	21.5
Mar-10				
Apr-10				
May-10	0.0024	0.0024	0.3	0.3
Jun-10				
Jul-10				
Aug-10				
Sep-10				
Oct-10				
Nov-10				
Dec-10	0.008	0.008	13.8	13.8

Jan-11	0.0078	0.0078	1.2	1.2
Feb-11	0.01	0.01	22.5	22.5
Mar-11	0.0096	0.01	7.45	21.5
Apr-11	0.0085	0.0097	4.3	11.2
May-11	0.0091	0.0099	10.8	14.2
Jun-11	0.0099	0.0099	5.4	5.4
Jul-11				
Aug-11	0.0027	0.0027	0.5	0.5
Sep-11	0.0043	0.0051	0.5	0.5
Oct-11				
Nov-11				
Dec-11	0.0088	0.009	6.8	15.5
Jan-12	0.0095	0.01	2.2	3.6
Feb-12	0.0044	0.0047	16.6	16.6
Mar-12				
Apr-12				
May-12				
Jun-12				
Jul-12	0.0045	0.005	0.5	0.5
Aug-12	0.0075	0.0075	0.5	0.5
Sep-12				
Oct-12				
Nov-12				
Dec-12				
Jan-13	0.0008	0.0008	11.2	11.2
Feb-13				
Mar-13	0.0096	0.0104	12.3	23.2
Apr-13				
May-13				
Jun-13				
Jul-13				
Aug-13				
Sep-13				
Oct-13	0.0084	0.0084	14.8	14.8
Nov-13				
Dec-13				
Jan-14				
Feb-14				
Mar-14				
Apr-14				
May-14	0.0035	0.006	19.9	20.8
Jun-14				
Jul-14				
Aug-14	0.0024	0.0024	0.4	0.4
Sep-14	0.0076	0.0076	0.4	0.4
Oct-14				
Nov-14				
Dec-14				

Jan-15				
Feb-15				
Mar-15				
Apr-15	0.01	0.01	26.4	26.4
May-15				
Jun-15				
Jul-15	0.0053	0.0085	1.2	1.2
Aug-15				
Sep-15				
Oct-15				
Nov-15				
Dec-15	0.01	0.01	6.6	6.6
Jan-16				
Feb-16				
Mar-16				

Outfall 011 Summary				
1991 Permit Limits	0.015	0.06	30	100
Minimum	0.0002	0.0002	0.3	0.3
Maximum	0.01014	0.0122	26.4	26.4
Average	0.0062	0.0068	7.8	9.2
# of violations	0	0	0	0
# of samples	32	32	32	32

Attachment B

Outline of § 316(a) Decision Criteria

As described earlier [or in the Fact Sheet, etc.], discharges of heat must satisfy both technology-based standards and any more stringent water quality-based requirements that may apply. Under Section 316(a), however, a less stringent thermal limit may be authorized where a permittee demonstrates to the satisfaction of the Administrator that the otherwise applicable thermal limit is more stringent than necessary to assure the protection and propagation of the waterbody's balanced, indigenous population of shellfish, fish and wildlife. 33 U.S.C. § 1326(a). EPA regulations define the term "balanced, indigenous population"—and its synonym, "balanced, indigenous community"—in the following way:

> . . . a biotic community typically characterized by diversity, the capacity to sustain itself through cyclic seasonal changes, presence of necessary food chain species and by a lack of domination by pollution tolerant species. Such a community may include historically non-native species introduced in connection with a program of wildlife management and species whose presence or abundance results from substantial, irreversible environmental modifications. Normally, however, such a
> community will not include species whose presence or abundance is attributable to the introduction of pollutants that will be eliminated by compliance by all sources with section 301(b)(2) of the act; and may not include species whose presence or abundance is attributable to alternative effluent limitations imposed to section 316(a).

40 CFR § 125.71(c).

In May 1977, EPA released draft CWA 316(a) guidance entitled, *Interagency 316(a) Technical Guidance Manual And Guide For Thermal Effects Sections Of Nuclear Facilities Environmental Impact Statements* (hereinafter "316(a) Technical Guidance Manual" or "Manual") to be used for, among other things, 316(a) determinations in NPDES permit renewals at nuclear facilities. The 316(a) Technical Guidance Manual uses the term "balanced indigenous community" and suggests that an assessment of thermal impacts be done on a community-by-community (i.e., phytoplankton, zooplankton, habitat formers, finfish) basis. In analyzing the effects of the discharge of heat from the Pilgrim Nuclear Power Station (PNPS) to the balanced, indigenous population ("BIP") of marine organisms in Cape Cod Bay, EPA followed the recommended framework of the Manual, because it provides a useful and considered analytical structure developed for this purpose. The 316(a) Technical Guidance Manual suggests that a variance may be appropriate where the applicant shows either that the site is an area of low potential impact for each community type, based on specific criteria, or that certain "decision criteria" or endpoints indicative of thermal degradation for each community type have not occurred as a result of the thermal effects of current operations. Communities showing little or no impact from current operations were deemed by EPA to have low potential for thermal effects from future operation assuming other stressors stay constant. . EPA considered these endpoints in its thermal assessment. These decision criteria are detailed below.

PNPS's § 316(a) Variance: The § 316(a) variance in the current PNPS discharge permit allows the station to have a maximum daily discharge temperature of 102^o F with a delta (change in temperature from intake to discharge) of 32^o F. These discharge limits must be met in the discharge canal prior to release into Cape Cod Bay.

As part of the permit renewal process, the permittee must reapply for the § 316(a) variance. A permittee can make a case for a variance retrospectively, by showing that monitoring data collected during plant operation show no evidence of appreciable harm to the BIP attributable to the thermal discharge. 40 CFR § 125.73(c). Permittees may also present a prospective analysis. This approach generally requires extensive modeling of the thermal plume and is usually undertaken when a facility is requesting a change to its operation and its thermal limits. Regardless of the method chosen, the demonstration must show that the requested variance, "considering the cumulative impact of [the permittee's] thermal discharge together with all other significant impacts on the species affected, will assure the protection and propagation of a [BIP]." *Id.* § 125.73(a). PNPS has opted for a retrospective analysis, with some data collection to confirm prior modelling efforts.

Phytoplankton

Phytoplankton are unicellular microscopic plants that are one of the most important sources of primary production for coastal and marine food webs. They are important food items for zooplankton, which include larval fish, filter feeding invertebrates and some species of fish. In addition, nuisance blooms of phytoplankton can cause aesthetic and ecological problems.

***i.* Low Potential Impact Areas for Phytoplankton (Open Ocean and Most Riverine Ecosystems)**

Areas of low potential impact for phytoplankton are defined in the 1977 EPA 316(a) Technical Guidance Manual as open ocean areas or systems in which phytoplankton is not the food chain base. Ecosystems in which the food web is based on detrital material; (e.g. embayments bordered by mangrove swamps, salt marshes, freshwater swamps and most rivers and streams) are in this category.

An area will not be considered one of low potential impact if preliminary literature review and/or abbreviated "pilot" field studies reveal that:

1. Phytoplankton contribute a substantial amount of the primary synthetic activity supporting the community;

2. A shift towards nuisance species may be encouraged by the thermal discharge; or

3. Operation of the discharge may alter the community from a detrital to a phytoplankton-based system.

If a receiving water is determined to be an area of potential impact for phytoplankton, the 1977 EPA 316(a) Technical Guidance Manual directs that the following decision criteria are to be used.

ii. Decision Criteria

Depending on the severity of the effect, denial of a 316(a) variance may be warranted unless the following decision criteria are met:

1. A shift towards nuisance species of phytoplankton is not likely;

2. There is little likelihood that the discharge will alter the indigenous community from a detrital to a phytoplankton based system; or

3. Appreciable harm to the balanced indigenous population is not likely to occur as a result of phytoplankton community changes caused by the heated discharge.

Zooplankton

Zooplankton are microscopic animals that live in the water column. Zooplankton are comprised of two different categories of organisms, holoplankton and meroplankton. Holoplankton spend their entire life cycles as planktonic creatures. Meroplankton, such as fish and crustacean eggs and larvae, only spend a portion of their life cycle as plankton. The zooplankton community is a primary food source for larval fish, shellfish and some species of adult fish.

i. Low Potential Impact Areas for Zooplankton

Areas of low potential impact for zooplankton are defined in the 1977 EPA 316(a) Technical Guidance Manual as those characterized by naturally low concentrations of commercially important species, rare and endangered species, and/or those forms that are important components of the food web or where the thermal discharge will affect a relatively small proportion of the receiving water.

Most estuarine areas will not be considered areas of low potential impact for zooplankton. However, where a logarithmic gradient of zooplankton abundance exists, those areas at the lowest level of abundance may be recognized as low potential impact areas at the discretion of the Regional Administrator.

If the receiving water is deemed a potential impact area for zooplankton, the 1977 EPA 316(a) Technical Guidance Manual recommends that the following decision criteria be used.

ii. Decision Criteria

Depending on the severity of the effect, denial of a 316(a) variance may be warranted unless the following decision criteria are met:

1. Changes in the zooplankton and meroplankton community in the primary study area that may be caused by the heated discharge will not result in appreciable harm to the balanced indigenous fish and shellfish population;

2. The heated discharge is not likely to alter the standing crop or relative abundance, with respect to natural population fluctuations in the far field study area, from those values typical of the receiving water body segment prior to plant operation; or

3. The thermal plume does not constitute a lethal barrier to the free movement (drift) of zooplankton and meroplankton.

Habitat Formers

Habitat formers are species whose presence provide cover, foraging, spawning or nursery habitat for other species. In the marine environment, these would typically include coral reefs, seagrass meadows, kelp beds and macroalgal stands. These environments tend to be limited resources and many other species utilize these habitats for spawning, nursery areas, foraging and refuge from predation.

i. Low Potential Impact Areas for Habitat Formers

In some situations, the aquatic environment at a site will be devoid of habitat formers. This condition may be caused by low levels of nutrients, inadequate light penetration, sedimentation, scouring stream velocities, substrate character, or toxic materials. Under such conditions the site may be considered a low potential impact area. However, if there is some possibility the limiting factors (especially man-caused limiting factors) may be relieved and habitat formers may be established within the area, the applicant will be required to demonstrate that the heated discharge would not restrict re-establishment. Those sites where there is a possibility that a thermal discharge will impact a threatened or endangered species through adverse impacts on habitat formers will not be considered low potential impact areas.

If the receiving water is deemed a potential impact area for habitat formers, the 1977 EPA 316(a) Technical Guidance Manual recommends that the following decision criteria be used.

ii. Decision Criteria

Depending on the severity of the effect, denial of a 316(a) variance may be warranted unless the following decision criteria are met.

1. The heated discharge will not result in any deterioration of the habitat formers community or no appreciable harm to the balanced indigenous population will result from such deteriorations; or

2. The heated discharge will not have an adverse impact on threatened or endangered species as a result of impact upon habitat formers.

Shellfish and Macroinvertebrates

Macroinvertebrate fauna, including shellfish, are important components of aquatic food webs and are directly important to man as a source of food and as bait for sport and commercial fishermen. Their burrowing and feeding activities promote oxygenation of sediments and recycling of important nutrients from the sediments.

i. Low Potential Impact Areas for Shellfish/Macroinvertebrates

A low potential impact area for shellfish/macroinvertebrates fauna is defined by the 1977 EPA 316(a) Technical Guidance Manual as an area which, within the primary and far field study areas, can meet the following requirements:

1. Shellfish/macroinvertebrate species of existing or potential commercial value do not occur at the site. This requirement can be met if the applicant can show that the occurrence of such species is marginal;

2. Shellfish/macroinvertebrates do not serve as important components of the aquatic community at the site;

3. Threatened or endangered species of shellfish/macroinvertebrates do not occur at the site;

4. The standing crop of shellfish/macroinvertebrates at the time of maximum abundance is less than one gram ash-free dry weight per square meter; and

5. The site does not serve as a spawning or nursery area for the species in 1, 2, or 3 above.

If the receiving water is deemed a potential impact area for shellfish and macroinvertebrates, then the 1977 EPA 316(a) Technical Guidance Manual recommends that the following decision criteria be used.

ii. Decision Criteria

Depending on the severity of the effect, denial of a 316(a) variance may be warranted unless the following decision criteria are met:

1. Reductions in the standing crop of shellfish and macroinvertebrates may be cause for denial of a 316(a) waiver unless the applicant can show that such reductions caused no appreciable harm to balanced indigenous populations within the waterbody segment;

2. Reductions in the components of diversity may be cause for the denial of a 316(a) waiver unless the applicant can show that the critical functions of the macroinvertebrate fauna are being maintained in the water body segment as they existed prior to the introduction of heat; or

3. Areas which serve as spawning and nursery sites for important shellfish and/or macroinvertebrate fauna are considered as zero allowable impact areas and will be excluded from consideration for the discharge of waste heat. Plants sited in locations which would impact these critical functions will not be eligible for a 316(a) waiver. Most estuarine sites will fall into this category.

Fish

Fish are important components of marine ecosystems and are important sources of food for people.

i. Low Potential Impact Area for Fish

According to the 1977 EPA 316(a) Technical Guidance Manual, a discharge may be determined to be in a low potential impact area for fishes within the primary and far field study areas if the following conditions are satisfied:

1. The occurrence of sport and commercial species of fish is marginal;

2. The discharge site is not a spawning or nursery area;

3. The thermal plume will not occupy a large portion of the zone of passage which would block or hinder fish migration under the most conservative environmental conditions (based on 7-day, 10-year low flow or water level and maximum water temperature); and

4. The plume configuration will not cause fish to become vulnerable to cold shock or have an adverse impact on threatened or endangered species.

If the receiving water is deemed an area of potential impact for fish, then the 1977 316(a) Technical Guidance Manual recommends that the following decision criteria be used.

ii. Decision Criteria

Depending on the severity of the effect, denial of a 316(a) variance may be warranted if the following decision criteria are not met. The discharge should not result in appreciable harm to fish communities from:

1. Direct or indirect mortality from cold shocks;
2. Direct or indirect mortality from excess heat;
3. Reduced reproductive success or growth as a result of plant discharges;
4. Exclusion from unacceptably large areas; or
5. Blockage of migration.

Other Vertebrate Wildlife

These include marine mammals, sea turtles and birds that may rely on estuarine and coastal waters for foraging, reproduction and other life functions.

i. Low potential Impact Areas for Other Vertebrate Wildlife

According to the 1977 316(a) Technical Guidance Document, most sites in the United States will be considered ones of low potential impact for other vertebrate wildlife simply because thermal plumes should not generally impact large or unique populations of wildlife. The main exceptions will be sites in cold areas (such as North Central United States) which would be predicted to attract geese and ducks and encourage them to stay through the winter. These would not be considered low potential impact areas unless they could demonstrate that the wildlife would be protected through a wildlife management plan or other methods from the potential sources of harm mentioned in the next section.

Other exceptions to sites classified as low potential impact would be those few sites where the discharge might affect important (or threatened and endangered) wildlife such as manatees or sea turtles.

For most other sites, brief site inspections and literature reviews would supply enough information to enable the applicant to write a brief rationale about why the site should be considered one of low potential impact for other vertebrates.

If the receiving water is deemed an area of potential impact for vertebrate wildlife, then the 1977 EPA 316(a) Technical Guidance Manual directs that the following decision criteria should be used.

ii. Decision Criteria

Depending on the severity of the effect, denial of a 316(a) variance may be warranted if the following decision criteria are not met. The discharge should not cause appreciable harm to other vertebrate wildlife communities from:

1. Excess heat or cold shock;
2. Increased disease and parasitism;
3. Reduced growth or reproductive success;
4. Exclusion from unique or large habitat areas;
5. Or Interference with migratory pathways.

§ 316(a) Community Impact Analysis

The Massachusetts Department of Environmental Protection (DEP) compiled an excellent summary of thermal monitoring done by PNPS, hydrodynamic modeling of the thermal plume and a review of thermal thresholds for a wide suite of resident species. A few of the key findings of that review are included here:

1. The thermal plume has contact with the bottom for a limited distance outside the discharge canal. It is predominantly a surface feature.
2. The thermal plume is highly mobile, it changes position with the tide and likely the wind.
3. Ambient temperatures in Cape Cod Bay have increased by about 2^{o} C since 1976. This warming trend has resulted in numerous marine species expanding their ranges into Cape Cod Bay.

The Massachusetts DEP review is included as Attachment C to the Fact Sheet. EPA also reviewed satellite imagery of the thermal plume from PNPS generated by Dr. John Mustard of Brown University. Dr. Mustard's analysis showed the thermal plume from PNPS is on average 3.53 km^2 in size and is on average 0.75^{o} C warmer than the surrounding bay waters. EPA utilized the Massachusetts DEP review document, an additional literature review by our contractor Tetratech, NOAA'S Endangered Species Act Consultation with the Nuclear Regulatory Commission (NRC) and our 316(a) guidance document to conduct a Community Impact analysis to determine whether the alternative effluent limitation desired by the discharger, considering the cumulative impact of its thermal discharge together with all other significant impacts on the species affected, will assure the protection and propagation of the BIP.

Phytoplankton Community: EPA does not consider western Cape Cod Bay a low potential impact area for phytoplankton, because phytoplankton do constitute a significant portion of the primary production in these waters. Extensive seagrass meadows and salt marsh do occur in Plymouth and Duxbury Bays, but the deeper water and open ocean nature of western Cape Cod Bay ensure that phytoplankton are still significant components of the total primary production. There has been no indication that the PNPS thermal discharge has caused or contributed to the proliferation of any nuisance species or has caused the system to shift from a detrital based system to a phytoplankton dominated one. Recent monitoring of Cape Cod Bay by the Provincetown Center for Coastal Studies does not show elevated levels of chlorophyll a (a proxy for phytoplankton abundance) and shows no clear trend in chlorophyll a concentrations through time (Costa and Hughes, 2012). This monitoring does not suggest that thermal impacts are occurring to the phytoplankton community and/or that changes to the phytoplankton community are causing impacts to the larger Balanced Indigenous Population (BIP) in western Cape Cod Bay.

Zooplankton Community: EPA does not consider western Cape Cod Bay a low potential impact area for zooplankton, due to the presence of large numbers of commercially important fish and shellfish species and the presence of endangered whale species that feed on copepods and other components of the zooplankton community. There have not been detected any changes in the zooplankton community that could be attributed to the thermal plume. Thus, impacts to the balanced indigenous fish and shellfish species are unlikely. The thermal plume is highly dynamic and relatively small compared to the size of Cape Cod Bay (Figure 1), thus no far field changes have been observed. During the Nuclear Regulatory Commission (NRC) relicensing process, NOAA assessed the potential impact of the thermal plume on copepods and endangered whales. NOAA concluded that there was no evidence of the operation of PNPS causing a negative trend in copepod or right whale abundance in western Cape Cod Bay.

Habitat Formers: EPA does not consider western Cape Cod Bay a low potential impact area for habitat formers, due to the presence of stands of kelp, extensive seagrass meadows and salt marsh. The thermal discharge has a small, but measureable impact on habitat formers in the receiving waters. There is an area of approximately 1 acre in size where the normal algal growth of *Chondrus crispus* has been completely eliminated or severely stunted. Additionally, several warm water species *Bryopsis plumosa*, *Codium fragile*, *Gracilaria folifera* and *Soliera tenera* have been found in close proximity to the discharge canal, but not at reference locations. All of these changes are in a small area (1 acre) immediately adjacent to the discharge canal. Due to the limited areal extent of the change, the balanced indigenous population of fish and shellfish are unlikely to be effected. Based on the limited areal impact to them and the more limited seasonal use of these habitats by sea turtles or other endangered species EPA concludes that there is no impact to sea turtles or other endangered species that might forage/use these habitats.

Shellfish/macroinvertebrate community: EPA does not consider western Cape Cod Bay a low potential impact area for shellfish and macroinvertebrates, due to the presence of a rich macroinvertebrate community and multiple commercially important shellfish species. The vast majority of shellfish/macroinvertebrates in this system exist as benthic infauna or are epibenthic. Either way, they spend the vast majority of their lives in, on or near the seafloor. PNPS's thermal plume has minimal contact with the seafloor and is predominantly a surface feature, thus it has an extremely limited opportunity to impact shellfish or macroinvertebrates. Massachusetts Division of Marine Fisheries (MDMF) collected close to 74,000 lobsters over a 5-year period from near the discharge and from reference areas. They found no difference in abundance, timing of molting, onset of maturity or growth rates between the test locations near the discharge and the reference areas. There is no data to suggest that the thermal plume is causing a reduction in shellfish or macroinvertebrates.

Fish community: EPA does not consider western Cape Cod Bay a low potential impact area for fish, because the area is a rich spawning habitat for multiple fish species. The thermal plume tends to be a surface plume and highly mobile, moving with wind and tide. The discharge is in an open ocean environment where it is diluted and dissipated relatively quickly. There is a small area where maximum temperatures in the summer could approach threshold values that could trigger acute mortality in some species. Due to the relatively small size of this area, if a fish did not avoid it, exposure time would be limited and as a result so would mortality. The mobility of the plume and the open ocean nature of this coast prevents the plume from being a block to normal migration. The thermal plume is relatively small compared to the receiving water, so there has been no evidence of thermal exclusion of large areas of western Cape Cod Bay by any resident fish species. There has been no evidence of mortality due to cold shock or from excess heat. There has been no evidence of impaired/reduced reproduction in fish resulting from exposure to the thermal plume.

Other vertebrate wildlife: EPA does not consider western Cape Cod Bay a low potential impact area for other vertebrate wildlife, due to the seasonal presence of several endangered marine mammals and sea turtles. As stated earlier, NOAA conducted an Endangered Species Act Consultation with the NRC during the PNPS relicensing process. The potential impact of the PNPS thermal discharge on whales and sea turtles was assessed. At the conclusion of its analysis, NOAA found that the thermal discharge from PNPS was not having an impact on any endangered species present in western Cape Cod Bay. EPA has received no reports from the permittee, DEP, or any third parties that the thermal plume serves as an attractant for migrating birds, such as ducks or geese. Migration of these species are not delayed by the presence of the thermal plume, nor has there been any evidence of birds foraging with greater/lesser frequency in the thermal plume than in the surrounding bay waters.

Conclusion: The thermal plume from PNPS is relatively small compared to the receiving water and it dissipates rapidly. It is predominantly a surface plume that moves with the tides and the wind. Minor impacts to the macroalgal community have been documented that can be attributed to the thermal plume, but this area is only roughly an acre in size. Thus, from a retrospective analysis, the past 40 years of operation of PNPS—during which the thermal component of the discharge has remained the same—has been protective of the balanced indigenous population of fish, shellfish and wildlife, in the context of § 316(a). Based on this information, EPA concludes that no appreciable harm has resulted from the current variance-based thermal limits in the PNPS discharge permit and that the continuation of the variance-based limits will assure the protection and propagation of a balanced, indigenous community of shellfish, fish and wildlife.

Figure 1: Satellite image from Mustard et al. (Brown University Report) of the thermal plume from PNPS

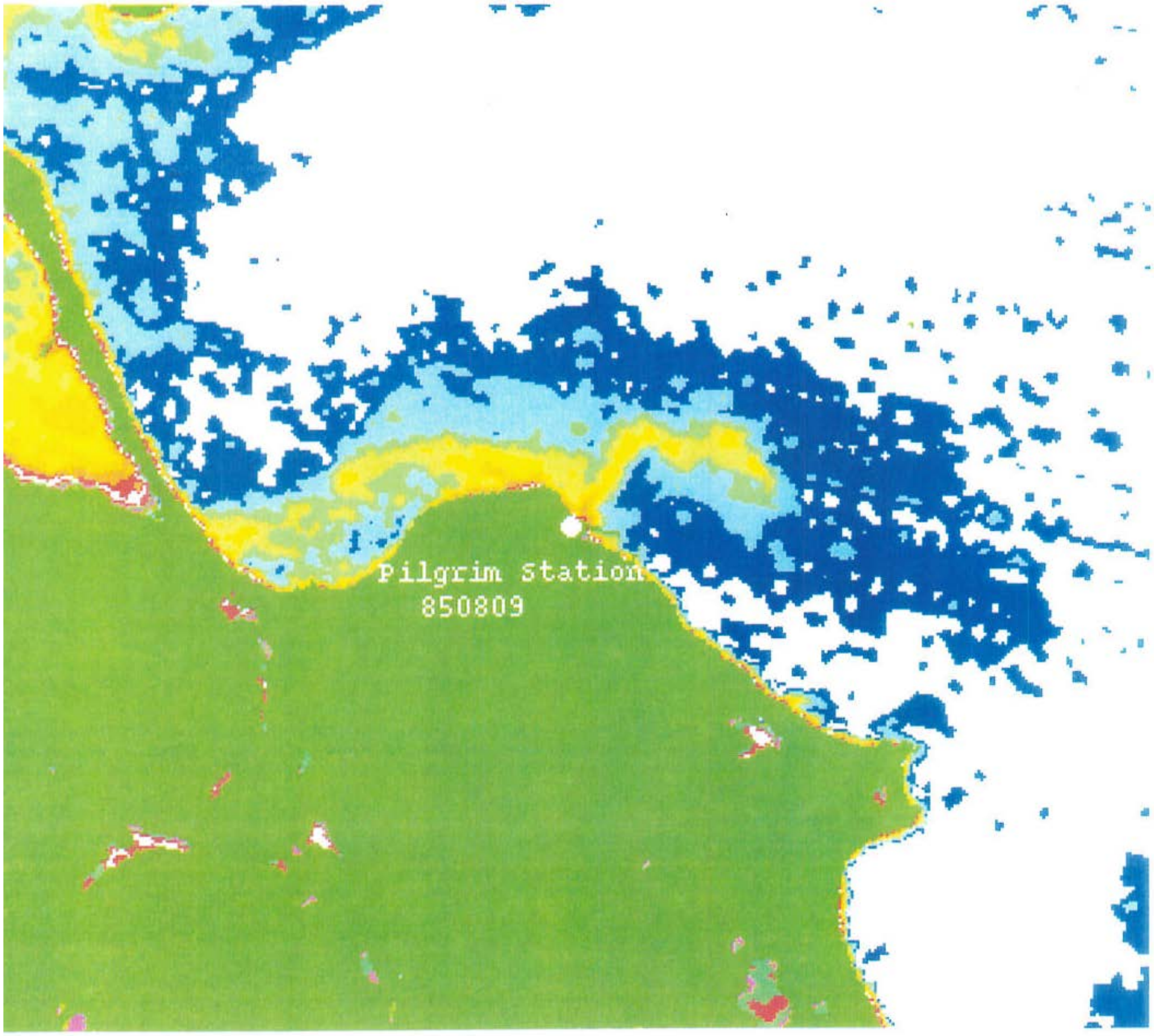


Figure 14: Example plume of Pilgrim station. Image acquired on 8/9/85. Temperature range: 294°K (red) – 291°K (green).

Attachment C

Massachusetts Department of Environmental Protection's Assessment of Impacts to Marine Organisms from the Pilgrim Nuclear Thermal Discharge and Thermal Backwash

Physical Water Temperature Characterization:

Overview: PNPS pulls cool ocean water into its condensers where a transfer of heat from the condensers to ocean water occurs. Heated water leaving the condensers is released into the PNPS discharge canal (discharge 001) and into the ocean adjacent to Pilgrim. The allowable rate of ocean water inflow to the condensers is 447 mgd as an average monthly rate with a maximum daily rate of 510 mgd. The allowable temperature rise in the water moving across the condensers is 32°F (17.8°C) and the maximum permitted temperature at discharge 001 is 102°F (38.9°C). In addition to the thermal discharge just described, the facility also uses a "backwash" of heated water to control bio-fouling. Thus, heat is discharged into the intake channel on occasion, as well through the typical route through the discharge canal.

The company's thermal discharge 001 and its effects on ocean temperatures were modeled by Pagenkopf and others from MIT (Pagenkopf, *et al*., 1974; 1976). Field characterizations of the plume were also conducted by MIT in the early 1970's in part to validate the model. Additional field studies to characterize ocean-bottom plume dimensions were conducted by EG&G (1995).

MIT's field studies took place in three phases: July 2-3, August 30 and November 13, 1973. The August 30 survey was coordinated with an airborne thermal infra-red survey through Aero-Marine Surveys. Ground-truth for the infra-red information was provided by Marine Research, Inc. (recently purchased by Normandeau), along with vertical temperature profiles of the water column. MIT constructed bathythermographs from these and other data collected by MIT personnel. Depictions of surface water, plume isotherms (delta temperatures beyond ambient, caused by the plume and depicted as areas of similar water-temperature), isotherms at different depths, and isotherms through vertical "slices" of the water column (i.e., through the center of the plume) were generated. Modeling of the plume was conducted that considered effects of tide, plume temperature and velocity, bottom contours, air temperature, water temperature, wind speed and direction and other factors. Because the variability in the vertical and horizontal plume dimension was great, modeling was needed to tease out how the variables described interacted to alter the shape, lateral extent and depth of the plume under different environmental conditions.

Tidal phase (e.g., high tide, low tide, periods in-between, etc.) was found to have a great influence on plume dimensions. Because the plume is warmer than ambient ocean temperatures it is less dense and, therefore, buoyant. As a result the plume is expected to have a greater or lesser contact with the bottom depending on the slope of the ocean bottom and the height of the water column into which the plume is released. These general expectations were confirmed in the field studies and data from these studies were depicted graphically in the MIT and EG&G reports.

The plume has the greatest contact with the bottom for the longest distance from its point of release from the discharge canal during low tide and during the tidal period slightly before and afterwards. As tidal height increases, plume contact with the bottom decreases and at high tide the plume is primarily confined to the surface (see dimensions below). Plume detachment from the bottom is partly due to its buoyancy, a drop in the bottom contour offshore from PNPS, and is also due to the rising tide and a relatively-high tidal amplitude (about 10 ft.) in this area of the coast.

The largest areas of temperature change at the surface of the water column due to the PNPS plume during the MIT studies occurred shortly after peak high tide and did not decrease until well after the mid-tide following high tide. In most of the isotherm delineations, the plume had little or no effect on background temperatures past about 4,000 ft. from the end of the discharge canal (although this could change with wind direction and several other factors; see below). A decrease in surface isotherm area was seen during the late part of low tide and the early part of the following rising tide.

Surface plume dimensions: The physical dimensions of the surface plume observed during each of the three field studies differed substantially. High tide surface plume dimensions in July and November for the 1°C isotherm were 138 and 56 acres, respectively, supporting the idea that during cooler, ambient conditions the plume dimensions decrease. Although the facility was only operating at 50% capacity during the November survey, the volume of the plume as well as the areal dimensions of each of the different isotherms were reduced well-beyond levels expected due to the difference in the plant's operational capacity factors alone. For example, the volume of the ≥3°C isotherm during the November survey was 56 acre-ft., while the volume for the same isotherm for the August survey was 864 acre-ft. MIT suggested that heat-exchange during November when air was much less humid, and when winds were higher, was greatly increased compared to the August survey.

The depth of the surface plume varied substantially with tidal phase and distance from the point of release. During all tidal phases the depth of the plume was greatest near the point of release from the discharge canal and lessened with distance from the canal. Far-field surface plume depth during high tide in all of the field studies ranged from about 3-8 ft. During low tide and tidal periods around low tide, plume depth was much greater, but the horizontal travel of the surface plume was greatly reduced. In all cases, the depth of the plume is greatest near the discharge as are the delta temperature changes. As the plume moves away from the point of discharge, it flattens and spreads out across the surface. During low tide, plume isotherms in touch with the bottom extended somewhat beyond 500 ft. (MIT's field-generated plume depictions did not include depths past about 500 ft.). However, during high tide plume interaction with the bottom extended to less than 50 ft. from the end of the discharge canal. Later studies of benthic flora and fauna (see **Benthic Flora** and **Benthic Fauna** sections below) support the idea that negative impacts from the plume to the benthos adjacent to the facility are very limited.

ENSR (2000) compared the model-predicted surface plume area with measured plume dimensions from the field surveys. Based on the model predictions, a surface plume of 1°C or less could encompass as much as 3,000 acres to a depth of about 5 ft. For reference, the surface area of Cape Cod Bay is about 365,000 acres (Stone and Webster, 1975). NOAA (May 17, letter to the NRC) used the MIT model results and the maximum distance between the 3 and 4°C isopleths to predict that the linear distance from the discharge point to the 1°C isotherm could be as great as 7,000 ft. (about 1.4 miles). For reference, NOAA also added that the distance from the Pilgrim shoreline to the tip of Cape Cod was about 18.8 miles and the distance to the most southern extent of Cape Cod Bay was about 18 miles. Additionally, the distance from the Pilgrim shoreline to the inner "elbow" of the cape (at Orleans) is about 31 miles (as measured through Google Earth).

Wind velocity, wind direction, air temperature and humidity level also had substantive effects on plume characteristics. MIT characterized the effects of wind velocity and direction on the plume through a description of changes in the area of the 5°C isotherm. Typically, the area of this isotherm was negatively related to wind speed, i.e., the area of the 5°C isotherm increased as wind velocities decreased and vice-versa. However, a northeast wind created larger areas of this isotherm. MIT's explanation of this phenomenon was that when the wind was from the northeast, a heated air mass was held against the shoreline, whereas a south-westerly wind carried the air mass out to sea tending to create lower areas of this isotherm. Although larger surface areas of delta temperatures were seen at high tide than at low, when the wind conditions mentioned above were in effect they over-ruled the simple tide effects. In addition, ocean currents within the bay move primarily in a counter-clockwise direction with a north to south movement along the Plymouth shoreline. However, most of MIT's surface-plume depictions show the plume bending to the north. This phenomenon was explained as an effect of winds driving the plume to the north at the times that the field studies were conducted.

Highly humid conditions with low air velocity created a "greenhouse" effect. This limited evaporative cooling and allowed the size of the plume to increase over time during certain of the summer studies. Dry conditions and high delta temperatures between air and water tended to have the opposite effect. Under very low wind conditions, the plume typically extends at a right angle to the shoreline although tidal effects may also bend the plume.

Plume dimensions at the bottom: EG&G (1995) conducted more extensive studies than MIT in the area directly adjacent to the facility on the bottom of the sea floor where they measured isotherm areas at the bottom (i.e., where the plume made contact with the ocean floor) at different times of the tidal cycle. Fifty-nine internally-recording temperature sensors were anchored in an offshore array and temperatures were recorded in approximately half-hour intervals during August, 1994. Data for five tidal cycles were collected from the full array before the facility unexpectedly shut down for a long period. The monitoring stations closest to the station were located 50 meters in distance from the mouth of the discharge canal. Stations farthest from the facility were 260 meters from the mouth of the canal. Station placement was based on findings from the earlier MIT studies discussed above.

EG&G found that the maximum area covered at low tide by the lowest detectable temperature increment (+1°C) was about 51,000 sq. ft., or about **1.2 acres**. The maximum linear extent of the 1°C isotherm in contact with the bottom was about 560 ft. (~170 m) from the end of the discharge canal and occurred at low tide. This finding concurs with the MIT work done in the 1970s (see above). The maximum width of the 1°C isotherm in the EG&G study was about 130 ft. (40 m) and occurred about 260 ft. (~80m) offshore. Temperatures above the 1°C level affected smaller areas. Isotherms ≥9°C affected about 0.12 acres at low tide.

Based on data from these studies EG&G researchers found (as did MIT from the studies outlined above) that as the tide moved from low to high the plume separated from the bottom beginning at the points farthest from the discharge. The most distant points of the bottom that were in touch with the plume (about 110-170 meters from the discharge) began to lose a temperature-signal from the plume as the tide rose after low tide. The terminal end (point of greatest distance from the discharge canal) of the plume's contact with the bottom moved towards the point of discharge during the rising tide. By mid-tide the plume was often in contact at about the 50-80 meter point, but typically not beyond this point. As the tide height increased beyond the mean-tide level the plume's contact with the bottom continued to decrease. Although no thermistors were located closer than 50 meters from the discharge canal, EG&G speculated that that at high tide the discharge plume separated from the bottom very near the end of the discharge canal (supporting MIT's findings).

In addition to characterizing the footprint of the plume dimensions on the ocean floor as summarized above, EG&G also hypothesized that if a number of environmental conditions[1] were to change, the bottom areas affected by the plume could exceed those described above from 4-7 times.

EG&G's field data support those of MIT from the mid-1970s which were discussed above, and demonstrate that the thermal plume affects only a relatively-small area of the ocean floor adjacent to PNPS.

Summary of Physical Water Temperature Characterizations: The PNPS 001 thermal discharge is released to Cape Cod Bay. The near-field shape of the plume and its degree of contact with the bottom are constantly changing throughout the tidal cycle. At stages near low-tide, the plume has its greatest effect on the bottom, but due to the slope of the bottom adjacent to the facility, the large tidal range (about 10'), and other variables, the most extensive measured plume effects (heat and velocity) to the bottom have been limited to about an acre or less although, in theory, plume effects to the bottom could be up to seven time that value. Due to its buoyancy, the bulk of the plume rises to the surface and its horizontal spread increases with distance from the point of release. The far-field shape and physical location of the plume vary greatly and are influenced by a number of factors. Far-field delta temperatures of 1°C from background are typically found in only the top 3-8 feet of the water column. Heat in the plume is extracted both by surrounding water and by the atmosphere. The rate of release of plume heat to the atmosphere is greatly affected by wind velocity, the difference between ambient air temperature and water temperature, humidity, tidal stage (which affects the horizontal and vertical shape of the plume) and other factors.

[1] The EG&G survey occurred during an "average" tidal stage, i.e., neither neap nor spring. If the study had been conducted during spring tides, during which the greatest tidal amplitudes are seen, the linear extent to which the plume touched bottom would have been greater than seen in the EG&G survey. In addition, if there were strong northwesterly winds and cooler temperatures, these conditions encourage down-welling which tends to push the plume deeper and somewhat farther offshore.

Because the shape of the plume is constantly changing throughout the day, from day to day and throughout the seasons, there is little consistency to the location of the impact of the far-field plume on water temperatures. The effect of the plume on near-field temperatures is much more consistent although it changes dramatically throughout the tidal cycle. In tidal periods around and including low tide, the plume can interact directly with the bottom to a distance of about 700 ft. (but changes with the degree of tidal fluctuation which varies over the course of each month and seasonally). As the tide progresses from low to high and the height of the water column increases, the plume lifts from the bottom but spreads to a much greater extent in the far-field.

Long-Term Warming Trends in Cape Cod Bay

The company has records of intake temperatures at the plant since at least 1976. Intake water temperatures are measured by two Resistance Temperature Detectors (RTDs), each in front of the 2 main circulating water pumps in the CWIS (screen-house) at elevations well-below mean low water. Because there is about a 10 ft. tidal range at this site, and the RTDs are stationary, the water depth at which these temperature elements collect information varies with tidal stage. Measurements taken by these two elements are averaged together by the facility and compiled every 10 minutes. This arrangement of thermistors is thought[2] to have been in place since about the time the plant was first built, although record keeping has evolved from hand records (hourly) to computer-assisted.

Based on a review of the 1976-2012 monthly average temperature records from the company, the Massachusetts Department of Environmental Protection (MassDEP) concludes that there has been a rather substantial thermal rise in intake temperatures over that period. Because heat from the discharge can be affecting intake temperatures, the intake temperatures recorded at the facility may not accurately depict ambient ocean temperatures. However, the facility's rate of heat release into the bay has not undergone a gradual increase since the time when the facility went on-line (although there have been extended "outages" and occasional reductions in plant capacity) and it is logical to assume that the impact of the discharge on intake temperatures has been fairly constant over the period of record. Given the above, MassDEP assumes that any long-term thermal rise over this period is due to a more widespread phenomenon than the PNPS release of heat to Cape Cod Bay. PNPS average monthly reported values for intake temperature are presented in Table 1. Note that some of the monthly values are missing from the record (20 missing values from a total of 444 possible values in the 37-year dataset).[3] In order to develop yearly averages, each month of any particular year must have a value. To estimate the missing values, the agency performed a regression of each month over all years in the dataset and used the statistically-generated regression values for the months with missing values.

[2] Information pertaining to the placement and measurement frequency of temperatures measurements is based on an e-mail (April 25, 2013) and a phone conversation (May 6, 2013) between Gerald Szal, MassDEP and Joseph Egan, PNPS.

[3] the reader should note that there are several outlying datapoints in 1993 and 1994 that appear suspicious to MassDEP but the agency has not been able to access original records to check these data.

There was a significant ($p<0.00002$) rise in the mean average intake temperature at PNPS over the 1976-2012 period (see Fig. 1) of about 0.058°C (0.1047°F) per year. This rise is about 45% higher than the yearly rise (0.04°C) noted by Nixon (2004) for the 1970-2002 period based on daily temperature measurements collected off a dock at Woods Hole, MA.

MassDEP also developed seasonal regressions for "winter" (December, January and February), "spring" (March, April and May), "summer" (June, July and August) and "fall" (September, October and November) to provide additional comparisons to the work conducted by Nixon who evaluated "winter" and "summer" using the same months indicated above, and also to provide input for the two remaining seasons. Note that certain monthly values in the PNPS dataset over 1993 and 1994 are exceptionally low compared to other years and the agency is concerned that the method of measuring temperatures over those months may have changed (e.g., only one of the two thermistors may have been registering temperatures, or the record keeping during this period changed due to a personnel change). Based on these regressions seasonal rises over the period of record and the p-value for the regressions were as follows: 1) winter: 2.13°C (3.83°F; $p<0.003$); 2) spring: 2.07°C (3.72°F; $p<0.002$); 3) summer: 1.9°C (3.42°F; $p<0.01$); and fall: 2.28°C (4.11°F; $p<0.003$).

Given these figures, the seasonal rise (on a yearly basis) ranged from a low of about 0.053°C to a high of about 0.063°C. Both the winter and summer seasonal rises are greater than those found by Nixon, *et al*. (2004) for the same seasons. All four seasonal rises reported above for the PNPS intake are statistically significant ($p<0.01$) which means that it is highly unlikely that there is no rise in temperature and it is highly unlikely that the rises seen are simply due to chance.

Based on the regressions discussed above, there has been a statistically-significant warming trend in both the intake and in surface waters in Cape Cod Bay over the 37-year period of record.

In its May 17, 2012 letter to the NRC, NOAA (2012) states that ocean temperatures in the northeast have been increasing and notes that if new information regarding climate change became available, re-initiation of their consultation with the NRC might be necessary:

> "*For example, there has been an increase in Boothbay Harbor's (Maine) temperature of about 1°C since 1970, and that, assuming that there is a linear trend in increasing water temperatures and decreasing pH, one could anticipate a 0.03-0.04°C increase each year, with an increase in temperature of 0.6-0.8°C between now and 2032 and a 0.003-0.004 unit drop in pH per year, with a drop of 0.06-0.08 units between now and 2032. Given this small increase, it is not likely that over the proposed 20-year operating period that any water temperature changes would be significant enough to affect the conclusions reached by us in this consultation. If new information on the effects of climate change becomes available then reinitiation of this consultation may be necessary*." (See pg. 28 of the NOAA letter to NRC)

As we noted above, the yearly rate of increase over the 37-year PNPS intake temperatures was 0.058°C which is well above the 0.03-0.04°C used by NOAA in their analysis. Given this, NOAA will have to decide if the PNPS intake data and the yearly temperature rise based on those data constitute "new information on the effects of climate change" sufficient to re-initiate consultation with the NRC regarding the PNPS license.

Biological Assessments of Thermal Plume Impacts

Impacts of the PNPS thermal discharge (Discharge No. 001) on marine organisms can occur from an array of different attributes/effects of the discharge, including but not limited to: heat; the rapid loss of the heated discharge, potentially resulting in "cold shock"; chemical (e.g., chlorine) additions to the discharge; alterations of the physical/chemical state of constituents naturally found in water (e.g., super-saturation of nitrogen); the high-velocity of the plume; and interactive effects among two or more of these and/or other variables. Back-flushing of heated water through the facility creates short-term heated plumes in the intake embayment as well, and organisms in this area are subjected to many of the same variables listed above, but to a much lesser degree.

The first scientists involved in evaluating the plume impacts at PNPS (see summaries in Boston Edison, 1978) used a "before/after, control/impact" ("BACI") research design. PNPS began operating in late 1972 and prior to this two years of pre-operational data were collected from "control" sites during this "before" period. After operations began, data were collected at the same sites, some of which had now become "impact" sites. Due to the great variability from season to season in physical, biological and chemical constituents of marine environments, these studies cannot properly be considered to have had a "controlled" component, as one might have in a laboratory study, because researchers were unable to control anything but the placement of the sample locations. Thus, the term "control site" is a misnomer. More correctly, these studies compared data from reference sites far-removed from "likely" plume effects, to data collected from test sites, i.e., those more likely to have been affected by the plume. The latter sites were located in areas that were in the direct path of the plume and/or directly adjacent to the discharge.

After these initial thermal plume studies were completed, biological, chemical and physical monitoring continued but with certain modifications. Most of the later monitoring studies were also designed to compare characteristics of "test" areas (i.e., areas directly in the path of the plume) to "reference" areas (areas distant from the plume). When fish kills occurred or when fish appeared stressed, special studies (both laboratory and/or forensic autopsies) were conducted to determine the potential cause(s) of mortality/stress. Impacts of the thermal plume based on these evaluations are characterized below.

The two primary contractors from initial studies through about year 2000 were the Massachusetts Division of Marine Fisheries (DMF) which was contracted by PNPS to conduct much of the lobster, fisheries and diver-assisted thermal-effects mapping, and Marine Research Incorporated (MRI, recently purchased by Normandeau Assoc.) which was contracted to conduct impingement, entrainment and certain other PNPS impact evaluations from initial studies through present.

<u>Plankton Studies</u> (Summarized from Toner, 1984): Beginning in the early 1970s, MRI was contracted by PNPS to evaluate entrainment effects on phytoplankton, zooplankton, fish eggs and larvae and lobster larvae. MRI conducted an abundance and distribution analysis of Cape Cod Bay ichthyoplankton during 1974-1977. The study was discontinued having demonstrated minimal impacts. It should be noted that ichthyoplankton studies continue today at PNPS that are specifically designed to evaluate entrainment effects of the PNPS operations. Although the Toner (1984) study primarily addressed entrainment effects, it is included here as many of the samples collected were considerably off-shore and have the potential to inform concerns about indirect effects to right whales that may be thermally-influenced.

Copepods: Toner (1984) reported on collections of monthly mid-depth samples at the PNPS intake and discharge stations and at offshore stations (the farthest off Rocky Point was about a mile from shore; one in Plymouth Bay was about 1.5 miles from shore) where samples were collected at various depths. Zooplankton densities in these samples exhibited seasonal cycles that varied over several orders of magnitude throughout the year, reaching highest densities in August, and minimum densities in January through February. Copepods dominated the samples, especially *Acartia clausi* and *A. tonsa*. Species of *Calanus* were found at both inshore and offshore stations in moderate densities. *Calanus finmarchicus*, one of the species targeted by right whales (see below), was present at in-shore stations as early as April 22 and was collected through August with densities typically in the 100s per m^3, sometimes exceeding 1,000 per m^3. *Pseudocalanus minutus* also occurred in moderate densities and was consistently present throughout the year (about 1,000 individuals/m^3). Certain species of *Pseudocalanus* are also fed upon by right whales.

Due to enormous variability in the makeup of copepod samples, Toner was unable to detect differences among the three off-shore stations and was thus unable to detect impacts from PNPS. These three stations were aligned perpendicular from shore in the direct line of sight of the effluent discharge channel. However, the author reported that higher densities of three species (*Oithona similis, Acartia clausi and Pseudocalanus minutus*) and nauplii were found in deeper[4] sections of the water column at all stations than were found at shallower depths. These findings suggest that the depth-related distribution of these copepods could be due to copepod avoidance of the thermal plume. However, the author suggested that depth-related abundance differences in these species might be due to diurnal migrations as had been found with *Acartia tonsa* in another study. Toner's studies were all conducted during the daytime so he was unable to test this hypothesis.

Bivalve larvae: Toner also studied the spatial distribution of bivalve larvae which are pelagic and are released into the water column in this area from late May through early April. Over the course of the year, bivalve densities ranged from zero to 100,000 per cubic meter. A non-parametric statistic (Mann-Whitney U-test) was used to determine if various groups of these larvae were more abundant at stations near the power plant than at stations farther off-shore at specific points in time. In 22 of 48 tests, a significant difference was seen and indicated that larvae were less abundant near the facility than farther offshore. Toner was not able to discern,

[4] Depth: Toner did not provide specifics on depth for this statement, although samples were collected at 0,3,6 meters at the station nearest shore and at 0,3,6,9 and 12-meter depths at the station farthest from shore.

however, whether the differences seen were due to entrainment or thermal effects, displacement of coastal water by the discharge, localized currents, none of the aforementioned or due to a combination of these and/or other effects. Toner did not conduct a comparison between outage years and operational years. This information could have shed some light as to whether or not the differences between on-shore and off-shore stations were related to PNPS operations but additional work would have to be done to determine whether differences were due to the plume, intake effects, or other variables.

Comparisons with Mt. Hope Bay: Densities of phyto- and zooplankton in Cape Cod Bay were compared by Toner to those in Mt. Hope Bay where MRI had done work for the Brayton Point power plant. Toner reported that the average phytoplankton density in Cape Cod Bay was only about 20% of that found in Mt. Hope Bay. Zooplankton densities were, as expected, also lower in Cape Cod Bay and averaged about 23,000 per m^3 compared to 94,500 per m^3 in Mt. Hope Bay, yielding a ratio (0.24) nearly the same as that of the two phytoplankton densities. The only conclusion drawn with regard to the differences between the two areas was that the Mt. Hope Bay system was much more productive than Cape Cod Bay due to higher nutrient levels in the former system.

Zooplankton and the North Atlantic right whale:

A number[5] of north-Atlantic right whales (*Eubalaena glacialis*) move into Cape Cod Bay each year, and some stay throughout the year. This species population is on the federal Endangered Species list and subsists primarily by feeding on high-density populations of certain zooplankton including species of *Calanu*s and *Pseudocalanus*. Right whales in Cape Cod Bay have typically remained in the western portion of the bay. However, on April 29, 2013, the following advisory appeared on the Massachusetts Division of Marine Fisheries Website:

HIGH RISK AREA FOR RIGHT WHALES IN WESTERN CAPE COD BAY

A large and stable aggregation of endangered North Atlantic right whales has been documented in western Cape Cod Bay, many of them outside the boundary of the Critical Habitat. The Division of Marine Fisheries is issuing a High Risk Advisory in this area due to the number of whales, their behavior, and their proximity to vessel traffic. Approximately 60 - 80 whales were seen surface and sub-surface feeding in a wide swath near the shipping lanes, from Green Harbor down to Sandwich. Dense concentrations of zooplankton at the surface and just below the surface are attracting the whales to this area. Whales feeding in this manner are incredibly difficult to see and at great risk for vessel strike. Vessel strike is a major cause of human-induced mortality for right whales. For the safety of both mariners and whales, **vessel operators in this**

[5] NOAA (2012) stated that the estimated number of right whales in Cape Cod Bay in 2005 was at least 365 individuals.

area are strongly urged to proceed with caution, reduce speed (less than 10 knots), and post lookouts to avoid colliding with this highly endangered whale.

(Taken from:
http://www.mass.gov/dfwele/dmf/marinefisheriesnotices/2013/right_whale_advisory_043013.htm)

Based on the map provided on the DMF website on April 30, 2013, the PNPS discharge is in the approximate center of the High Risk Area, and thus, in the center of the area frequented by right whales at the time the DMF advisory above was developed. Their presence in the area is apparently due to high-densities of zooplankton. According to the May 17, 2012 letter from NOAA to the NRC (NOAA, 2012) regarding the re-licensing of PNPS, it is highly unusual for right whales to occupy this area of Cape Cod Bay, as, prior to the sightings referenced above, there had been only six sightings records (5 definite, one probable) of 12 right whales within 2 miles of the PNPS discharge since 1997.

In addition, DMF[6] reports that a mother right whale and a calf were observed very close to shore off PNPS. It is possible that the mother and calf were partially warmed by the PNPS thermal plume. According to DMF right whales usually bear their young off the coasts of Florida and Georgia. This begs the question whether or not the presence of the thermal plume played a role in modifying the more typical migratory and birthing patterns of this particular right whale.

One of the issues investigated by NOAA in their 2012 letter to the NRC was whether or not the discharge of heat from PNPS might be having a negative effect on the right whale's food supply within Cape Cod Bay. NOAA concluded the following relative to this issue (but in the entrainment-related impact section of their letter):

> "*While there may be significant annual variability in copepod abundance (sic) and associated right whale foraging in the Bay, which is thought to be due at least party (sic) to weather and oceanic conditions (e.g., differences in 2010 as compared to other years are thought to be due to the changes in the Western Maine Coastal Current (Stamieszkin et at (sic).. 2010), the available information does not suggest that there has been a long-term negative trend in copepod abundance or distribution or right whale abundance or distribution since the Pilgrim facility became operational that may be attributable to operations of the facility*." (See pg. 12 of the NOAA letter to NRC)

NOAA analyzed the potential effect that the facility's discharge might have on oceanographic features that interact to aggregate copepods. Right whales feed on dense aggregations of certain copepods and any factor that would serve to destabilize these aggregations could be detrimental to right whales. NOAA's comments on this subject include the following:

[6] June 3, 2013 e-mail from Erin Burke, MA DMF to Gerald Szal. Ms. Burke's e-mail (in part) reads: "In January 2013 a right whale mother and calf spent a couple weeks in the shallow waters off Plymouth, including areas off Gurnet Light and the PNPS. Based on physical characteristics, the calf was believed to be around two weeks old and born in the Northeast, although we don't know exactly where. This is highly unusual, as calves are typically born off Florida and Georgia. Many scientists were concerned about the effect of the cold water temperatures on the calf's ability to thrive."

"*Several factors are thought to concentrate copepods in Cape Cod Bay. These include currents and circulation patterns, bathymetric features (basins, banks, and channels), oceanic fronts, density gradients, and temperature regimes (Wishner et al.. 1988, Mayo and Marx 1990, Murison and Gaskin 1989, Baumgartner et al.. 2003a, Jiang, et a12007, Pace and Merrick 2008). The major oceanographic features include the Maine Coastal Current (MCC), Georges Bank anticyclonic frontal circulation system, the basin-scale cyclonic gyres (Jordan, Georges and Wilkinson), the deep inflow through the NEC, the shallow outflow via the Great South Channel and the shelf-slope front (SSP) (Gangopadhyay et al.. 2003, Pace and Merrick 2008). It is also thought that some variability in the availability of copepods is linked to water temperature changes associated with the North Atlantic Oscillation (Greene at al. 2004). It is thought that these features combine to result in conditions that affect the distribution of copepods throughout the Gulf of Maine, including Cape Cod Bay. We have considered whether the thermal plume from Pilgrim could affect any of these conditions in a way that would affect copepods and therefore, foraging right whales. However, because these conditions and patterns are regional to global scale, and temperature increases from Pilgrim are not detectable at distances more than 1.4 miles from the outfall, it is extremely unlikely that any of these conditions would be affected by the thermal plume. Therefore, it is extremely unlikely that the factors that serve to aggregate copepods in Cape Cod Bay would be affected by continuing operations of Pilgrim.*" (From pgs. 24 and 25 of the NOAA letter to NRC)

NOAA's analysis includes the following relative specifically to the heated discharge and direct effects to zooplankton utilized by right whales:

"*Copepods are mobile and can move through the water column. During the time of year when right whales are foraging in Cape Cod Bay (January -May), ambient water temperatures are typically 0-10°C. Copepod distribution is not likely to be affected at temperatures below 21°C (see citations referenced above). At ambient water temperatures of 11.5°C and below, the area which would experience an increase in water temperature more than 11°C above ambient is limited to less than 0.5 acres (see table 5.1-1 in ENSR 2000); the area at the bottom which would experience temperatures this high is less than 0.13 acres. Given the small size of the area where the distribution of copepods would be affected (0.5 acres; less than 0.0002% of the surface area of Cape Cod Bay) and that copepods are likely to avoid the area rather than be injured or killed, any effect to foraging right whales is extremely unlikely.*" (from pg. 24 of the NOAA letter to NRC)

<u>MassDEP conclusions regarding Zooplankton:</u> Given the information discussed above, MassDEP concludes that there is no evidence that the facility's heated discharge into Cape Cod Bay has had a significant deleterious effect on zooplankton populations within the bay or on the behavior of right whales within the bay but retains the right to change that conclusion based on further input from NOAA. This statement, and other conclusions made in the thermal effects section of the Fact Sheet, do not take into account the effect of heat on organisms passing *through* the plant. Effects due to the entrainment of organisms into and through the plant, and heating to those organisms that takes place during their transit through the facility, are dealt with in the 316(b) section of the Fact Sheet.

<u>Benthic flora:</u> A number of benthic evaluations of flora adjacent to the Pilgrim discharge were conducted from 1969 through 1999 to characterize effects of the Pilgrim thermal discharge on organisms inhabiting the seafloor adjacent to PNPS. These included studies of both commercial and non-commercial flora.

<u>Irish moss:</u> The effect of the facility's discharge on the commercial harvest of Irish moss (*Chondrus crispus*) was evaluated by DMF (Lawton, *et al*., 1992) in the first years of impact studies at PNPS. At the time (the early 1970s) Irish moss was being collected by workers in small boats using rakes. DMF estimated that the local harvest of Irish moss during the period of study was between $10,000 – $25,000.00 per year (based on 1983 wet-weight prices). Landing data were collected from 1971-1977 which included two years of pre-operational information and five years of operational data. The approximate wet weight of Irish moss collections from eight different harvesting "zones", stretching from Warren Cove to the northwest of PNPS to Manomet Point to the southeast, was tallied over these years and compared.

The DMF scientists conducting this work concluded that natural fluctuations in Irish moss abundance had a major effect on moss harvest and that these fluctuations were so high that they exceeded any alterations that could possibly be attributed to PNPS operations. Although no statistically-significant differences were seen in the area that received the thermal discharge from Pilgrim, compared to other areas during pre- and post operations, DMF personnel estimated that about 10% of the test area (one of the harvest zones) had been negatively affected by the PNPS discharge (see also: Pilgrim Nuclear, 1978; and Lawton, et al., 1984)

<u>Algae in intertidal and subtidal Zones:</u> Algal evaluations (reported by Grocki, 1984) of the intertidal and subtidal zones adjacent to PNPS were conducted at four sites from Rocky Point through Manomet Point, from 1974 through 1981 including a test site (i.e., near the effluent discharge; this site had two stations) and 3 reference sites (with 1-2 stations apiece). These studies characterized patterns of species richness, dominance, community structure and biomass and examined whether or not any differences between sites might be attributable to PNPS operations.

More species were captured at test stations than at reference stations; in addition, four "warmwater" taxa not normally seen north of Cape Cod were regularly found at the effluent station but not at reference stations. These are: *Bryopsis plumosa, Codium fragile, Gracilaria folifera and Soliera tenera*. Grocki states that the distribution of these species north of Cape Cod is restricted to the "warmer waters of shallow bays and estuaries and occurs only during the summer months". All four warmwater taxa were collected from a small area of a few meters from the discharge plume at the end of the discharge jetty. Grocki attributed their settlement in this area to the thermal discharge. They were not found in other areas and did not appear to decrease the number of indigenous species found at the discharge station in comparison to other stations. A fifth species, *Enteromorpha aragonensis*, was also found at the effluent station but not at reference stations, and the significance of its exclusive presence at this station was not determined. In addition, sub-tidal habitats at the effluent site exhibited significantly lower biomass of *Chondrus crispus* than the reference stations. This was attributed both to scouring effects of the discharge as well as a somewhat different habitat type than the other sites. No attempts were made to map the extent of the area where differences in algal metrics were detected.

Near-shore macrofaunal benthic evaluations were conducted from 1969-1998 using several different approaches. Although differences were seen between the stations in the direct path of the effluent compared to reference stations, the only studies that were useful in delimiting the areal extent of the thermal plume effects on the benthos were those that employed divers that directly measured the distance on either side of the central line of the plume that was devoid of *Chondrus crispus* or where the growth of this macroalga was visually "stunted" compared to *C. crispus* growth farther distant. The dive surveys took place from 1980-1998 and the diver observational information along with temperature and plant operation data were statistically analyzed (see: ENSR, 2000, *in* Entergy, Semiannual report #55, Jan.-Dec. 1999). Results of the analysis revealed that the denuded zone increased greatly in the warmer months compared to the winter and that the size of the denuded zone was positively correlated with the monthly mean power output from the plant.The total area of stunted and denuded zone was relatively small and ranged from much less than an acre to slightly greater than one acre. The greatest area observed to be affected (stunted zone) through these surveys was about 4,500 m^2 (**about 1.1 acres**).

> **MassDEP conclusions regarding Benthic Flora**: Based on the information available to date, effects of the PNPS thermal plume on benthic flora appear to be *de minimis.*

Benthic Fauna:

Commercial Lobster Fishery (Summarized from Lawton, *et al*., 1984b**):** In the 1970s, DMF compared data pertaining to the growth and movement of lobsters in areas adjacent to Pilgrim to data for the same variables from reference areas (i.e., areas far removed from the thermal plume). A lobster tag-and-retrieval program was conducted from 1970-1975 during which 50-100 lobsters, 64-81 mm carapace length were measured, tagged and released on each of the three ledges near PNPS (from northwest to southeast: Rocky Point, White Horse Beach and Manomet Point, respectively) three times each year. Additional individuals were tagged and released on an off-shore ledge (Coles Hole) located north of the facility. Tag-return data (from about 49% of the tagged lobsters released) indicated that movement was localized and primarily toward adjacent ledges. Dispersal of the lobsters at the test site (Rocky Point) and at the reference site (Manomet Point) was similar during both pre- and post-operational years. In addition, there was no significant ($p>0.05$) difference in lobster growth between these two areas in pre- vs. post-operational years.

DMF also studied the commercial catch of lobsters in lobster pots from 1970-1976 in areas adjacent to PNPS and from reference areas to evaluate potential effects of the PNPS discharge on harvest rates. A sampling grid was constructed of 0.8km^2 cells and catch records were kept separately for each cell. Three cells (two entire and one partial cell along the shoreline) were considered to be "surveillance" cells (henceforth called test cells) as they were closest to the discharge and were known to be affected by the plume at the bottom. Cells outside that area were considered to be "control" cells (henceforth called reference cells). Study design was such that reference and test cells used in the comparison were from similar depths and substrate types. During the study period, DMF sampled 22,519 lobster pots and acquired information on 73,398 lobsters. Four possible thermal effects were evaluated: alteration of growth rate; change in size at lobster maturity; onset of molt; and change in catch rate. This last metric was assumed to reflect abundance changes.

No detectable differences were seen between test and reference stations in the overall size composition of lobsters caught in pots. There was a slight increase in the numbers of small, mature ("berried", i.e., egg-bearing) females found in the test areas during operational periods compared to non-operational periods. No differences were seen in the time of onset of molting in the test areas vs. the reference areas, and the catch rate of legal lobsters was not statistically different ($p>0.05$) in test and reference quadrants. In summary, DMF found no statistically-significant impacts from the PNPS discharge on the commercial harvest of lobsters. A long-term annual decline in catch rate was noted throughout the study area (both near and distant from Pilgrim) and DMF personnel suggested that this might be due either to fishing pressure and/or to natural temperature trends.

Benthic Fish Assessments via Otter Trawl (summarized from Pilgrim Nuclear, 1978; and Lawton, et al., 1984b): Personnel from DMF conducted a benthic fish sampling program over the years 1970-76 using an Otter Trawl. The period evaluated included three years of pre-operation and four of post-operation. Three areas of Cape Cod Bay were studied: two reference stations (stations 1 and 3) and one test station (station 2), nearest the outfall. Sampling was conducted bi-weekly at each station over the study period. Each tow of the trawl was 20 minutes in duration and tows were approximately 0.75 nautical miles in length. A total of 843 tows were made and 43,502 fish were captured. Fish were keyed to species (when possible), and their lengths recorded. Forty-one different taxa were collected. Six taxa were dominant and comprised 91.4% of the total catch. These were: 1) winter flounder, *Pseudopleuronectes americanus* (46.7% of the catch); 2) ocean pout, *Macrozoarces americanus* (12.4%); 3) yellowtail flounder, *Limanda ferruginis* (12.2%); 4) longhorn sculpin, *Myoxocephalus octodecemspinosus* (8.6%); 5) windowpane, *Scophthalmus aquosus* (5.8%); and 6) skate, genus *Raja*, which was not keyed to species (5.7%). According to DMF, this assemblage is typical of other northern-temperate fish communities. Trawl data were assessed in terms of catch per unit effort (CPUE) of sampling.

Over the 1970-75 period, Annual Mean Catch per Tow (i.e., CPUE) at all three stations dropped precipitously. From 1970-1973, the CPUE at the test station (station 2) was intermediate between the two reference stations (1 and 3). In 1974 it fell below both of the other two stations, then rose to nearly the same as the higher of the other two stations in 1975. At the end of 1975 it was slightly below that at the other two stations.

Based on these data, DMF concluded that there was no detectable difference between the CPUE in overall catch at the test station compared to the two reference stations due to a change from pre- to post-operations. Additionally, DMF saw no statistically-significant differences between test and reference stations in the study period after operations began.

A second component of the DMF analysis was an inter-station comparison of densities of each of the most abundant fish. CPUE for winter flounder and yellowtail flounder at the test station was, for the most part, between that from the two reference stations. However, for Ocean Pout, the CPUE at the test station was consistently higher (i.e., "better") than that at the other two sites throughout the study period. For skates, the CPUE at the test station was consistently higher than that at one of the reference stations (Station 3) but was both higher and lower than that at station 1, depending on the year in question. Skate CPUE decreased at both stations 2 (the test station) and 3 in 1972 but later rebounded at both stations. Because the effect took place at both the test station and one reference station, negative changes in CPUE were not judged to have been due to the discharge. Longhorn sculpin and windowpane fared similarly: annual mean catch for each at the test station was typically intermediate between that at the two reference stations and did not appear to change in any different manner after Pilgrim operations began.

DMF researchers (Pilgrim Nuclear, 1978) reporting on the trawl results conclude that the PNPS thermal discharge had no apparent deleterious effects on the overall abundance of benthic fish over the period of study (1970-1975) or on the densities of the five most commonly-found taxa. These same researchers publishing at a later date (Lawton *et al.* ,1984) added that after the dramatic declines seen in groundfish stocks over 1970-1974, CPUE for certain species (e.g., winter flounder, yellowtail flounder, windowpane and skate) increased substantially in 1975, and/or 1976 even though the facility was operating over these years. The Otter Trawl studies were continued through 1981, although in the last year the frequency of sampling was reduced. No findings of impact at the test station, compared to the reference studies, were noted during the 1970-1981 period when the 3-station Otter Trawl program was in effect.

Near-Shore Benthic Assessments via Shrimp Trawl. In 1981, DMF instituted the use of a Shrimp Trawl to sample near-shore stations in the vicinity of the Pilgrim discharge. This trawl was smaller than the Otter Trawl and was pulled by smaller boats allowing more maneuverability around lobster buoys that were in high concentrations near to Rocky Point where the Pilgrim discharge is located. This program consistently sampled a "Surveillance" (i.e., "test") station in front of the discharge and two reference stations. The latter were located in Warren Cove and northwest of Priscilla Beach. All stations were trawled monthly from January-March and biweekly from April-December during the daylight hours (See: Pilgrim Nuclear, 1990). Station selection was based on bottom types, depth contours, available substrate for trawling and known patterns of the thermal plume. The program continued into the 1990s with duplicate tows at each station; the tow duration increased from 10-minutes to 15-minutes over the course of the program. Catch per unit effort was used as a measure of relative abundance and because year-to-year trends were evaluated as a ratio of CPUE between reference and test stations, the difference in tow duration should not affect the long-term analysis. Catch figures for replicate tows were averaged for each station (by species) to produce mean catch estimates.

One of the methods used to evaluate station impacts in this program was to analyze catch information by species. In the annual report for 1984, DMF reviewed the mean catch per unit effort by year over the 1981-1984 period. Catch rates (i.e., per unit effort) of winter flounder were lower in Surveillance (i.e., "test") station 3 than at Reference Station 1, but catch rates of yellowtail flounder and skate spp. were higher at the Surveillance station than at the reference station. If the abundance of these species was influenced by the thermal discharge, one would expect that the catch rates would have changed if the company stopped discharging. 1984 was an "outage" year for the facility and the discharge was much reduced that year. Relative abundances of the three groups mentioned above did not undergo any noticeable changes in 1984 compared to other years, i.e., winter flounder catch rates in the surveillance station remained low compared to the catch rates at the reference station, and the relative abundances of yellowtail flounder and skate spp., also remained similar between Reference Station 1 and Surveillance Station 3. As a result, DMF surmised that the PNPS thermal discharge did not have any measurable effects on the relative abundance of the most abundant species, and that slight differences in habitat structure were responsible for the consistent differences seen between sites in the catch rates of different benthic species.

DMF added a second surveillance station to the near-shore trawling program in 1984. This new station was located in the intake embayment. There is no continuous thermal discharge at this site (unlike at Station 3) but only occasional thermal backwashes that could potentially impact the fish community. DMF found that length frequencies for little skate, and winter flounder were different between the intake station and reference station 1. For both species, there was a disproportionate abundance of smaller fish at the intake station relative to the size distribution at the reference station. DMF concluded that this was probably a difference of habitat but also that this put certain individuals of these two species at greater risk to intake effects because smaller fish are more susceptible to being drawn into the intake than are larger fish.

Several additional "outage" years occurred in 1984, 1986, 1987 and 1988 where the capacity factor was either near zero (1984, 1987 and 1988) or less than 20% (1986). Data from these years were compared to years when the operational capacity of the facility was 80% or greater (see Semi-Annual Report #33, January – December, 1988 and Semi-Annual Report #35, January-December, 1989). During the low/off operational years, current moving through the canal was variable, but heat was negligible during the outage period. Annual mean trawl catch per unit effort (CPUE) was used to measure changes in relative abundance in the three most abundant benthic species, winter flounder, little skate and windowpane.

Changes in the relative abundance between the primary Surveillance (Station 3) and Reference (Station 1) stations (i.e., whether one of these stations showed a higher abundance than the other) did occur for winter flounder in 1986 and 1987 but not in 1984 and 1988 (1989 was a "low-operational" year – about 30% capacity - and cannot be evaluated in terms of the low/no capacity format mentioned above). No changes in relative abundance were seen over the 1981-89 period for little skate. Changes in the relative abundances of windowpane between these two stations only occurred in two of the nine years of the study.

Based on this information, DMF concluded that the relative abundances between reference and test stations did not follow a pattern expected if the discharge was having a direct effect on these fish species.

DMF also compared the size distributions of winter flounder in the two sites in different seasons and found that in both summer and fall, the relative proportion of small winter flounder was much greater in the intake than in the reference station. DMF concluded that this contributed to the risk of winter flounder and coupled that with impingement information that showed high impingement rates of small (5-12mm total length) flounder.

Rather than continue reporting on specific gear types, DMF changed the format of impact reporting after 1989 to reporting impacts on specific indicator species. Additional information on the benthic trawls can be found in the section of this Fact Sheet entitled Thermal Effects to

Target Species.

> **MassDEP conclusions regarding lobsters and benthic fish:** Based on the information available the agency considers impacts of the PNPS thermal plume on lobsters, and on benthic fish studied through the Otter Trawl and Shrimp Trawl programs, to be *de minimis*.

Pelagic and In-shore Fish Assessments:

Haul-Seine Program (summarized from Kelly, *et al*., 1992)**:** Haul-seine surveys of near-shore fish were conducted by DMF from 1981-1991 to evaluate, in part, the potential effects of thermal backwashes on the population of fish residing in the intake canal at PNPS but also to evaluate potential intake effects. Six stations (five reference and one test station) were located along the western shoreline of Cape Cod Bay and into Kingston Bay, from White Horse Beach in the south-east, to Gray's Beach, within Kingston Bay to the north-west. The single test station was located within the PNPS intake embayment. DMF personnel used a 45.7 m x 1.8 m mesh net with 0.20 in openings. The net, when deployed, enclosed about $225m^2$ of bottom. Over the 11-year period, 185,000 fish were captured representing 46 different species. Two sets were made at each site on a sampling day. The program evaluated three different metrics among sites: a) relative abundance of Atlantic silverside (*Menidia menidia*) which was typically the most abundant species at all sites; b) relative abundance of winter flounder, a commercially important species; and c) species diversity.

No statistically-significant trends in either the relative abundance of silversides or winter flounder were seen at the test site compared to the reference sites. Over all years of study combined, species diversity was highest at the test station and lowest at the sites that were more open-coastal in nature. In summary, based on an 11-year study of trends at these stations, no negative effects of heated backwash on the near-shore fish community were seen.

Gill Net: Over the 1971-1976 period, DMF deployed a 600' by 10' six-panel (each panel with a different hole size) gill net along the 10' depth (at MLW) contour, just adjacent to the direct line of the thermal discharge from Pilgrim. This net was set over-night and fish were collected the day following the initial set. This work was conducted to determine if there were noticeable trends in species composition and/or abundance in pre-operational datasets vs. those from post-operation. The study yielded 17,072 fish, comprising 25 species in 99 gill net sets. Four species comprised >80% of the total catch: Pollock, *Pollachius virens* (39.0%); Atlantic herring, *Clupea harengus harengus* (17.8%); cunner, *Taugogolabrus adspersus* (13.0%) and alewife, *Alosa pseudoharengus*.

DMF concluded from the Gill Net studies in the early-to-mid-70s that PNPS had little or no influence on pelagic species near the ledges that were adjacent to the PNPS discharge. Although there was an apparent local decline in the abundance of cod (one of the less abundant fishes) it was not determined whether the decline was due to sampling bias, or a real decline. No trends were apparent from a review of the data that would implicate the facility in negative impacts to either overall catch, or catch of individual species.

Gill Net studies continued at PNPS through the early 1990s. These studies were focused on long-term trend analyses in which particular species were monitored for changes in abundance that might be associated with changes in PNPS capacity factor. Although large differences were seen in pelagic species caught in the gill net deployed in the direct path of the thermal discharge, no statistically significant differences in species abundances were found to be related to plant capacity factor over the course of these studies.

> **<u>MassDEP conclusions regarding the Haul-seine and Gill Net programs</u>**: The agency considers thermal plume effects on the marine fish evaluated through these two programs to be *de minimis*.

Sport Fishing (Summarized from Boston Edison, 1978): The sport-fishing evaluation is included here to characterize the composition of fish species caught by anglers in comparison to what is expected for the region. The shorefront area of PNPS was designed and constructed in part to provide marine sport fishing access to Rocky point. A parking area was installed adjacent to the plant to allow fishermen to park and walk to the two jetties that formed the discharge canal and to the intake breakwater. DMF conducted a “creel census” over a 3-year period, from July-Nov., 1973 and April-November, 1975 and 1975. The census was conducted during four randomly selected half-day segments each week over these periods. DMF estimated angler effort and success from their time at PNPS as follows: a) number of anglers visiting PNPS during the 3-yr. study period: 21,120; b) number of hours spent fishing: 41,405; c) number of fish caught: 9,332; d) overall catch rate: 0.22 fish/angler hour; e) number of species caught: 16; species accounting for most (>80%) of the catch: cunner (37.1%), bluefish (31.8%), pollock: (13%). Angling effort peaked in June-August.

DMF reported that sport-fish catch composition was typical of a temperate open coast region, and there was no catch of southern (warm-water) fauna in the harvest that was reported. Sport fishing was allowed at PNPS from April, 1973 to shortly after September 11, 2001, when security became a concern. The facility grounds are now closed to public fishing.

<u>Thermal Effects to Target Species:</u>

Biomonitoring at PNPS underwent a significant change in the late 1980 and early 1990s as the focus of the monitoring program shifted towards an evaluation of potential effects to target species and away from comparisons of impact based on gear types. The gill-net program and near-shore shrimp trawl monitoring programs were dropped during this period.

DMF selected eight aquatic species as indicator species in the Pilgrim area. These were divided into 6 categories, and are listed below:

Benthics:	Winter flounder, American lobster
Predatory Pelagics/sportfish:	Bluefish and Striped bass
Pelagic Schooling fish/Commercially harvested:	Atlantic menhaden
Most abundant shoreline fish:	Atlantic silverside
Resident, abundant, groundfish:	Cunner
Groundfish/sportfish:	Tautog

DMF used this list to develop information relating to impact studies and/or observational information from personnel working to evaluate potential impacts from the facility. Summaries of the thermal-related impact work for each species is provided below. Where data were available, these were used to approximate the size of a thermal "exclusion" zone for each species.

Benthics:

American Lobster (*Homarus americanus*): No relationship between annual catch ratios in surveillance and reference areas was seen in extensive evaluations of lobster-pot catch compared to degree of station operation. In addition, no statistically-significant differences were seen in lobster catch from stations near the discharge to reference stations much farther distant from the discharge.

EG&G's (1995) bottom plume mapping (see: **Physical Water Temperature Characterization: Plume Dimensions at the Bottom**) demonstrated that the maximum contact of the plume with the bottom occurred during the low-tide period. On an average tide (i.e., neither neap nor spring) only about 1.2 acres of bottom (at 1°C or more) was affected by the thermal plume at low tide. The area affected by the plume where delta temperatures beyond ambient are less than 1°C will be larger than the 1.2-acre figure. However, isopleth areas for plume-induced temperature changes <1°C were not provided. As the tide moved past about mean tide level, the plume lifted and was in contact with the bottom only to about 50-80 meters from the end of the discharge canal. As the tide progresses further in its cycle, the plume lifted even more. The maximum linear contact of the plum (during low tide) occurred out to about 150-170 meters. Beyond that point, water temperatures were indistinguishable from background.

Based on the above, and based on the lobster work conducted by DMF (see: **Benthic Fauna: Commercial Lobster Fishery)** , MassDEP has no data to support the contention that PNPS impacts to lobster are any greater than those of the plume's dimensions at the bottom, and MassDEP considers these to be *de mimimis* considering the fact that the PNPS facility discharges to the open ocean. These data support conclusions reached by MassDEP above (See: **Benthic Fauna**).

Winter flounder (*Pseudopleuronectes americanus*): This fish is considered a target species for PNPS primarily due to the negative effects of the intake on flounder eggs and larvae due to entrainment. In the juvenile and adult stages, these fish are bottom-dwellers and because only a small (<1 acre to <2 acres) area of the bottom is affected by the thermal plume, flounder in the adult and juvenile stages are not thought to be negatively affected by the plant's discharge outside this area.

MassDEP used the following information to estimate the size of a thermal zone of impact for winter flounder larvae. In the larval stage, winter flounder are pelagic. In developing a winter-time upper tolerance value for the Brayton Point permit relative to winter flounder larvae, the Region I EPA (EPA, 2002) referenced Dr. Grace Klein-MacPhee who recommended 8°C as best for larval survival and growth and a figure up to 12°C where survival and growth was reduced. Dr. MacPhee also recommended that temperatures above 10°C from March to mid-April should not be exceeded but beyond mid-April, the metamorphosing larvae could tolerate higher temperatures. EPA chose **8°C** as the **target** value, **10°C** as **suboptimal** and **12°C** as not suitable (i.e., as an acutely-toxic value) for the March-mid April period and MassDEP used the same approach for this review.

MassDEP compared the figures above to the mean monthly intake temperatures in March and April and the delta temperature isotherm areas in the ENSR 316 document (Table 5.1-1, ENSR 2000) using MIT's mid-November measured surface plume isotherm areas as a surrogate for the March-April time frame. No isotherm projections were developed for the March-April time period by MIT. Of the three time periods studied by MIT (July, August and November) the November information is expected to be closest to water temperatures (but not other factors) that persist in the March-April time frame.

Ambient surface water temperature at the time of the MIT November, 1973 survey was 8.5°C (47.3°F). By comparison, the regression line through all the average monthly March temperatures from the PNPS intake over 1976-2012 yields a statistically-generated figure of about 40°F (~4.4°C) for post-2012 and a similarly-generated figure of about 44.5°F (~7°C) for post-2012 April temperatures. Because the statistically-generated temperature figures are lower than that from November, 1973, MIT's isotherm areas developed during November, 1973 should provide a slight over-estimate of the isotherm areas for March-April if other factors (wind, humidity, ambient air temperature, etc.) are not considered.

Using the approach outlined above, MassDEP expects that in March there would be less than 0.1 acres that would be "not suitable" for winter flounder; and less than 0.9 acres that would be sub-optimal. For April, these estimates are: less than 0.9 acres as "not suitable"; and less than 14 acres that would be considered "sub optimal". Because larvae are unable to maintain a position in current, the agency expects that any drifting winter flounder larvae would be quickly pushed out of the "not suitable" and "sub optimal" areas due to the high velocity of the plume's current. As a result, MassDEP does not do not expect winter flounder larvae moving past the facility to suffer from heat-effects of the PNPS thermal discharge into Cape Cod Bay.

Effects of larval travel through the facility, delta temperature change during this period of travel (and afterwards), ultimate temperature effects and other effects of larval travel through the facility are evaluated in the **Entrainment** section of this report.

<u>MassDEP conclusions regarding winter flounder:</u> Based on the information reviewed, the agency concludes that effects to winter flounder from the PNPS discharge of heated water into Cape Cod Bay have been *de minimis*.

<u>Predatory/Pelagics/Sport Fish:</u>

<u>Bluefish (*Pomatomus saltatrix)* and Striped bass (*Morone saxatilis*</u>): Both species are important game fish and both are attracted to the PNPS 001 discharge at certain times of the year. DMF personnel noted that the attraction of bluefish and striped bass to the plume is at least partly due to the velocity of the discharge:

> "*Both gamefish are voracious predators that are attracted to moving water, e.g., currents and tidal rips, where the velocity of the running water incapacitates smaller fish and invertebrates making them easy prey (Wooner and Lyman 1983). Ristori (1989) adds that most marine game species feed when there is a current running but cease this activity in slack water. Pilgrim Station's once through, open-cycle cooling system produces a continuously flowing, pump generated thermal current that can attract game fish to the outfall area.*" (Taken from Lawton, *et al*., 1992a)

Lawton *et al*. (1992a) noted that when the facility was operating and discharging a noticeable current, Striped bass numbers near the facility that were observed by divers, through the sportfish catch and in Gill nets, were typically higher than when the facility had an outage. In addition these authors posit that the attraction of bass and bluefish to the plume in the spring and late fall is due to the fact that plume temperatures at that time are near to those preferred by these two species. However, in August and early September both species appear to be repelled by high temperatures and Lawton *et al.* (1992a) asserted that the plume creates an exclusion zone in the near-field outfall area during these months.

The attraction of these two species to the plume had both positive and negative effects. When sport-fishing was allowed at PNPS (prior to 9/11/2001), the attraction of both species to either the thermal plume or the higher-velocity water increased the contact of bluefish with fishermen (positive to anglers, negative to fish). In addition, the nearness of bluefish fish to the plume also increased the likelihood that if the plant ceased operations for a time these fish could be subjected to cold shock (negative to fish and anglers). However, there is no record of fish kills for either species at PNPS and DMF observed that these fish simply left the area[7].

By comparison to the situation at PNPS, striped bass residing in the discharge canal at the Brayton Point electrogenerating station in Somerset MA were known to forego their usual southward migration. Prior to the installation of cooling towers at that facility, and a drastic diminution in the amount of cooling water discharged, many striped bass remained in the canal all year long. The discharge canal at Brayton is about 0.5 miles long, over three times the length of the PNPS canal (~0.14 miles long); fish residing in the Brayton Point canal were completely separated from other Mt. Hope Bay waters and were, apparently, not cognizant of changing ambient temperatures. By contrast, striped bass at PNPS were caught by fishermen outside the

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[7] Personal communication from Vincent Malkoski, MADMF to Gerald Szal, MassDEP, May 29, 2013.

canal itself, and have not been known to over-winter in the plume[8]. DMF reported that the PNPS canal was too exposed and conditions in the discharge canal got "too rough" in the winter to support overwintering fish[9]. The departure of striped bass and bluefish from areas adjacent to the thermal plume at PNPS typically occurred sometime during the November-December time frame each year[10].

Estimated area of thermal avoidance: MassDEP used a figure of 25°C (Coutant and Benson, 1990) as an upper avoidance temperature for striped bass. We also used the highest, monthly-mean summertime temperature (65.9°F [~19.4°C] seen in August of 2000) from the PNPS reports over the 2000-2012 July-September period to approximate the worst-case high ambient temperature near PNPS. To estimate the greatest area that would be avoided by striped bass due to the thermal plume (under worst-case ambient conditions as described above), we used the MIT estimates of isopleths acreage based on delta temperatures above ambient (as outlined in ENSR, 2000, Table 5.1-1). Based on this information, a delta T of 5.6°C would be needed to cause avoidance to striped bass if ambient water temperatures reach the highest monthly mean temperature (19.4°C) seen over the 2000-2012 period. This equates to between 2.6 acres (at a delta T of 6°C) and 12 acres (at a delta temperature of 5°C). If ocean warming continues to increase, this acreage will also increase.

The following paragraph is based on Pottern, *et al*.'s (1989) review of the literature. Adult bluefish prefer temperatures in the 18-20°C range. In laboratory experiments adult bluefish increased swimming rates at temperatures both above this range and below this range. Based on an acclimation temperature in the preferred range (18-20C), loss of equilibrium was seen at 35°C (95°F) in fish subjected to a slow rise in temperature beyond the acclimation range. In addition, swim speed greatly increased as temperatures increased from 20-30°C and at 30°C, was about 3 times the rate seen at 18-20°C and the fish showed little interest in food.

The 30°C temperature would only occur in areas very near the discharge, and a temperature of 35°C would occur only within the direct plume in the very near field during the height of summertime temperatures. More importantly, based on DMF's observations, bluefish avoided the thermal plume in the mid-summer. In addition, the DMF dive team studying the benthic plume did not report thermal stress to this species.

> **MassDEP conclusions regarding bluefish and striped bass**: Given all of the above, MassDEP concludes that the PNPS thermal discharge at PNPS does not appear to pose a threat to populations of striped bass or bluefish and effects to date appear to have been *de minimis*.

Pelagic Schooling fish/Commercially harvested:

Atlantic menhaden (*Brevoortia tyrannus*): Two fish kills have occurred at PNPS which were thought to be due to heat-stress. Both included menhaden and/or other clupeids (the family of

[8] Personal communication from Vincent Malkoski, MADMF to Gerald Szal, MassDEP, May 29, 2013.
[9] Personal communication from Vincent Malkoski, MADMF to Gerald Szal, MassDEP, May 29, 2013
[10] Personal communication from Vincent Malkoski, MADMF to Gerald Szal, MassDEP, April, 2013

fishes that includes Atlantic menhaden). The first occurred on August 2, 1975 in which about 3,000 menhaden died. A second event occurred over August 21-25, 1978 in which an estimated 2,300 clupeids (the family of fish that includes menhaden), including menhaden, succumbed to what was thought to be heat stress, "perhaps aggravated by chlorine" (Lawton, et al., 1992b). The suggestion that chlorine may have been involved was not accompanied by any effluent data relative to chlorine. It is certainly possible that that chlorine-aggravated heat stress was responsible for these deaths because both heat and chlorine are the two factors most likely to have caused stress in fish frequenting the discharge after Gas-Bubble Disease has been ruled out. Fish suffering from Gas Bubble Disease typically have bubbles on their outer surfaces and this manifestation was not found on the fish that were examined. It is also likely that if there was any time that the facility might have had problems associated with chlorine toxicity it would have been during the early years of operations.

If heat-stress alone was the cause of the menhaden fish-kill events in the 1970s, it is puzzling to MassDEP that schools of menhaden have not continued to succumb to similar circumstances. This may be explained by the apparent inconsistency in patterns of menhaden movements from year to year. DMF reports that, in some years, the species can almost completely by-pass MA waters as they head farther north[11].

Two other discharge-related fish-kill events took place in April of 1973 and 1975. These two events were judged to be due to Gas Bubble Disease and are discussed in the section by that title. A net was kept in the canal for many years to keep fish, especially menhaden, out of the canal but primarily because of concerns relating to Gas Bubble Disease.

To conclude that the menhaden at PNPS were stressed by heat alone conflicts with certain literature information. Natural Resources, Canada (2013) conducted a thermal review of Atlantic menhaden and reports that adults avoid temperatures in excess of 26°C (78.8°F), and prefer temperatures in the 15-21°C range. In addition, the agency states that menhaden have been known to suffer mass mortalities from cold shock, i.e., due to sudden exposure to falling temperatures as might occur at a power plant if the heated discharge were to suddenly cease. No outages were reported in the characterizations of the two Atlantic menhaden kills at PNPS, thus cold-shock was probably not the cause of these two fish kills.

Given that there have been no reported heat-related kills of menhaden at the facility since the mid-1970s, it seems inappropriate to the agency to mandate that technologies or operational changes be instituted at PNPS to control against heat-stress to menhaden. However, daily monitoring for potential stress to this species does not take place on a regular basis at the facility, and since 9/11/2001, there are no fishermen to report if there is evidence of stressed fish in or alongside the discharge canal. Consultants are occasionally on-site, but not on a daily basis, and thermally-related events may have taken place since 9/11/2001 but gone un-noticed.

> **MassDEP conclusions regarding menhaden:** Given the above, MassDEP asserts that there have been impacts to populations of menhaden that frequent the western side of Cape Cod Bay. Due to the fact that these events are not frequent, and that there is no

[11] Personal communication from Vincent Malkoski, MADMF to Gerald Szal, MassDEP, May 29, 2013.

evidence that such events have occurred in the recent past, the agency does not feel that technological changes need to be made to mitigate an on-going problem. However, the agency maintains that it is prudent to institute a set of protocols for daily, visual monitoring of the canal and areas adjacent to the canal, to look for signs of stressed fish, as well as a mitigation plan that would lessen the potential for thermal-related kills to menhaden populations (or other fish populations) or the potential for long-duration events of stress that could be damaging to populations of menhaden or other fish.

Most abundant shoreline fish:

Atlantic silverside *(Menidia menidia)*: this species has consistently been the most abundant fish in the area near the PNPS. Silversides were targeted as an important fish in the PNPS assessment by DMF both for this reason and the fact that this species is an important "forage" fish (i.e., one that his preyed upon by other fish).

DMF estimated that, based on their thermal tolerance, there was about an exclusion area of about 4.5×10^4 m^2 (~11.1 acres) during mid-to-late summer. After more than 15 years of monitoring, DMF personnel also surmised, however, that the negative impacts of the thermal plume, at the population level, are probably negligible to their population for three reasons: a) the relatively small size of the exclusion zone; b) the ability of silversides to avoid stressful temperatures; and c) the fact that Atlantic silverside population numbers are so high that an exclusion area of the size mentioned above would not have an important negative effect on the population in the vicinity of the facility.

MassDEP conclusion regarding Atlantic silversides: Based on the information above, the agency concludes that the effects of the PNPS thermal discharge on Atlantic silversides are *de minimis*.

Resident, abundant, groundfish:

Cunner (*Tautogolabrus adspersus*): Also known as a sea perch[12], the cunner is a relatively small fish, often captured by anglers, that inhabits rocky shorelines and reefs to a depth of about 11 m but is also found in off-shore banks and ledges sometimes as deep as 21 m (Clayton, et al., 1978). Bigelow and Schroeder (1953) provide a preferred temperature range of 0-22°C (32-71°F) for this species. Haugaard &Irving (1943) developed upper lethal temperatures of 82.4-84.2F (28-29°C) for juveniles acclimated to 64.4-71.8°F (18-22.1°C). Cunner were observed by DMF divers in the early summer feeding on mussels that accumulated at the end of the discharge canal. When ambient water and plume temperatures were at their highest in the mid-late summer, and mussels were dying (apparently from the high plume temperatures), divers observed that cunner avoided the plume (see Appendix 1).

[12] Bigelow and Schroeder, 1953.

To approximate the area of unusable habitat for cunner due to the PNPS plume, the agency first estimated an avoidance temperature based on toxicity information. We used Coutant's (Natl. Acad. 1972) estimate for a "safe" (one with no associated death) acute temperature as 2°C less than the upper lethal temperature[13]. Using this approach and the information in the previous paragraph, we arrive at a "safe acute" level of 26°F for juveniles acclimated to 18°C (64.4°F). Coutant demonstrated that acute and chronic toxicity as well as avoidance are all tied to acclimation temperature.Knowing that avoidance temperatures are typically less than temperatures that cause acute toxicity, the agency estimated an avoidance temperature (**25°C**) for this species by subtracting 1°C from the "safe acute" level for the 18°C acclimation value. The 18°C acclimation value is close to the post-2012 statistically-derived mean August temperature (17°C; 62.6 °F) and the similarly-derived September mean temperature (16.8°C; 62.3°F) developed from the PNPS intake dataset.

Based on the information above, we can estimate unusable area due to the plume in two ways: a) using MIT's field data; and, b) using MIT's model results. About 0.9 acres would have temperatures above the estimated 25°C avoidance temperature for cunner based on the August 1973 MIT field-derived delta temperature isopleths (summarized in ENSR, 2000, Table 5.1-1). Using MIT's model results, the predicted surface plume areas during High Tide (see Table 5.1-2 from ENSR, 2000) that would have exceeded the estimated avoidance temperature for cunner would be about 4 acres.

The facility's impacts on the recruitment of cunner juveniles to the bottom was studied by Nitschke (1998). This researcher evaluated factors that influence cunner recruitment in Cape Cod Bay at several sites, one of which was near and in the direct path of the PNPS discharge. Recruitment with regard to cunner refers to the process of pelagic larvae (<12mm) leaving this stage of the life cycle and settling to the bottom. Within 24 hours of this event, cunner darken in color and the small (10-45mm, age=0), pigmented fish now residing on the bottom are called "recruits". Nitschke set up a number of line-transects at each of four sites of similar habitats over one reproductive season in the vicinity of PNPS and he counted recruits along a 1-meter swatch along these lines from July 24, 1995, before recruits were present, until November 7, 1995, just prior to "hibernation"[14] of recruits.

Of all the sites studied, the site nearest the PNPS discharge had the highest recruit abundance over the "settlement period"; however, post-settlement numbers toward the end of the period of study were not significantly different among the different sites. Nitschke postulated that plume-related currents may have been at least partly responsible for the high rates of settling at the discharge site, but also suggested that density-dependent mechanisms (e.g., competition and other intra-specific interactions; predation), and not the plume itself, were responsible for the apparent drop in densities at the discharge site during the post-settlement period. The researcher, and later, DMF personnel (Lawton, et al., 2000), concluded that settlement of recruits and post-settlement densities did not appear to be negatively affected by the PNPS discharge.

[13] Charles Coutant (Natl. Acad., 1972) suggested that one can approximate a temperature where no acute effects are seen for a particular thermal acute toxicity test if one subtracts 2°C from the TL50 value [the temperature lethal to 50% of the exposed organisms].

[14] Cunner enter a state of torpor during the coldest months during which they remain, usually hidden, on the bottom. This stage is sometimes referred to as "hibernation".

<u>MassDEP conclusions regarding cunner:</u> Based on the information above, the agency expects that there is a small area of thermal exclusion for cunner in the summertime due to the PNPS discharge. In addition, it appears that cunner avoid the plume when temperatures are above the levels that might be acutely toxic. Given the information presented, the agency concludes that deleterious effects to cunner from the PNPS thermal plume have been *de minimis*.

<u>Groundfish/sportfish:</u>

<u>Tautog (*Tautoga onitis*)</u>. (Summarized from Lawton, *et al*., 1990b and 1992a). Tautog is an important game fish. Although DMF reported that tautog are routinely seen by divers in the discharge canal area they also reported that there was no relationship between tautog catch in gill nets that were set near the discharge and the degree of plant operation; additionally, no tautog kills have been reported. Thus, the heated discharge itself does not appear to be attracting tautog. Instead, it appears that mussels, which "set" in the discharge channel and at the end of the canal every year, are responsible for tautog presence at the end of the canal, as tautog feed on mussels.

<u>MassDEP conclusions related to tautog:</u> As a result of the DMF diver's reports, and the lack of tautog kills related to the discharge, MassDEP concludes that PNPS thermal plume effects to this species are *de minimis*.

<u>Rainbow Smelt (*Osmerus mordax*)</u><u>:</u> For this Fact Sheet MassDEP added rainbow smelt (*Osmerus mordax*), to the list of "target" species originally generated by DMF because of this species'diminishing numbers along the coast of Massachusetts, and the fact that one of the last remaining spawning runs in Cape Cod Bay is the Jones River, which is very close to PNPS. Impingement of this species at PNPS is problematic and is discussed in the impingement section of this document.

ENSR (2000) estimated that with an ambient water temperature of 19.6°C (67.3F) in the upper water column rainbow smelt would be excluded from the area encompassed by a 2°C (3.6°F) delta temperature above ambient. In their report, ENSR stated that this temperature was seen, as a monthly average, only once (during 1975) in the ten-years prior to the report publication. The exclusion area was estimated at about 1,000 acres of the top 1/8th of the water column. Because rainbow smelt could utilize deeper waters as habitat, they were not expected to be negatively affected. Using the second highest monthly-mean ambient temperature (18.2°C [64.7°F]) seen during that ten-year period, ENSR estimated that rainbow smelt would have been excluded from an area of about 400 acres at the top 1/8th of the water column.

Bigelow and Schroeder (1953) report that this fish is "an inshore fish confined to so narrow a zone along the coast that none has ever been reported more than a mile or so out from the land, or more than two or three fathoms in depth". As such, there is question that the thermal discharge may interfere with its free movement up and down the coast. ENSR (2000) used a temperature of 71°F (~21.7°C) as the "low end of the thermal tolerance threshold" to estimate the area encompassed by the plume that would be too warm for this species to inhabit during the summer months.

ENSR's 71°F figure was not supported with a reference, but appears to be based on toxicity rather than avoidance information. Clayton, *et al*. (1978) conducted a literature review of marine fishes in coastal Massachusetts. They report that de Sylva (1969) provided upper lethal temperature limits for smelt at 21.5 to 28.5 (70.7°F to 83.3°F) for fish acclimated to 10-15°C (50-59°F). Judging from these reports, we expect that the ENSR estimate is actually an estimate of 50% survival upon exposure to 71°F, based on an acclimation temperature of 10°C, rather than an avoidance temperature. It is reasonable to assume that the avoidance temperature is below temperatures known to cause a toxic response. Coutant (Natl. Acad., 1972) recommended a "safety factor" of 2°C below the TL50 to estimate a no-acute-effect temperature (see footnote 9 above). MassDEP estimates (as we did for cunner; see above) that the avoidance temperatures for acclimation temperatures of 10 and 15°C would be about 3°C (5.4°F) below the upper lethal temperatures mentioned above. This yields avoidance temperatures of 18.5°C and 25.5°C [65.3°F and 77.9°F] respectively for smelt acclimated to 10 and 15°C (50 and 59°F). Note that the 71°F avoidance figure used by ENSR falls at about the middle of the 65.3 to 77.9°F range that we estimate would induce avoidance, and we assume that the temperature inducing avoidance depends on the acclimation temperature.

To approximate a summertime acclimation temperature for rainbow smelt, we consulted the PNPS intake temperatures over the months of July-September, 2000-2012, figuring that these would provide estimates of near-shore temperatures similar to those that would be inhabited by rainbow smelt. Monthly average summertime intake temperatures at PNPS have been in the range of 14.2-18.8°C (57.6-65.9°F) with a median of about 16.5°C (61.7°F) over the period 2000 to 2012. These temperatures either exceed those evaluated by de Silva, or are in the very upper range of the de Silva acclimation temperatures. Based on this information, temperatures causing avoidance in rainbow smelt might range into the high 70s and low 80s (Fahrenheit). Thus, the ENSR (2000) estimates of habitat lost to this species due to avoidance appear to be higher than would be expected based on summertime, ambient acclimation temperatures in the western side of Cape Cod Bay.

Even considering the above, however, the plume is buoyant, and rainbouw smelt should be able to move underneath the plume at tidal elevations above mid-tide. DMF personnel projected that the PNPS thermal plume should not negatively impair the Jones River population because

> "juvenile and adult smelt are mobile and should avoid the thermal plume if the temperature or current are unfavorable" (Lawton, et al., 1990).

Aside from one incident where impinged smelt were sluiced into the discharge canal in December of 1978, and were subjected to heat shock as well as physical damage from the impingement event, no thermal-shock or plume-related stress has been reported for this species at PNPS. Because the plume's effect is primarily at the surface except for areas very near the shoreline, MassDEP expects that plume would not unduly affect this species' movement past the facility.

MassDEP's conclusions regarding rainbow smelt: Based on the information reviewed by MassDEP, the agency concludes that deleterious effects to rainbow smelt from the PNPS thermal plume have been *de minimis*.

River Herring (Bluebacks: *Alosa aestivalis*; and Alewives: *Alosa pseudoharengus*):
MassDEP added bluebacks and alewives to the list of fish species needing attention in the PNPS thermal review for several reasons: **a)** both are important "forage" species for other fish; **b)** both are species that have incurred dramatic declines in population levels along the Atlantic coast; **c)** both are commercially harvested as adults although there is currently a "ban" on the take of adult river herring in MA due to their greatly-diminished numbers; **d)** both species frequent the PNPS area.

Blueback and alewife adult specimens are relatively small (maximum lengths of each are about 13 and 14 inches, respectively[15]) and the two species are easily confused. In the spring, they migrate into and up streams along the east coast to breed. Blueback herring breed in flowing water and are sometimes attracted to effluent discharges. The agency has a video that was taken by consultants to the Kendall Power Plant (Cambridge MA) in which river herring can be seen displaying breeding behavior *within* the thermal discharge pipe from the power plant. Although bluebacks and alewives are difficult to tell apart, bluebacks breed in flowing water which alewives breed in lentic environments. As a result, MassDEP believes that the river herring in the Kendall video were bluebacks rather than alewives.

It is common knowledge that the urge to breed can cause many organisms to "take risks", both physiologically and behaviorally. This behavior can place organisms in unhealthy environments that can lead to diminished health of the individuals. In the specific case where river herring were found breeding in a thermal discharge pipe, the behavior may also result in the demise of eggs released in those areas, and may also result in the diminishment of the number of population-specific spawning events that occur in more healthful environments.

Based on work conducted by EPA and state agencies for the Kendall facility[16] alewives and bluebacks respond differently to warm water depending upon the season during which they encounter that water. In the spring, adult migration into streams is initiated when fish have found their way to the mouths of rivers/streams and the stream temperatures reach certain levels. Inward migrations are halted when stream temperatures rise above certain levels and spawning typically stops when the stream water exceeds certain limits.

High-temperature water can be toxic to river herring but toxicity varies, within certain limits, with the species, life stage, acclimation temperature of the exposed individual, and the frequency, duration and delta temperature (difference between acclimation temperature and exposure temperature) of the exposure[17]. Low-temperature water can also be toxic to herring when there is an abrupt decrease in temperature as might occur if either species had been

[15] See: http://www.nefsc.noaa.gov/sos/spsyn/af/herring/

[16] See the Mirant Kendall Determination Document:
http://www.epa.gov/region1/npdes/mirantkendall/assets/pdfs/draftpermit/Kendall_Determin-Doc_06_08_04.pdf

[17] See, for example, Otto, et al., 1976

attracted to the discharge and the facility were to drastically cut back on the discharge of heat (e.g., when a plant outage occurs). As a result of these relationships both the temperature maxima and minima to which a certain fish species (and life stage) can be exposed without harm varies throughout the year because ambient temperatures (i.e., the acclimation temperatures) also vary throughout the year.

Based on the research conducted for the Kendall NPDES permit MassDEP expects that alewives would be repelled by the discharge at most times of the year. There is a possibility that adults could be attracted by warmer temperatures in the spring, but this agency expects that as alewives moved closer to the discharge, due to the very high delta temperature (32°F) between ambient sea water and the discharge, these adults would be repelled rather than attracted to the plume. It is also possible that adult alewives could become confused by the thermal plume which could delay migration past the facility, but there is no evidence to support this possibility.

Due to our knowledge of blueback behavior in the Lower Charles at the Kendall facility, there is the potential for bluebacks to be attracted to the plume in the spring due to the high velocity of the plume. If this were the case there is the potential for thermal-stress to occur. However the events in the Charles occurred in fresh water, which is the environment within which bluebacks spawn. Because the PNPS discharge is comprised of salt water only (rather than fresh water) this may preclude *any* attraction of adult bluebacks to the discharge. If there were attraction to the plume, the individuals attracted could become stressed from the high delta temperature compared to ambient or their further migration could be delayed. However, there is no evidence to support that blueback attraction to the thermal plume has occurred at PNPS.

Unless evidence is presented to the contrary, based on the information presented above, it appears most likely that both adult alewives and bluebacks would avoid the plume rather than be attracted by it. EG&G (2000) came to this same conclusion for alewives, but did not evaluate the issue for bluebacks. In addition, EG&G developed estimates for the area of thermal exclusion to adult alewives during the summer when ambient temperatures are highest. After spawning in fresh water, alewives return to the sea and could encounter the PNPS discharge during those times of the year when ambient and discharge temperatures are at their highest.

Meldrin & Gift (1971) list preferred temperatures of adult alewives to be in the 68-71°F range (~20-21°C), and state that the avoidance temperature is 76°F (24.4°C). We assume that this is the avoidance temperature at the warmest time of the year (avoidance temperatures during migration, or at other times, would vary with acclimation temperature). If we use 24.4°C as the avoidance temperature, and the very highest monthly-average intake temperature (65.9°F [18.8°C] – see Table 1 below) seen at PNPS over the 1976-2012 period, we can estimate the surface area of Cape Cod adjacent to PNPS that would be inhospitable to alewives using the MIT model results (see Table 5.12 in ENSR, 2000). MIT's results provide the area enclosed by various delta T isotherms during high tide. Based on these figures, the area that would exceed a 5.6°C thermal rise above 18.8°C (i.e., (24.4 – 18.8) = 5.6) is about 40 acres of the surface to a depth of about 7-8 feet below the surface. Bluebacks tolerate slightly higher temperatures than alewives; therefore, the area expected to be avoided by bluebacks would be somewhat less.

EG&G suggested that alewives would simply move beneath the thermal plume. MassDEP accepts the EG&G conclusion and also expects that this would be the case for bluebacks as well.

> **MassDEP Conclusions re: thermal impacts to Bluebacks and Alewives:** Unless MassDEP receives evidence to the contrary, the agency concludes from the above that while some habitat exclusion probably occurs to both bluebacks and alewives due to the PNPS discharge of heat, the negative impacts to populations of these two species that move past the PNPS facility are *de minimis*.

Gas Bubble Disease (GBD):

The following summary is based on Clay *et al*. (1976) and Lawton *et al*. (1986). There have been several documented GBD-related events at PNPS. Two substantial kills of Atlantic menhaden (*Brevoortia tyrannus*) attributed to GBD occurred in the PNPS discharge canal since the facility began operations. The larger of the two occurred over April 9-19, 1973 (See: Table 4, Impingement Section, PNPS Report #57, Jan-Dec. 2000) when an estimated 43,000 adult menhaden succumbed to GBD in the PNPS discharge canal and thermal plume. Over April 2-15 (See PNPS Report #57, as above), 1975 about 5,000 adult menhaden also died from GBD in the same areas. A third incidence of GBD occurred in late fall-early winter in 1975, this time with striped mullet (*Mugil cephalus*). In the latter event, fish exhibited external abnormalities indicative of GBD but no mortality was observed. Smaller events in which fish have exhibited external GBD symptoms, but no mortality was observed, have been reported by DMF involving Atlantic silverside (*Menidia menidia*), menhaden and river herring (*Alosa sp*.). The largest of these occurred in 1985 where an estimated 600 silversides and about 300 clupeids (in this case, menhaden and river herring) were observed with GBD symptoms. Although no mortality was noticed in the 1985 event, DMF reports that many of these fish were "severely stressed".

Events where mortalities were observed (those in April of 1973 and 1975) were coincident with the following: a) seasonally-increasing ambient seawater temperatures (i.e., spring/early summer); b) >80% PNPS operating capacity; c) super-saturation of nitrogen and other gases in the discharge; and d) attraction of large schools of fish to the thermal discharge. GBD occurs when water with highly super-saturated levels of gases (especially nitrogen) come in contact with certain fish. The gas enters the bloodstream through the gills, is too concentrated to be safely absorbed and/or released and causes emboli that can destroy tissues. The condition manifests externally as bubbles on the outer tissues of affected fish but also occurs internally. The most extreme of all reported events have occurred in the springtime.

Cold water can hold a higher concentration of dissolved gases than warm water. Thus, a water sample that is 100% saturated with nitrogen at, for example, 10°C, will have a higher nitrogen concentration than a 15°C water sample that is also 100% saturated. When completely-saturated cool water enters the PNPS it is quickly warmed and the heated effluent can, for a short time, have a super-saturated concentration (beyond 100% saturation) of nitrogen. This situation exists because it takes time for dissolved gases to leave the water and for the gases in the water to equilibrate with atmospheric pressure. Thus, the highest levels of (super-) saturation are nearest the point where the heated discharge leaves the facility. In addition, PNPS contractors found that the level of nitrogen-saturation changed with depth, even in the effluent channel, and the highest levels were found closest to the surface. This may be, at least in part, why it is possible for the upper level of the water column to exhibit saturation levels that are considered too high for fish, but for fish to still remain either in the discharge canal or in the direct line of the discharge close to the canal and not succumb to GBD.

Super-saturation of nitrogen gas in the effluent is, by itself, not problematic. It only becomes a problem when super-saturation events are coupled with the presence of fish schools. Fish are attracted to the effluent for different reasons, depending on species and season. During the 1980s and 1990s the facility contracted a pilot to conduct “over-flights” once per week in order to determine if large schools of fish were in the area. The presence of large schools of fish was reported to PNPS in order to warn the facility and its contractors to be on alert for GBD and/or impingement events.

Menhaden, the species involved in the two mortality events, annually migrate from as far as Florida up the east coast to the Gulf of Maine. DMF reports that the preferred temperature for menhaden adults is higher than that found in ambient Cape Cod Bay waters in the spring when they may pass PNPS. Based on literature information, DMF hypothesized that the springtime migrants were attracted to the plume because of its higher temperature (unlike other clupeid species, e.g., blueback hering [*Alosa aestivalis*], that spawn in fast-moving waters and are naturally attracted to effluent discharges because the water *velocity* in these discharges is higher than ambient). When the facility operates, nitrogen-saturation levels in the discharge often exceed the recommended tolerance value (115%) for menhaden. DMF suggested that during the summer and fall attraction of menhaden to the discharge does not occur because the discharge temperatures exceed the preferred temperatures (20°C) of menhaden during that part of the year.

PNPS conducted several evaluations of alternatives to prevent GBD events from occurring at the facility (see: Marcello, et al., 1975, Doret, et al., 1976; and Krabach and Marcello, 1978). In 1973 a fish barrier net was installed in the discharge canal at about 61 m from the downstream end of the canal. The location of the net was partially dictated by engineering considerations that included protection from storm damage. This first net did not function as well as intended as it tended to lift up from the bottom and allow schools of fish to move past the net to points farther up the discharge canal. In 1976, a better support system which included concrete side and bottom sills for anchoring the net was installed about 2/3 of the distance toward the terminal end of the canal. This net was made of a stretchable material and had openings about 2” wide.

Staff from DMF (Lawton, et al., 1986), contracted by PNPS to evaluate potential impacts from the facility, summarized GBD concerns at Pilgrim and the company’s attempts to prevent future events through the installation of the barrier net described above. The effectiveness of the net varied in part with the tide. Gas-saturation levels were found to greatly decline at periods around low tide because during this part of the tidal cycle turbulent mixing of the effluent occurs in the canal due to increased contact with the bottom of the canal. By contrast, during high tide, ambient sea water moves part way into the canal and the discharge plume moves over this water at the far reaches of the canal, decreasing contact of the plume with the bottom of the canal, and also decreasing the degree to which turbulent mixing occurs. During periods around low tide, the area of high levels (>115%, a figure found to be a critical level for adult menhaden; see Clay, et al., 1976) of super-saturated nitrogen greatly decreases and is primarily contained within the first

2/3 of the discharge canal. As the tide rises, plume contact with the bottom decreases and areas exceeding the 115% saturation level are found well-beyond the end of the discharge canal. As a result, the net's effectiveness in preventing GBD varies with the tide. DMF also noted that although the net reduces movement of large fish into the canal, smaller fish, such as silversides, can move through the mesh and enter the upper canal such as occurred in the GBD event in 1985 (see above).

Marcello, *et al.* (1975) evaluated a number of different technologies to decrease or eliminate GBD events. They concluded that the most cost-effective method to prevent GBD was to install an air-diffuser system into the canal. Bubbling air into the canal at high rates would require structural modifications to the canal and would also increase the cost of operating the facility.

In the recent past, PNPS has only rarely monitored for nitrogen-saturation levels in the effluent. Their consultant (Normandeau) provided the permitting agencies with monitoring records from 2003-2012. Monitoring over these years has taken place in both the discharge canal and in the intake between 3 and 7 times per year over this time period. Since 2008, monitoring has occurred 3x per year.

Monitoring for stressed fish in the discharge canal may not be taking place on a daily basis at PNPS and it is not currently required in the NPDES permit. Through the 1990s DMF divers were periodically present in the discharge canal, or in the near-field path of the discharge, and had very few reports of stressed fish during this period. This does not mean that events of stress did not occur in-between dive events at PNPS.

Since there has been only one known GBD event at PNPS since the 1970s MassDEP does not feel that installation of an air diffuser into the canal is imperative at this point in time. However, since dive events and other monitoring were not conducted on a daily basis at the facility, GBD or other stress-producing events could have occurred in-between dives. In addition, since diving was halted in about 2000, and very little monitoring (by the facility) for stressed fish has occurred at the facility since that time, we have little opportunity for observing events if they should occur. The lack of sportfishing at PNPS since 9/11/2001 further decreases the potential for knowledge of plume-induced stress events.

> **Recommendation regarding GBD monitoring**: Given the information above, MassDEP asserts that it is prudent to mandate daily, visual monitoring of the canal and areas adjacent to the canal to screen for events where fish may be stressed due to GBD or other causes.

Thermal Backwash: A number of times per year, as needed, heated water (up to 120°F) may be flushed through the condenser unit to control bio-fouling. This is allowed through the NPDES permit. Based on conservations with plant personnel, the facility typically conducts five (5) thermal backwashes per year under normal operations and four (4) during years where there is a re-fueling outage[18]. Although the 1991 permit limited such thermal backwashes to a flow limit of 255 MGD, the draft permit limits backwashes to 28 million gallons per day, to reflect the

[18] Telephone conversation between Gerald Szal, MassDEP and Joe Egan, PNPS, Feb. 27, 2013.

actual flow through the intake bay for each backwash event. The draft permit also limits thermal discharges to three (3) hours per day and one (1) per week, per intake bay.

Normandeau (1977) characterized the physical extent of the thermal plume during backwash operations under different tidal regimes. During the studies, the heated backwash resulted in a fairly thin surface plume, averaging 3 to 5 feet in depth with shoreline areas along the intake only being affected for the top 1 foot or so. Water depths in this area ranged from 18-24 feet below mean low tide level. When the backwashing stopped, the plume was seen to disappear within 2-4 hours. Most of the plume was dissipated within the first several hundred feet of the intake with delta temperatures of 10 to 15°F in excess of ambient, although some of the plume extended into the outer breakwaters into Cape Cod bay during one of the two surveys.

Potential impacts to marine communities from backwashing operations were evaluated through the Haul Seine Program (see above). No substantial impacts to species populations were discerned through these studies.

MassDEP conclusions regarding Thermal Backwash: Based on the information available, the agency concludes that backwash events are not a cause for appreciable harm to fish populations in the environs of the PNPS intake.

End of Thermal-Effects Evaluations at PNPS: Due to the lack of any findings of significant impacts other than those from the 1970s, DMF stopped the thermal-effects monitoring in 1999. After that time the biological monitoring program focused on evaluating effects of entrainment and impingement on marine fish populations. Based on a review of the available literature and on information from both PNPS personnel and its long-time consultant[19] (Mike Scherer from Normandeau) the company and its consultants have no knowledge of thermally-related fish kills occurring at PNPS since the 1970s.

[19] July 18, 2013 e-mail from Joe Egan at PNPS (with consultation from Mike Scherer) to Gerald Szal, MassDEP.

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Table 1: Mean monthly intake temperatures (degrees Fahrenheit) from PNPS plant records and PNPS annual or semi-annual reports are found in un-colored cells. Values in colored cells were derived from regressions of monthly values over the 1972-2012 time period. See text for a full description of these data and how they were derived.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2012	40.8	40.2	43.4	47.2	52.4	60.4	63.5	62.5	60.6	56.9	52.2	46.6
2011	36.5	35.8	39.8	43.2	52.6	58.6	62.5	61.7	60.9	58.8	51.7	47.3
2010	37.2	36.1	42.4	46.8	52.7	56.9	63.0	60.4	62.8	57.3	50.8	42.4
2009	36.0	36.2	39.5	43.8	49.3	58.2	62.4	63.0	63.3	55.8	52.5	43.1
2008	39.3	38.1	39.8	45.0	50.3	56.8	58.2	65.7	63.4	57.1	49.4	43.5
2007	41.6	34.6	38.7	41.9	51.5	59.8	59.8	62.1	61.3	57.4	49.9	41.2
2006	40.5	38.8	38.5	46.0	51.8	57.5	57.6	63.8	62.8	56.0	51.9	46.6
2005	38.4	36.6	37.2	43.0	49.0	55.7	61.7	61.3	58.9	53.0	50.6	41.9
2004	34.6	34.3	38.1	43.6	50.0	56.5	61.2	60.9	60.9	58.5	50.2	44.1
2003	36.7	34.3	37.2	41.1	50.8	56.4	57.6	61.1	63.4	55.8	50.7	42.9
2002	40.1	39.8	42.0	47.0	50.9	57.0	64.1	64.6	63.6	57.3	50.4	42.1
2001	37.1	37.6	39.8	44.3	52.1	57.6	59.5	60.7	59.4	55.3	50.0	46.6
2000	37.6	36.2	41.1	44.9	51.1	57.3	60.8	65.9	61.8	57.1	50.0	41.1
1999	39.1	39.0	38.5	45.7	50.8	59.2	59.4	61.9	61.5	55.7	49.6	44.3
1998	40.5	39.6	40.1	45.2	51.4	52.6	57.5	57.7	60.0	54.4	49.9	45.3
1997	38.8	37.4	39.2	44.1	47.8	58.7	60.6	62.3	61.7	55.7	50.8	41.0
1996	37.1	35.8	37.4	41.8	48.6	56.0	56.1	60.8	62.9	57.5	49.6	45.2
1995	41.1	36.6	39.5	41.7	48.8	56.4	58.1	67.3	62.4	57.9	50.6	40.3
1994	28.2	29.2	30.9	37.9	44.3	45.2	56.8	59.3	60.4	63.3	55.8	44.9
1993	37.3	32.2	35.2	41.2	48.3	52.7	56.8	53.7	50.5	43.9	39.9	34.5
1992	36.3	34.3	36.5	43.4	51.6	54.2	55.9	60.4	57.4	53.8	50.8	43.1
1991	37.6	36.7	39.7	44.5	53.8	60.1	61.7	58.5	58.6	52.0	47.9	41.7
1990	38.4	38.1	37.9	46.6	50.9	53.6	61.2	64.7	63.3	55.1	47.9	42.9
1989	38.4	43.0	38.4	41.4	48.7	57.4	61.6	59.8	58.6	53.9	45.6	35.6
1988	36.8	36.0	36.2	41.3	48.8	50.2	52.8	58.8	56.9	52.3	47.2	38.9
1987	38.4	38.7	40.7	42.9	49.5	56.7	63.0	61.0	58.2	52.7	47.5	41.3
1986	36.0	35.0	37.2	45.0	48.8	56.1	61.5	63.3	58.3	58.6	52.2	44.0
1985	35.6	33.4	37.8	41.9	50.6	56.3	59.0	63.4	63.7	57.8	52.0	42.4
1984	33.6	36.1	37.6	42.6	49.2	53.9	67.0	64.6	60.9	55.9	45.7	42.3
1983	38.9	37.1	40.3	43.1	47.3	57.5	59.4	61.5	61.1	55.4	49.6	41.4
1982	35.5	34.4	37.5	43.6	49.7	55.1	56.0	60.2	59.0	55.6	50.4	44.6
1981	32.0	32.7	39.0	37.6	46.0	52.7	61.0	63.7	63.7	54.1	47.9	40.4
1980	35.3	34.1	37.4	41.8	48.2	49.5	52.8	58.0	55.9	54.6	46.3	39.3
1979	36.8	30.4	35.5	39.9	49.6	54.4	55.6	56.7	53.8	51.9	48.8	40.9
1978	34.5	32.9	35.0	40.7	47.2	50.0	56.0	60.5	58.6	52.8	49.2	40.4
1977	31.9	30.9	36.4	42.9	50.8	54.2	57.0	60.4	58.1	53.7	47.3	39.8
1976	34.8	33.7	42.6	49.0	52.6	52.1	58.5	61.6	58.9	54.2	45.4	38.2

Appendix 1.

Personal Communication (phone-call) to Gerald Szal, MassDEP from Vin Malkoski, MA Division of Marine Fisheries, April 23, 2013; reviewed by Vincent Malkoski on May 29, 2013.

Vincent Malkoski, biologist at MADMF, worked on the PNPS impact assessment team for about 18 years (approximately 1982-2000). During that time he was involved in monthly dives, typically April through October, to document effects of the discharge on the bottom of the bay and to catch (i.e., spear) fish for radiological testing. Divers were required to swim into the discharge canal at regular intervals to take fish for radiological testing and also dove in the area adjacent to the discharge to measure the areas of the bottom where Irish moss was denuded or stunted due to effects from the discharge. Fish caught for radiological testing were taken both from the discharge canal as well as from spots farther away from the discharge canal.

Mr. Malkoski stated that the most commonly-seen fish during dives in the area directly adjacent to PNPS were striped bass, bluefish, winter flounder, cunner and tautog. Although the bass and bluefish were attracted to the discharge there appeared to be no mortality to these fish due to their attraction to the plume. Dead fish were seen on occasion, but only during times when fishing was allowed at the facility, and divers assumed that these fish were "discards", i.e., fish that were caught and thrown back by the fishermen.

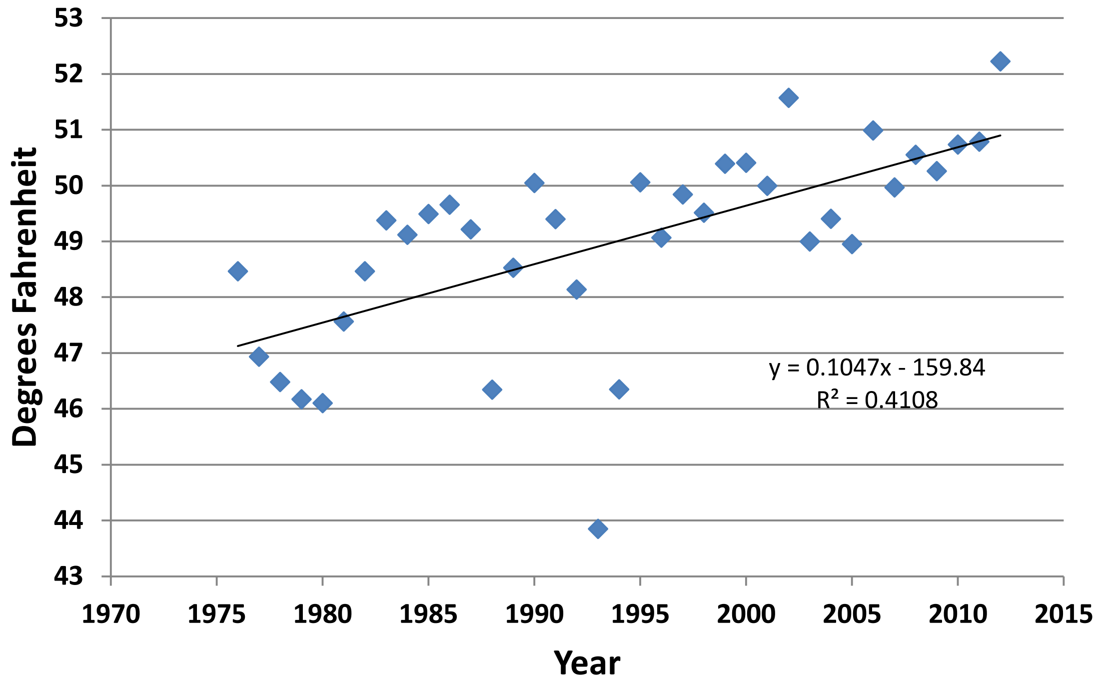
The discharge would "hold" (be attractive to) bass into the fall into November and even December in some years, but this varied from year to year. Bluefish left the discharge area much earlier than bass. During the periods of the year that bluefish and bass were present, they did not simply remain in the plume, but moved in and out of the current (and heat) in attempts to catch prey. Mr. Malkoski also saw bluefish and striped bass inside the canal at various times but their presence varied by time of year. By mid-summer when temperatures were highest, the bass and bluefish would be seen no more than about 10 or so yards into the canal (**see: Physical Temperature Characterization);** during much of the tidal cycle, the thermal plume mixes with ocean water inside the canal and the hottest water in the canal is at the surface during these times). In mid-summer, most of the bass and bluefish would be gone from the plume.

Blue mussels (*Mytilus edulis*) grew in large numbers at the end of the discharge canal through the spring but would die and fall off from their benthic attachments (byssal threads) in "sheets" during the heat of the summer when discharge temperatures reached their highest levels (mussels are one of the primary "fouling" organisms with which the facility has concerns as they can clog cooling pipes; because mussels are sensitive to high temperatures, they are controlled by "back flushing" with heated water).

Tautog and cunner were seen in abundance near the shore adjacent to PNPS. Both eat mussels and may have been attracted to the large numbers of mussels that were found in the path of the discharge. Tautog were often seen around large rocks near the mouth of the discharge canal but their abundance decreased as one proceeded farther up into the canal. The divers used to shoot (spearfish) tautog in the canal as they also were taken for radiological analysis. During the mid-late summer when ambient and plume temperatures were at their highest (and mussels were dying, apparently from the high plume temperatures) cunner avoided the plume.

Lobsters were also seen both adjacent to the path of the discharge as well as in the direct path of the discharge near the mouth of the canal but not usually inside the canal. Depending on time of year, divers would also see lumpfish, sea ravens and sculpins within the influence of the plume but these were not the dominant fishes observed.

Fig. 1. Yearly Means of Monthly Intake Temperatures (°F) at PNPS, 1976-2012



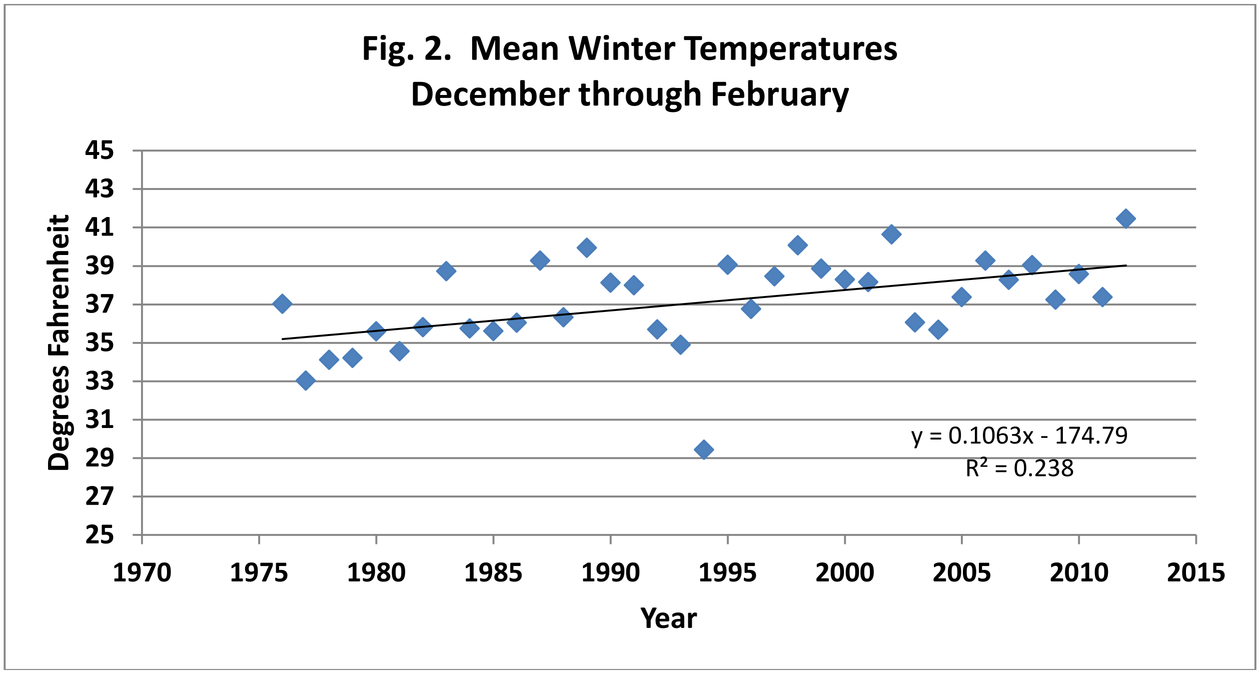


Fig. 2. Mean Winter Temperatures
December through February
Degrees Fahrenheit
45
43
41
39
37
35
33
31
29
27
25
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
Year
y = 0.1063x - 174.79
R² = 0.238

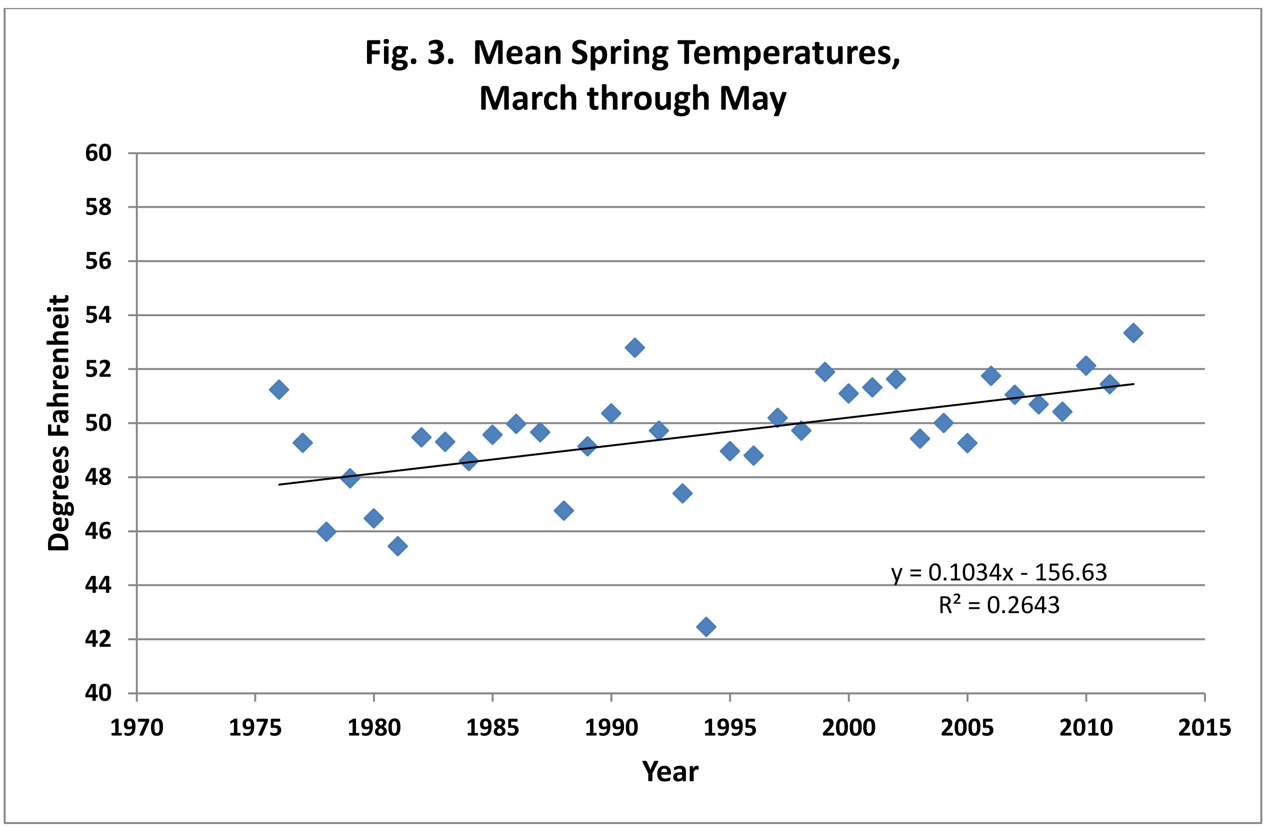


Fig. 3. Mean Spring Temperatures,
March through May
Degrees Fahrenheit
60
58
56
54
52
50
48
46
44
42
40
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
Year
y = 0.1034x - 156.63
R² = 0.2643

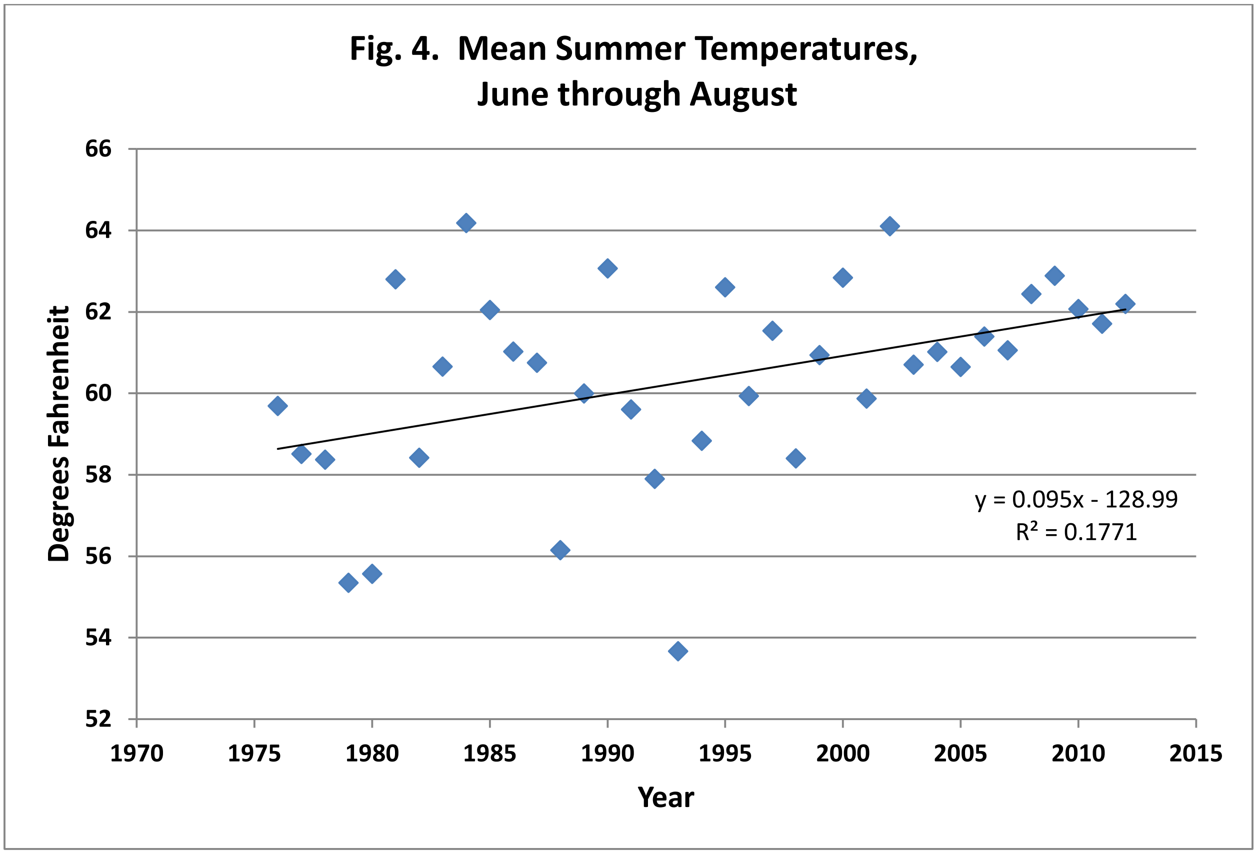


Fig. 4. Mean Summer Temperatures,
June through August
Degrees Fahrenheit
66
64
62
60
58
56
54
52
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
Year
y = 0.095x - 128.99
R² = 0.1771

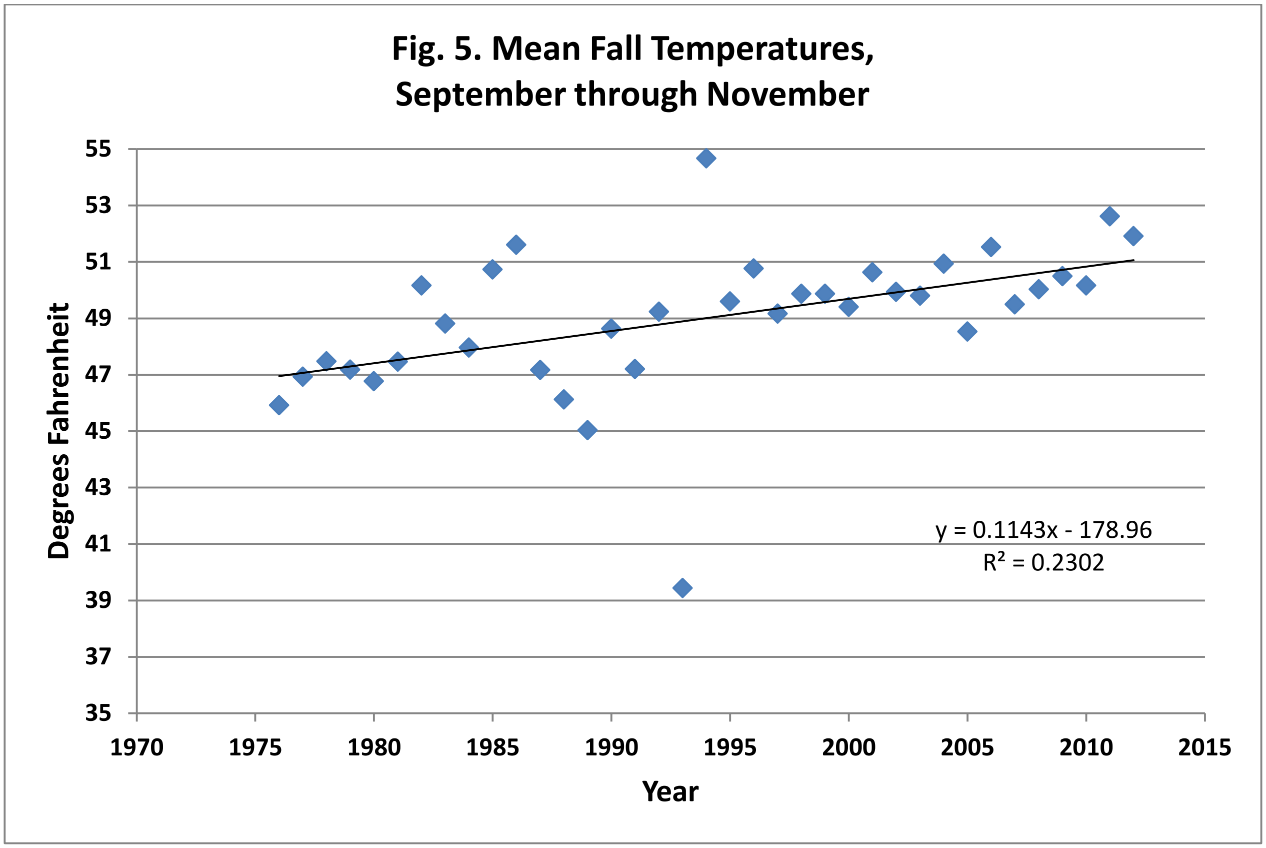


Fig. 5. Mean Fall Temperatures,
September through November
Degrees Fahrenheit
55
53
51
49
47
45
43
41
39
37
35
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
Year
y = 0.1143x - 178.96
R² = 0.2302

Attachment D
Assessment of Cooling Water Intake Structure Technologies and Determination of Best Available Technology Under CWA § 316(b)

Table of Contents

1.0 INTRODUCTION

With any NPDES permit issuance or reissuance, EPA is required to evaluate or re-evaluate compliance with applicable standards, including those specified in Section 316(b) of the CWA, 33 U.S.C. § 1326(b), cooling water intake structures (CWISs). Specifically, CWA § 316(b) provides that:

> *[a]ny standard established pursuant to [CWA sections 301 or 306] and applicable to a point source shall require that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact.*

33 U.S.C. § 1326(b). To satisfy §316(b), the location, design, construction, and capacity of the facility's CWIS(s) must reflect "the best technology available for minimizing adverse environmental impacts" ("BTA"). Such impacts include death or injury to aquatic organisms by "impingement" (the process by which fish and other organisms are killed or injured when they are pulled against the CWIS's screens as water is withdrawn from a water body) and "entrainment" (the process by which fish larvae and eggs and other very small organisms are killed or injured when they are pulled into the CWIS and sent through a facility's cooling system along with the water taken from the source water body for cooling). *See, e.g.*, 40 C.F.R. § 125.92(h) and (n). Entrained organisms are subjected to thermal, physical and, in some cases, chemical stresses in the facility's cooling system.

CWA § 316(b) applies to facilities with point source discharges authorized by a NPDES permit that also withdraw water from waters of the United States through a CWIS for cooling purposes. CWA § 316(b) applies to this permit due to the operation of a CWIS withdrawing water from Cape Cod Bay and used for cooling at the Pilgrim Nuclear Power Station (PNPS).

1.1. History of Rulemaking under CWA § 316(b)

EPA first promulgated regulations to implement § 316(b) in 1976. *See* 41 Fed. Reg. 17,387 (Apr. 26, 1976). The U.S. Court of Appeals for the Fourth Circuit remanded these regulations to EPA, *see Appalachian Power Co. v. Train*, 566 F.2d 451, 457 (4th Cir. 1977), which withdrew them, leaving in place a provision that directed permitting authorities to determine the BTA for each facility on a case-by-case basis. In the absence of applicable regulations, EPA has historically made § 316(b) determinations on a case-by-case basis based on best professional judgment ("BPJ"), for both new and existing facilities with regulated CWISs.

In 1995, EPA was sued for failing to promulgate regulations applying the BTA standard under § 316(b). The parties to the case settled the litigation by entering into a consent decree in which EPA committed to develop new § 316(b) regulations in three phases. Phase I was to set BTA requirements for *new facilities* with CWISs, while Phase II was to set BTA standards for *large, existing power plants* with CWISs (defined as those with intake flows of 50 MGD or more). Phase III was to address all remaining existing facilities with CWISs, such as manufacturing facilities and smaller power plants.

In December 2001, EPA promulgated new, final § 316(b) regulations that provide specific technology-based requirements for *new* facilities of any kind with a CWIS with an intake flow greater than two (2) million gallons per day ("MGD") (the "Phase I Rule"). *See generally* 66 Fed. Reg. 65,255 (Dec. 18, 2001). The Phase I regulations for new facilities are currently in effect and are codified at 40 C.F.R. Part 125, Subpart I. They do not, however, apply to *existing* facilities like PNPS.

In July 2004, EPA published final regulations applying § 316(b) to large, *existing* power plants withdrawing at least 50 MGD or more and generating and transmitting electric power as their primary activity (the "Phase II Rule"). *See* 69 Fed. Reg. 41,576 (July 9, 2004). Subsequent to litigation that resulted in the remand to EPA of many of the rule's provisions, *see Riverkeeper, Inc. v. U.S. EPA*, 475 F.3d 83 (2d Cir. 2007), *rev'd in part*, *Entergy Corp. v. Riverkeeper, Inc.*, 556 U.S. 208, 227 (2009), the Agency suspended the Phase II rule in July 2007, with the exception of 40 C.F.R. § 125.90(b), which remained in effect. *See* 72 Fed. Reg. 37,107 (July 9, 2007). According to 40 C.F.R. § 125.90(b) (2004), "[e]xisting facilities that are not subject to requirements under this [subpart J] or another subpart of this part [125] must meet requirements under section 316(b) of the CWA determined by the Director on a case-by-case, best professional judgment (BPJ) basis."

On June 16, 2006, EPA published the Phase III Rule under § 316(b) of the CWA, which established categorical requirements for new offshore oil and gas extraction facilities that have a design intake flow threshold of greater than 2 MGD, but dictated that the BTA would be determined on a case-by-case, BPJ basis for existing facilities with a design intake flow less than 50 MGD. *See* 71 Fed. Reg. 35,006 (June 16, 2006). As with the Phase I and II Rules, the Phase III Rule was challenged in federal court. EPA defended the Phase III Rule's provisions regarding new offshore oil and gas facilities, but, following the Supreme Court's 2009 decision in *Entergy*, the Agency sought a voluntary remand of the Phase III Rule to the extent that it addressed existing facilities. EPA explained that it planned to reconsider the Phase III Rule decision with regard to existing facilities in conjunction with its reconsideration of the Phase II Rule. In other words, EPA planned to consider requirements for all existing facilities together. The Fifth Circuit granted EPA's motion, while at the same time affirming the Phase III Rule's provisions pertaining to new offshore oil and gas extraction facilities. *See ConocoPhillips Co. v. EPA*, 612 F.3d 822, 842 (5th Cir. 2010).

After the suspension of the Phase II and III Rules (as it applies to existing facilities), and under the then-effective terms of 40 C.F.R. § 125.90(b), EPA continued to make BTA determinations on a case-by-case, BPJ basis. Neither the CWA nor EPA regulations dictate specific, detailed methodologies for determining a site-specific BTA under § 316(b). Therefore, EPA developed reasonable, appropriate approaches for its BPJ determinations of site-specific BTAs. EPA looked by analogy to the factors considered in the development of effluent limitations under the CWA and EPA regulations for guidance concerning additional factors that might be relevant to consider in determining the BTA under § 316(b). In setting effluent limitations on either a national categorical basis or a site-specific BPJ basis, EPA considers a set of factors specified in the statute and regulations. *See, e.g.*, 33 U.S.C. §§ 1311(b)(2)(A) and 1314(b)(2); 40 C.F.R. § 125.3(d)(3).[1] These factors include: (1) the age of the equipment and facilities involved, (2) the process employed, (3) the engineering aspects of applying various control techniques, (4) process changes, (5) cost, and (6) non-water quality environmental impacts (including energy issues). EPA also considered the appropriate technology for the category or class of point sources of which the applicant is a member and any unique factors relating to the applicant. *See* 40 C.F.R. § 125.3(c)(2)(i)–(ii). Thus, EPA considered these factors in making its case-by-case, BPJ determinations of the BTA for a facility's CWISs. In addition, as discussed above, and as is considered when setting BPT and BCT effluent limitations, EPA also considered the relationship of an option's costs and benefits in determining the BTA.

1.2. New CWA § 316(b) Regulations for Existing Facilities

On April 20, 2011, EPA published a proposed rule that would establish requirements under § 316(b) of the CWA for existing power generating facilities and existing manufacturing and industrial facilities that withdraw more than 2 MGD of water from waters of the United States and use at least 25 percent of the water withdrawn exclusively for cooling purposes. *See generally* 76 Fed. Reg. 22,174 (Apr. 20, 2011). The proposed rule included several options for addressing adverse environmental impacts from impingement and entrainment. EPA published two Notices of Data Availability (NODA) on June 11, 2012 and June 12, 2012 that further clarified EPA's approach to promulgating a Final Rule establishing CWIS requirements for existing facilities under § 316(b) of the CWA.

On August 15, 2014, EPA published the Final Rule establishing requirements for existing facilities under § 316(b) of the CWA. *See* 79 Fed. Reg. 48,300 (Aug. 15, 2014) ("Final 316(b) Rule for Existing Facilities" or "Final Rule").[2] The Final Rule's requirements reflect the BTA for minimizing adverse environmental impact, applicable to the location, design, construction, and capacity of cooling water intake structures for existing power generating facilities and existing manufacturing and industrial facilities. The Final Rule responds to the remands of the Phase II Rule and aspects of the Phase III Rule that applied to existing facilities by consolidating the universe of potentially regulated

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[1] *See also NRDC v. EPA*, 863 F.2d at 1425 ("in issuing permits on a case-by-case basis using its 'Best Professional Judgment,' EPA does not have unlimited discretion in establishing permit limitations. EPA's own regulations implementing [CWA § 402(a)(1)] enumerate the statutory factors that must be considered in writing permits.").

[2] EPA notes that following its promulgation, multiple petitions challenging the Final 316(b) for Existing Facilities have been filed in federal court.

facilities in a single proceeding. The Final Rule applies to all existing power generating facilities and existing manufacturing and industrial facilities that have the design capacity to withdraw more than 2 MGD of cooling water from waters of the United States and use at least twenty-five (25) percent of the water they withdraw exclusively for cooling purposes. The Final Rule, which became effective on October 14, 2014, applies to this permit because PNPS is an existing power generating facility that withdraws more than 2 MGD from waters of the United States and uses at least 25 percent of that withdrawal exclusively for cooling purposes.

2.0 METHODOLOGY FOR IMPLEMENTING THE NEW CWA § 316(B) REGULATIONS

Under the Final Rule, existing facilities are subject to "best technology available" (BTA) standards for impingement mortality and entrainment that are expected to minimize the adverse environmental impacts of CWISs. The Final Rule became effective October 14, 2014 and the requirements of the rule are implemented in NPDES permits as they are issued. In part, the Final Rule requires an existing facility to submit information and studies pertaining to its cooling water intake structure(s) and the resulting impingement and entrainment. The Final Rule provides a timeline for submitting this information with the NPDES permit application. However, in some cases, a facility's NPDES permit will expire before the permittee is able to collect the necessary information required in 40 C.F.R. § 122.21(r). Such is the case at PNPS, where the facility's NPDES permit has expired and is administratively continued, and the facility submitted an application for permit renewal long before the Final Rule was published.

As explained above, in the decades prior to promulgation of the Final § 316(b) Rule for Existing Facilities, EPA determined the BTA for individual permits on a site-specific, BPJ basis. In many ways, the new process for determining the BTA created by the Final Rule builds upon that prior site-specific, BPJ determination process. The Final Rule continues to call for the BTA to be determined on a facility-specific basis. Unlike the case-by-case nature of "pure BPJ permitting," however, the Final Rule lays out specific provisions for the site-specific analysis.

2.1. Final § 316(b) Rule's BTA Standard for Impingement Mortality

In the Final Rule, EPA's BTA impingement mortality standard is based on a modified traveling screens with a fish-friendly return as the best performing technology for impingement mortality reduction at existing facilities on a national basis. *See* 40 C.F.R. § 125.94(c)(5); 79 Fed. Reg. at 48,337 and 48,344. EPA's definition of this technology at 40 C.F.R. § 125.92(s) describes screens with collection buckets designed to minimize turbulence, a fish guard rail/barrier to prevent fish from escaping the collection bucket, "fish-friendly" smooth, woven, or synthetic mesh that protects fish from descaling and other abrasive injuries, continuous or near-continuous rotation, and a low pressure spray wash. In addition, the fish handling and return system must provide sufficient water flow to return organisms to the source waterbody in a manner that does not promote predation or re-impingement or require a large vertical drop. *See also* 79 Fed. Reg. at 48,374.

However, rather than specify a single technology or standard, the Final Rule requires a facility to choose from a number of alternatives for complying with the BTA standard for impingement mortality. Three of the compliance pathways are based on pre-approved technologies: a closed-cycle recirculating system (*See* 40 C.F.R. § 125.94(c)(1)), a CWIS with a design maximum through-screen intake velocity of 0.5 feet per second (fps) (*Id*. § 125.94(c)(2)), and an existing offshore velocity cap (*Id*. § 125.94(c)(4)). Three compliance pathways offer a streamlined approach to compliance which require the permittee to demonstrate that the technology (or combination of technologies) represents BTA performance under the conditions at the facility: a CWIS with an actual maximum through-screen intake velocity of 0.5 fps (*Id*. § 125.94(c)(3)), modified traveling screens (*Id*. § 125.94(c)(5)), and a system or combination of technologies whose demonstrated performance is the BTA for impingement reduction at the site (*Id*. § 125.94(c)(6)). The seventh alternative allows a facility to demonstrate compliance with the numeric impingement mortality performance standard through biological monitoring (*Id*. § 125.94(c)(7)). The regulations also have a number of additional provisions that pertain to specific issues concerning impingement, such as fragile species, *de minimis* effects and more. *See, e.g.*, 40 C.F.R. §§ 125.94(c)((9), (10), (11) and (12). Consequently, a permittee may choose to comply with the BTA standard for impingement mortality by employing a properly designed, built, and operated modified traveling screen as defined at § 125.92(s) or one of six alternative methods of compliance.

2.2. Final § 316(b) Rule's BTA Standard for Entrainment

Although modified traveling screens constitute BTA for impingement mortality, they do not minimize adverse environmental impacts associated with entrainment. Only three technologies – dry cooling, wet closed-cycle cooling, and a far offshore intake – performed well enough to serve as potential candidate best performing technologies for establishing BTA entrainment standards (See the *Technical Development Document for the Final Section 316(b) Existing Facilities Rule* (Final Rule TDD) at p 7-3[3]). In the Final Rule, EPA identified closed-cycle recirculating cooling systems as the best performing technology for entrainment (See the Final Rule TDD at p 7-6), but, despite numerous retrofits of existing units to closed-cycle cooling, rejected this technology as the basis for a uniform national entrainment standard because, among other things, it is not nationally available and in some instances has unacceptable non-water quality impacts. The Final Rule at 40 C.F.R. § 125.94(e) does require mechanical draft wet cooling as the BTA for impingement and entrainment at new units (as defined at § 125.92(u)).

For existing units, EPA did not identify any single technology or group of technology controls as available and feasible for establishing national performance standards for entrainment. Instead, the Final Rule expressly calls for the permitting agency to make a

[3] An electronic version of this document is available at http://water.epa.gov/lawsregs/lawsguidance/cwa/316b/upload/Cooling-Water_Phase-4_TDD_2014.pdf

site-specific determination of which technologies and/or practices satisfy the BTA standard for each individual facility. *See* 40 C.F.R. § 125.94(d). It puts in place a framework for establishing entrainment requirements on a site-specific basis, including the factors that must be considered in the determination of the appropriate entrainment controls, including the number or organisms entrained, emissions changes, land availability, and remaining useful plant life. 40 C.F.R. § 125.98(f)(2). The Final Rule also establishes factors that may be considered when establishing site-specific entrainment requirements, including: entrainment impacts of the waterbody, thermal discharge impacts, credit for flow reductions associated with unit retirements, impacts of controls on reliability of energy delivery, impacts on water consumption, and availability of alternative sources of water. *Id*. § 125.98(f)(3).

Finally, the United States Supreme Court held that EPA is authorized, though not statutorily required, to consider a comparative assessment of an option's costs and benefits in determining the BTA under CWA § 316(b). *Entergy Corp. v. Riverkeeper, Inc.*, 556 U.S. 208, 222-26 (2009), *rev'g in part, Riverkeeper v. EPA*, 475 F.3d 83 (2d Cir. 2007). In that regard, and as noted above, the Final Rule directs the permitting authority, under certain circumstances, to base site-specific entrainment requirements on, among other factors, the "[q]uanitfied and qualitative social benefits and costs of available entrainment technologies when such information is of sufficient rigor to make a decision." 40 C.F.R. § 125.98(f)(2)(v); *see also id.* § 125.92(x), (y) (defining "social benefits" and "social costs"). [4] The rule also provides the permitting authority with the discretion to "reject an otherwise available technology as a BTA standard for entrainment if the social costs are not justified by the social benefits." *Id.* § 125.98(f)(4); 79 Fed. Reg. at 48,351-52.

2.3. Additional Provisions of the Final 316(b) Rule

The Final Rule provides that the permitting authority may establish additional control measures and monitoring or reporting requirements in the permit in order to protect Federally-listed threatened and endangered species and designated critical habitat. 40 C.F.R. § 125.94(g). The permitting authority may include such conditions "that are designed to minimize incidental take, reduce or remove more than minor detrimental effects to Federally-listed species and designated critical habitat, or avoid jeopardizing Federally-listed species or destroying or adversely modifying designated critical habitat (*e.g.*, prey base)." *Id.*

Finally, applicable to both impingement mortality and entrainment and PNPS, the rule

[4] As described in EPA's *Guidelines for Preparing Economic Analyses* (December 2101) (EPA 240-R-10-001), social costs "represent the total burden that a regulation will impose on the economy and are defined as the sum of all opportunity costs incurred as a result of a regulation where an opportunity cost is the value lost to society of any goods and services that will not be produced and consumed as a result of a regulation." (Chapter 8, p. 8-1). The Economic Analysis for the Final Section 316(b) Existing Facilities Rule (May 2014) (EPA-821-R-14-001) defines social costs of regulatory actions as "the opportunity cost to society of employing scarce resources to prevent the environmental damage otherwise occurring except for the design and operation of compliance technology." (Chapter 7 p. 7-1).

provides that, if the owner or operator of a nuclear facility demonstrates to the permitting authority, upon the permitting authority's consultation with the Nuclear Regulatory Commission ("NRC"), that "compliance with this subpart [i.e., Subpart J—Requirements Applicable to Cooling Water Intake Structures for Existing Facilities Under Section 316(b) of the Clean Water Act] would result in a conflict with a safety requirement established by" the NRC, the permitting authority must establish site-specific BTA requirements that would not result in a conflict with the safety requirement. *Id.* § 125.94(f); 79 Fed. Reg. at 48,322-23.

2.4. Final § 316(b) Rule's Provision for Ongoing Permit Proceedings

In the Final Rule, EPA also sought to address ongoing permitting proceedings like the reissuance of the PNPS NPDES permit. Specifically, EPA recognizes that, in some cases, a facility may already be in the middle of a permit proceeding at the time the new regulations were promulgated. Relevant to the PNPS permit proceeding, 40 C.F.R. § 125.98(g) provides as follows:

> (g) *Ongoing permitting proceedings*. In the case of permit proceedings begun prior to October 14, 2014 whenever the Director has determined that the information already submitted by the owner or operator of the facility is sufficient, the Director may proceed with a determination of BTA standards for impingement mortality and entrainment without requiring the owner or operator of the facility to submit the information required in 40 CFR 122.21(r). The Director's BTA determination may be based on some or all of the factors in paragraphs (f)(2) and (3) of this section and the BTA standards for impingement mortality at 125.95(c).[5] In making the decision on whether to require additional information from the applicant and what BTA requirements to include in the applicant's permit for impingement mortality and site-specific entrainment, the Director should consider whether any of the information at 40 CFR 122.21(r) is necessary.

The Final Rule makes clear that for an ongoing proceeding, when sufficient information has already been collected, the permitting authority may proceed to a site-specific BTA determination for entrainment and impingement mortality. It is evident that EPA does not intend that the ongoing permit proceeding must backtrack and go through the full information gathering and submission process set out by the Final Rule where sufficient information has been submitted upon which to base a site-specific BTA determination. *See also* 79 Fed. Reg. at 48,358 ("… in the case of permit proceedings begun prior to the effective date of today's rule, and issued prior to July 14, 2018, the Director should proceed. See §§ 125.95(a)(2) and 125.98(g)."). The Final Rule also states that the permitting authority may base its site-specific BTA determination for entrainment on some or all of the factors specified in 40 C.F.R. §§ 125.98(f)(2) and (3).

[5] So in original. Correct reference is likely 125.94(c).

PNPS was first issued a NPDES permit in 1975 and has been collecting and submitting information to EPA and MassDEP about its CWIS for more than 30 years. Region 1 was working on the permit prior to promulgation of the Final § 316(b) Rule for Existing Facilities and had gathered substantial additional information from the permittee as required under its current, administratively-continued permit through the use of information request letters (sent under CWA § 308(a)) and site visits. In this case, the Region has considered whether any of the permit application information specified at 40 C.F.R. § 122.21(r) is necessary to support this permit decision, but has determined that the information already submitted by the Facility is sufficient. This information includes, but is not limited to, the following:

- *Engineering Response to United States Environmental Protection Agency CWA § 308 Letter – Pilgrim Nuclear Power Station, Plymouth, Massachusetts* (Enercon June 2008);
- *Adverse Environmental Impact Assessment for Pilgrim Nuclear Power Station* (LWB and Normandeau June 2008);
- *Economic Assessment of Fish Protection Alternatives at Pilgrim Nuclear Power Station* (NERA June 2008) ;
- *Entrainment and Impingement Studies Performed at Pilgrim Nuclear Power Station, Plymouth, Massachusetts from 2002 to 2007* (Normandeau, June 2008);
- *Assessment of Finfish Survival at Pilgrim Nuclear Power Station Final Report 1980-1983* (Marine Research, Inc. 1984);
- *Winter Flounder Area-Swept Estimate Western Cape Cod Bay* (Normandeau 2013);
- *Engineering Response Supplement to United States Environmental Protection Agency CWA § 308 Letter – Pilgrim Nuclear Power Station, Plymouth, Massachusetts* (August 2014);
- *316 Demonstration Report – Pilgrim Nuclear Power Station* (ENSR March 2000);
- *Study of Winter Flounder Transport in Coastal Cape Cod Bay and Entrainment at Pilgrim Nuclear Power Station* (ENSR and Marine Research, Inc. November 2000); and
- Annual entrainment and impingement reports from 1991 to the present.

As explained below, the BTA determination for controlling impingement mortality and entrainment at PNPS has been developed on a site-specific basis, consistent with EPA's Final § 316(b) Rule for Existing Facilities and under the ongoing permit proceeding provision at 40 C.F.R. § 125.98(g). In addition, EPA has considered any conditions necessary to meet Massachusetts surface water quality standards at 314 CMR 4.00 as they apply to the effects of CWISs on the State's waters.

2.5. State Water Quality Standards

In addition to satisfying technology-based requirements, NPDES permit limits for CWISs must also satisfy any more stringent provisions of state water quality standards (WQS) or other state legal requirements that may apply, as well as any applicable conditions of a state certification under CWA § 401. *See* CWA §§ 301(b)(1)(C), 401(a)(1) &(d), 510; 40 C.F.R. §§ 122.4(d), 122.44(d), 125.84(e), 125.94(i). This means that permit conditions for CWISs must satisfy numeric and narrative water quality criteria and protect designated uses that may apply from the state's WQS.

The CWA authorizes states to apply their WQS to the effects of CWISs and to impose more stringent water pollution control standards than those dictated by federal technology standards.[6] The United States Supreme Court has held that once the CWA § 401 state certification process has been triggered by the existence of a discharge, then the certification may impose conditions and limitations on the activity as a whole – not merely on the discharge – to the extent that such conditions are needed to ensure compliance with state WQS or other applicable requirements of state law.[7]

With respect to cooling water withdrawals, both sections 301(b)(1)(C) and 401 authorize the Region to ensure that such withdrawals are consistent with state WQS, because the permit must assure that the overall "activity" associated with a discharge will not violate applicable WQS. *See PUD No. 1*, 511 U.S. at 711-12 (Section 401 certification); *Riverkeeper I,* 358 F.3d at 200-02; *In re Dominion Energy Brayton Point, LLC,* 12 E.A.D. 490, 619-41 (EAB 2006). Therefore, in EPA-issued NPDES permits, limits addressing CWISs must satisfy: (1) the BTA standard of CWA § 316(b); (2) applicable state water quality requirements; and (3) any applicable conditions of a state certification under CWA § 401. The standards that are most stringent ultimately determine the final permit limits.

The Massachusetts Department of Environmental Protection (MassDEP) has designated Cape Cod Bay in the vicinity of this discharge a Class SA waterbody. Class SA "waters are designated as an excellent habitat for fish, other aquatic life and wildlife, including for their reproduction, migration, growth, and other critical functions, and for primary and secondary contact recreation." 314 CMR 4.05(4)(a). Though the standard for Class

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[6] The regulation governing the development of WQS notes that "[a]s recognized by section 510 of the Clean Water Act [33 U.S.C. § 1370], States may develop water quality standards more stringent than required by this regulation." 40 C.F.R. § 131.4(a). The Supreme Court has also recognized that the Clean Water Act allows states to adopt water quality requirements more stringent than federal requirements. *PUD No. 1 of Jefferson County v. Wash. Dep't of Ecology,* 511 U.S. 700, 705 (1994) (citing 33 U.S.C. §§ 1311(b)(1)(C), 1370; 40 C.F.R. § 131.4(ad)). *See also* 40 C.F.R. § 125.80(d); *Riverkeeper, Inc. v. U.S. Environmental Protection Agency,* 358 F.3d 174, 200-02 (2d Cir. 2004) ("*Riverkeeper I*").

[7] In *PUD No. 1,* the Supreme Court held that, in setting discharge conditions to achieve WQS, a state can and should take account of the effects of other aspects of the activity that may affect the discharge conditions that will be needed to attain WQS. 511 U.S. at 711-12. "The text [of CWA § 401(d)] refers to the compliance of the applicant, not the discharge. Section 401(d) thus allows the State to impose 'other limitations' on the project in general to assure compliance with various provisions of the Clean Water Act and with 'any other appropriate requirement of State law.'" *Id.* at 711. For example, a state could impose certification conditions related to CWISs on a permit for a facility with a discharge, if those conditions were necessary to assure compliance with a requirement of state law, such as to protect a designated use under state WQS. *See id.* at 713 (holding that § 401 certification may impose conditions necessary to comply with designated uses).

SA waters does not include any specific numeric criteria that apply to cooling water intakes, it is nevertheless clear that MassDEP must impose the conditions it concludes are necessary to protect the designated uses of the bay, including that it provide excellent quality habitat for fish and other aquatic life and a recreational fishing resource. In addition, 314 CMR 4.05(1) of the Massachusetts WQS provides that each water classification "is identified by the most sensitive, and therefore governing, water uses to be achieved and protected." This means that where a classification lists several uses, permit requirements must be sufficient to protect the most sensitive use.

Massachusetts interprets its WQS as being applicable to cooling water withdrawals. EPA agrees with the Commonwealth's interpretation. First, the Massachusetts Clean Waters Act provides that "[n]o person shall engage in any other activity which may reasonably be expected to result, directly or indirectly, in discharge of pollutants into waters of the [state] without a currently valid permit" from the Department. M.G.L. ch. 21, § 43(2); 314 CMR 3.04. MassDEP's position has been that the cooling water withdrawal associated with a once-through cooling water operation is an integral component of the "activity" that directly results in a thermal discharge. Therefore, PNPS's cooling water withdrawal is an activity subject to regulation under the permit that MassDEP must issue to authorize the discharge of thermal pollution under the Commonwealth's Clean Waters Act. Second, the state's CWA provides that MassDEP water permits may specify "technical controls and other components of treatment works to be constructed or installed," that MassDEP "deems necessary to safeguard the quality of the receiving waters." M.G.L. ch. 21, § 43(7). "Treatment works" is broadly defined to include "any and all devices, processes and properties, real or personal, used in the collection, pumping, transmission . . . recycling . . . or reuse of waterborne pollutants." M.G.L. ch. 21, § 26A; 314 CMR 3.02. MassDEP has concluded that a CWIS constitutes an integral component of a facility's once-through cooling water "treatment works," and therefore, MassDEP has further authority to regulate such structures.

On December 29, 2006, Massachusetts amended its WQS to make explicit its interpretation of the implicit meaning of its pre-existing WQS, adding the following provision in several locations: "in the case of a [CWIS] regulated by EPA under [CWA § 316(b)], the Department has the authority under [CWA § 401], M.G.L. c. 21, §§ 26 through 53 and 314 CMR 3.00 to condition the CWIS to assure compliance of the withdrawal activity with 314 CMR 4.00, including, but not limited to, compliance with narrative and numerical criteria and protection of existing and designated uses." 314 CMR 4.05(3)(b)(2)(d), 4.05(3)(c)(2)(d), 4.05(4)(a)(2)(d), 4.05(4)(b)(2)(d), 4.05(4)(c)(2)(d). Entergy promptly challenged the regulation in state court, alleging that MassDEP had no such authority under the state Clean Waters Act. *Entergy Nuclear Generation Co. v. Dep't of Envtl. Prot.,* 944 N.E.2d 1027, 1032 (Mass. 2011). On January 11, 2007, Massachusetts submitted this revision (among others) to its WQS to EPA for review pursuant to Section 303(c) of the federal CWA. On July 29, 2007, EPA wrote a letter to MassDEP stating that "there is nothing in the CWA that prohibits MassDEP from adopting and enforcing WQS related to CWISs to ensure that water withdrawals are conducted in a manner that protect[s] designated and existing uses and compl[ies] with narrative and numeric criteria." Letter from Stephen S. Perkins, EPA, to

Arleen O'Donnell, MassDEP (July 29, 2007), at 3. In 2011, the Massachusetts Supreme Judicial Court upheld the revision to Massachusetts' WQS, concluding that the state Clean Waters Act "confers on [MassDEP] authority to protect the water resources of the Commonwealth, and that that authority is broad enough to encompass the regulation of CWISs." *Entergy*, 944 N.E.2d at 1030, 1036-42.

In summary, the Massachusetts WQSs apply to CWISs. Furthermore, the PNPS permit's requirements must be sufficient to ensure that the facility's CWISs neither cause nor contribute to violations of the WQS and must satisfy the terms of the state's water quality certification under CWA § 401. EPA anticipates that the MassDEP will provide this certification before the issuance of the final permit.

2.6. Conclusion

The permit requirements in PNPS's new NPDES permit must satisfy the federal technology-based BTA standard of CWA § 316(b) as well as any more stringent requirements necessary to achieve compliance with state water quality standards. As presented below, EPA has developed a site-specific BTA determination for PNPS's CWIS consistent with the Final 316(b) Rule for Existing Facilities. This determination is based on information sufficiently similar to the information required by the Final Rule at § 122.21(r) and which has been provided by the permittee in response to EPA's requests under § 308 of the CWA as well as supplemental biological information provided by the permittee. EPA's determination of permit requirements for CWISs is set forth in the following sections and, as stated above, these requirements will be subject to the CWA § 401(a)(1) water quality certification process.

3.0 Biological Impacts of Cooling Water Intake Structures

The principal adverse environmental impacts typically associated with CWISs evaluated by EPA are the *entrainment* of fish eggs, larvae, and other small forms of aquatic life through the plant's cooling system, and the *impingement* of fish and other larger forms of aquatic life on the intake screens. *See, e.g.*, 79 Fed. Reg. at 48,318. In Section 316(b) Rulemaking, the effects of impingement and entrainment are referred to as adverse environmental impacts (AEI). *See* 79 Fed. Reg. at 48,303. Entrainment and impingement can kill large numbers of aquatic organisms, which can have immediate and direct effects on the population size and age distribution of the affected species. In some cases, losses of fish from impingement and entrainment may contribute to diminished populations of local species of commercial and/or recreational importance, biologically important local forage species, and local threatened or endangered species. In effect, CWISs can degrade the quality of aquatic habitat by adding to the ecosystem a significant anthropogenic source of mortality to resident organisms. The resulting losses of particular species could alter a wide range of aquatic ecosystem functions and services at the community level, including disrupting predator-prey relationships, ecological niches, and food webs. Mortality from long-term impingement and entrainment could lead to reductions in local community biodiversity, decrease ecosystem resistance and resilience (i.e., the ability to resist and recover from disturbance, both from anthropogenic impacts and natural variability), and contribute to overall degradation of the aquatic environment. In addition to considering these adverse impacts directly, their effects as cumulative impacts or stressors in conjunction with other existing stressors on the species are also considered. *See* 79 Fed. Reg. at 48,318-21 (Aug. 14, 2014).

Entrainment of organisms occurs when a facility withdraws water into a CWIS from an adjacent water body. Fish eggs and larvae are typically small enough to pass through intake screens and become entrained along with the cooling water within the facility. Organisms carried through the cooling system can be exposed to shear forces from mechanical pumps, physical stress or injury from contact with pipe surfaces, a rapid increase in water temperature as heat is transferred to the cooling water from the facility's condensers and high concentrations of chlorine or other biocides. After passing through the cooling system, organisms that survive are likely exposed to rapid decreases in water temperature as the heated cooling water mixes with the receiving waters. These physical, chemical, and thermal stressors, individually or in combination, can kill or injure the entrained organisms. *See* 79 Fed. Reg. at 48,318. The number of organisms entrained is dependent upon the volume and velocity of cooling water flow through the plant and the density of organisms in the source water body that are small enough to pass through the screens of the CWIS.[8] The extent of entrainment can be affected by the intake structure's location, the biological community in the water body, seasonal variation in ichthyoplankton densities, and by the characteristics of any intake screening system or other entrainment controls used by the facility.

Impingement of organisms occurs when organisms too large to pass through the screens at a CWIS but unable to swim away become trapped against the screens and other parts of the intake structure. Impinged organisms may be killed, injured, or weakened from exhaustion, starvation, asphyxiation (from being removed from the water or pressed against a screen preventing proper gill movement), descaling (loss of scales upon contact with screens), and other physical harms. *See* 66 Fed. Reg. at 65,263 (Dec. 18, 2001). Injured or weakened organisms that initially survive and are returned to the water may suffer delayed mortality. The quantity of organisms impinged is a function of the intake structure's location and depth, the velocity of water at the entrance to or in front of the intake screens (approach velocity) and through the screens (through-screen velocity), the seasonal abundance of various species of fish, and the size of fish relative to the size of the mesh in any intake barrier system (e.g., screens).

At PNPS, the productive aquatic community in Cape Cod Bay near the CWIS results in the presence of high egg and larval densities, numerous juvenile and adult fish and invertebrates, and anadromous fish migrating to spawning habitat, all of which have contributed to high rates of entrainment and impingement. The following section

[8] As described in the Phase I proposed rule (65 Fed. Reg. at 49,060) and the Phase II NODA (66 Fed. Reg. at 28,853), absent any other controls, withdrawal of a unit volume of water from a waterbody will result in the entrainment of an equivalent unit of aquatic life (e.g., eggs and larvae) from that volume of the water column. *See* 79 Fed. Reg. at 48,321 n.37.

discusses the potential for adverse environmental impacts to aquatic organisms as a result of the operation of PNPS's CWIS.

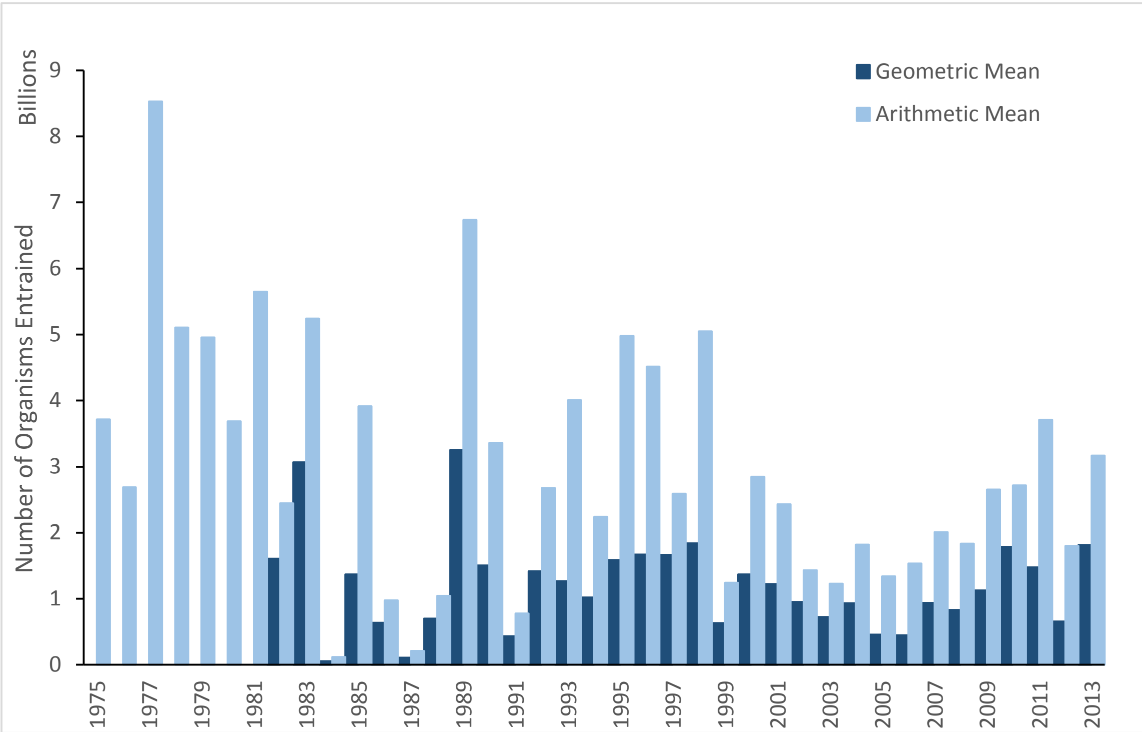
3.1. Entrainment at Pilgrim Nuclear Power Station

Fish eggs, larvae, and other aquatic organisms small enough to pass through the mesh of intake screens become entrained in a facility's cooling system. As previously described, once entrained, the eggs and larvae may be subjected to high velocity and pressure, increased temperature, and chemical anti-biofouling agents in the system. These factors are highly lethal and, in most cases, sensitive early life stages are unlikely to survive entrainment. EPA has found that eggs collected after passing through the CWIS show poor survival and larvae collected after interacting with the CWIS show essentially zero survival. For the purposes of the Final Rule, EPA concluded that no entrained organisms would survive and that, without entrainment control, entrainment is assumed to lead to 100% entrainment mortality. *See* 79 Fed. Reg. at 48,330. For issuance of the draft NPDES permit for PNPS, EPA also assumes 100% mortality of entrained organisms due to the absence of site-specific analysis demonstrating entrainment survival.

Entrainment data is available for PNPS from 1975 to the present, although collection of species-specific data began in 1980. Until 1994, entrainment sampling was conducted weekly from March through September, and semi-monthly during the remaining months. In the current revised protocol, introduced in 1994, entrainment samples representing the morning, afternoon, and night periods are collected during alternate weeks in January, February, October, November and December. From March through September, samples are collected on a weekly basis. All entrainment samples are collected using a 60-cm diameter plankton net mounted 30 meters from the headwall in the discharge canal.

Average annual egg entrainment (arithmetic) from 1975 to 2013 is approximately 2.8 billion eggs per year (range is 593 million to 8.4 billion) while annual average larval entrainment from 1975 to 2013 is about 354 million larvae per year (range is 76 million to 938 million). Based on geometric means, annual average egg entrainment is about 1.3 billion per year (range is 305 million to 3.7 billion) and annual average larval entrainment is about 205 million per year (ranging from 42 million to 744 million). The average (geometric and arithmetic) number of eggs and larvae entrained at PNPS from 1975 through 2013 is presented in Figure 1. According to Normandeau, geometric mean densities cannot be generated from entrainment data collected from 1975-1980 and these years were excluded from comparison (Normandeau 2015). Larval entrainment in 2013 was the highest value recorded in the time series and more than twice the long term mean of the data set, while total egg entrainment in 2013 was less than the long term mean of the data set. Historically low cooling water withdrawals during 1984 and 1987 likely resulted in the relatively low entrainment values during those years. On average, eggs accounted for more than 80% of the total entrainment in any given year.

Figure 1. Average density of eggs and larvae entrained at PNPS from 1975 through 2013 expressed as geometric and arithmetic mean (Normandeau 2015).



The average number of species observed in entrainment samples from 1980 to 2014 is 39 (range is 34 to 45). In 2013, 37 species of fish were identified in the entrainment samples while 38 species were identified in the 2014 entrainment samples. Generally, species that were dominant in entrainment samples in 2013 were the same as those observed in large numbers in the past decade, including: American plaice eggs, Atlantic cod eggs, sand lance larvae, and grubby larvae in the winter and early spring; cunner/tautog/yellowtail eggs and cunner larvae and winter flounder larvae in summer; and tautog/cunner/yellowtail eggs and fourspot windowpane eggs in late summer and autumn. Record high levels of larval entrainment in 2013 can be partly attributed to high densities of tautog, fourbeard rockling, cunner, and winter flounder larvae in July and August. In particular, unusually high densities of tautog were observed on 21 of 27 sampling dates and unusually high densities of fourbeard rockling were observed on 13 of 27 sampling dates in July and August. In both cases, densities in 2013 were the highest ever observed.

The large scale loss of eggs and larvae to entrainment can result in substantial environmental harm that may justify engineering or operational changes to a facility's CWIS. One approach that provides context to the loss of billions of eggs and larvae annually is to standardize losses as equivalent numbers of adult fish using species-specific survival tables based on life history and age-specific mortality rates. EPA recognizes that this approach considers early life stages solely as a means to perpetuate the local population and likely overlooks the critical ecological role eggs and larvae plays as a prey item for many other organisms. Mortality of early life stages is exceedingly high and many aquatic species generate thousands or even millions of eggs when spawning to secure survival of a single individual to adulthood. Still, there is an ecological benefit to early life stages even if they would not survive to adulthood. EPA considers, to the extent possible, the complex ecological benefits of early life stages on a qualitative basis. *See* 79 Fed. Reg. at 48,403. Here, EPA discusses the simplified approach of adult equivalents.

Normandeau (2015) calculated equivalent adults for a subset of species using species- and life-stage specific survival rates from the scientific literature and the number of eggs and larvae entrained. A number of assumptions go into this analysis, including the assumption of a 100% mortality rate for eggs and larvae that transit the facility. Entrainment is highly lethal in most cases, and even if an egg survives initially, its chances of surviving beyond the larvae stage are dramatically lower than eggs that were never entrained. As discussed above, EPA assumes that 100 percent of entrained organisms suffer mortality. *See* 79 Fed. Reg. at 48,318. In addition, adult equivalent analysis is dependent on the life-stage and species-specific survival rates used in the calculation, which are often not well understood, or several, often conflicting, values may be available in the literature.[9] Still, this approach provides a useful perspective on the potential impact of the loss of large numbers of eggs and larvae (in this case, billions of organisms) in terms of adult fish.

Entrainment losses presented as annual equivalent adult losses for several, key species are presented in Figure 2. Equivalent Adult loss estimates are presented for winter flounder, Atlantic cod, cunner, and Atlantic mackerel, because of their ecological value and/or commercial importance. On average, entrainment results in annual losses of 17,047 adult winter flounder, 785,219 adult cunner, 2,508 Atlantic menhaden, 12,837 Atlantic herring, 1,816 adult Atlantic cod, and 1,437 adult Atlantic mackerel. Adult equivalent losses of cunner are an order of magnitude greater than losses of other species because this species is entrained in significantly greater numbers than any other.

[9] In its analysis, Normandeau calculated values for adult equivalents using multiple sets of survival values for each species and calculated an average number of adult equivalents from these values. In most cases, as in Normandeau 2015, EPA presents the average adult equivalent value calculated from the values for each method. For winter flounder, EPA presents the average over three staged methods. For cunner and Atlantic cod, EPA presents adults equivalents based on survival values used in the (remanded) Phase II Rule.

Figure 2. Estimated annual age-specific adult equivalent losses for select species at PNPS from 1980 through 2014 (Normandeau 2015).

Based on mean annual entrainment values provided by Entergy, since coming on-line in 1975, PNPS has potentially entrained more than 100 billion eggs and 13 billion larvae. These entrainment losses have effectively removed more than 590,000 adult winter flounder, 450,000 adult Atlantic herring, and more than 27 million adult cunner, as well as tens of thousands of other adult fish, from the population. In addition to the millions of adult equivalent fish that can be quantified, there are untold additional losses for those species, such as fourbeard rockling and sand lance, for which life history data is insufficient to calculate adult equivalent losses. These species comprise a substantial proportion of entrainment at PNPS and play significant roles in the ecology of Cape Cod Bay. In particular, sand lance are a preferred prey of humpback whales in the Gulf of Maine (*see*, *e.g.*, Hain et al. 1995, Hazen et al. 2009, and Friedlaender et al. 2009). As a result, the analysis performed by Normandeau and presented here may underestimate the true impact of adult losses due to entrainment.

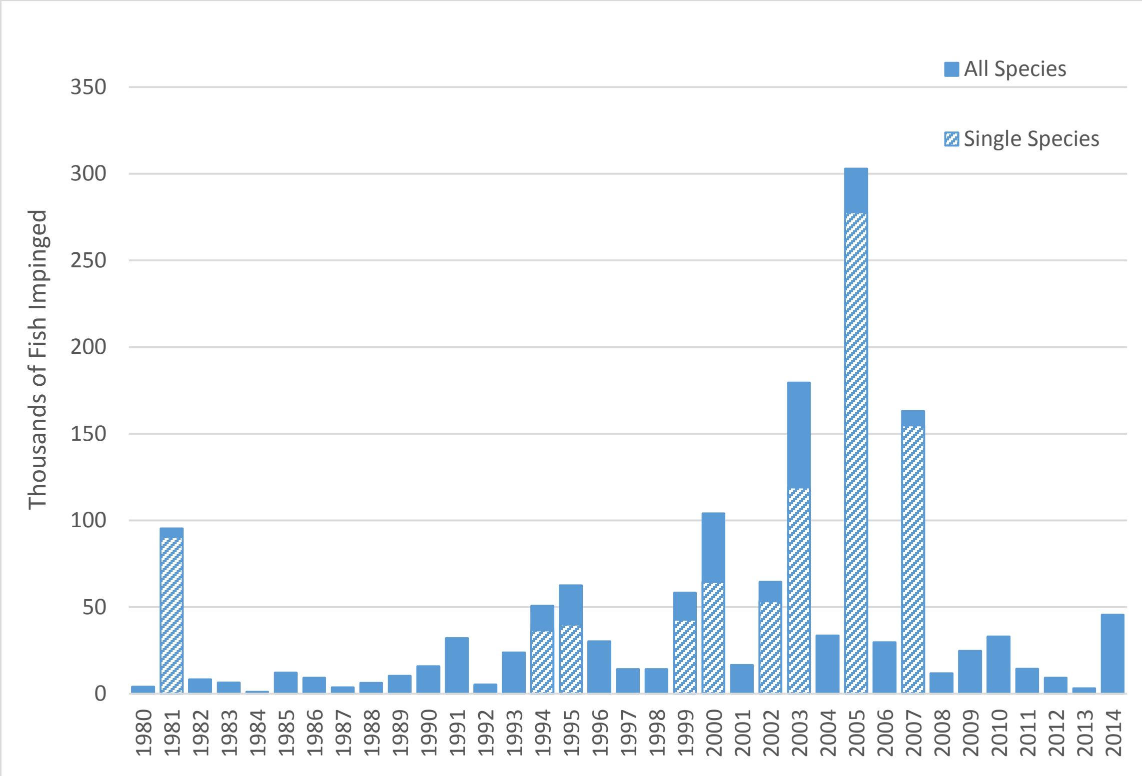
3.2. Impingement at Pilgrim Nuclear Power Station

The impingement of organisms occurs when water is drawn into a facility through PNPS's CWIS and organisms become trapped against the traveling screens. Impinged fish may suffer from improper gill movement, de-scaling, starvation, exhaustion or other injury while trapped against intake screens. If an organism is returned to the waterbody through a debris return trough, it may suffer further injuries from contact with debris in the trough or the trough itself. Upon being returned to the waterbody, any injured or disoriented organisms may be more susceptible to predation. *See* 66 Fed. Reg. 65263 (December 18, 2001) (Preamble to the Phase I Rule).

Impingement sampling at PNPS started in 1980. Currently, samples are taken three times per week and each sample represents an eight hour period. Sample collection occurs in conjunction with entrainment sampling on Monday morning, Wednesday afternoon and Friday night.

Since 1980, PNPS has impinged between 21 and 39 species of fish per year, with a total of 81 different species of fish impinged from 1980 to 2014. Eight species (alewife, Atlantic silverside, blueback herring, cunner, grubby, hakes, rainbow smelt and winter flounder) have been impinged every year. Eight other species (Atlantic herring, Atlantic menhaden, Atlantic tomcod, lumpfish, northern pipefish, rock gunnel, three-spine stickleback and windowpane) have been impinged during 90% of the years since 1980. The number of fish impinged per year at PNPS, illustrated in Figure 3, is highly variable and has fluctuated by 2 orders of magnitude. Above average impingement is commonly associated with high impingement of a single species and, in many cases, corresponds to the occurrence of a high impingement event (see Table 2).

Figure 3. Number of fish impinged at PNPS since 1980 (Normandeau 2015).



The lowest annual total for impingement losses was 1,104 fish (in 1984), while the highest was 302,883 fish (in 2005). The long-term mean for annual impingement losses is 42,806 fish. In 2014, 45,577 fish were impinged, primarily Atlantic silversides (36% of total impingement), Atlantic menhaden (31.1%), red hake (5.7%), rainbow smelt (3.9%), and blueback herring (3.6%). Generally, impingement in 2014 was slightly above the long-term average. Two impingement events occurred in December 2014 in which 8 species were impinged on each date at relatively high rates (a combined rate of 33 and 223 fish per hour for all species). Rainbow smelt and Atlantic silversides dominated the catch on December 3rd (at 33.3% and 30.3%, respectively), while 93.7% of the December 10th catch was Atlantic silversides.

Table 1. Species composition of mean annual impingement at PNPS 1980-2013 (Normandeau 2015).	
Species	Percent of Total
Atlantic menhaden	53.5%
Atlantic silverside	23.3%
Alewife	4.7%
Rainbow smelt	3.3%
Sand lance	2.2%
Winter flounder	2.2%
Atlantic herring	2.1%
Blueback herring	1.7%
Grubby	1.3%
Other species	5.7%

Fish species that experienced the highest mean annual impingement losses primarily include pelagic schooling fish, though substantial numbers of demersal winter flounder were also lost to impingement. From 1980 through 2013, more than 94% of mean annual impingement was comprised of just nine species (Table 1). Since 1980, Normandeau extrapolates that over 1.5 million fish have been impinged, including more than 32,800 winter flounder, 48,800 rainbow smelt, 26,800 blueback herring, 350,000 Atlantic silversides, and 790,000 Atlantic menhaden.

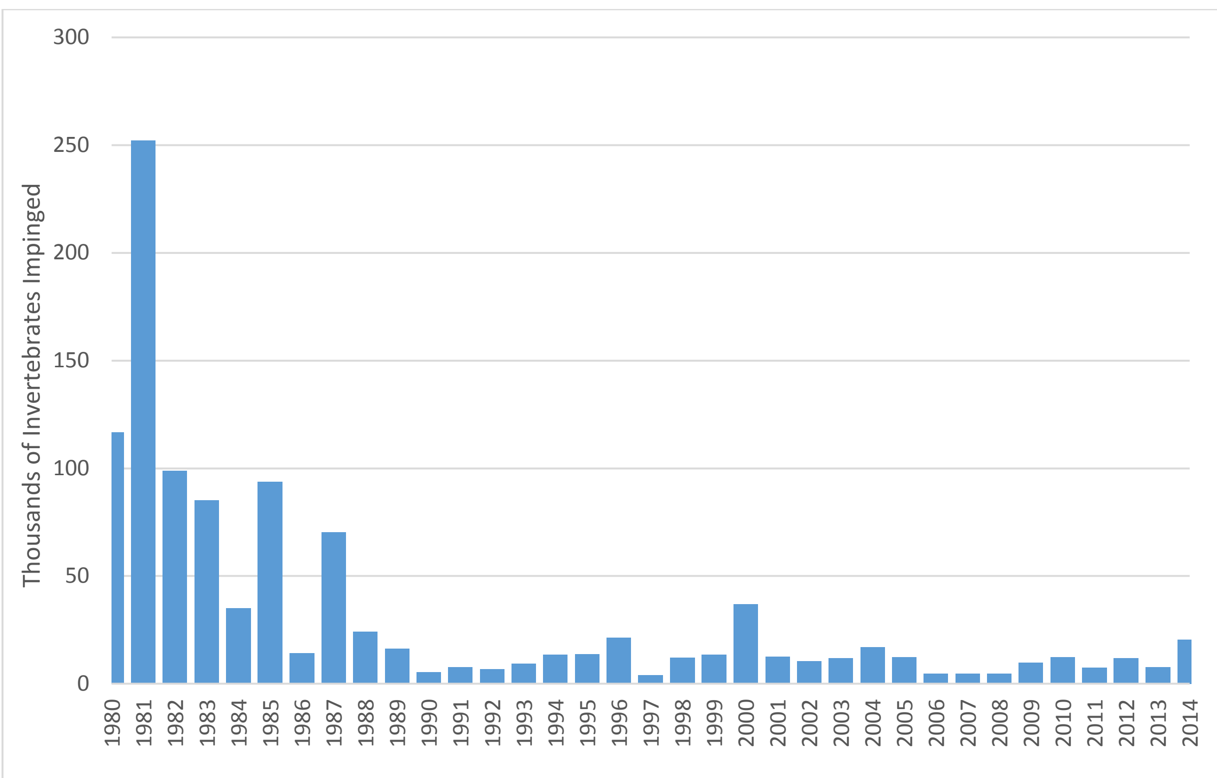
Levels of annual impingement that exceeded the long-term mean can be attributed to unusually high levels of impingement of a single species. The current permit for PNPS requires the permittee to report incidents when the impingement rate of fish exceeds 20 fish per hour and the overall total is 1,000 fish or more. These large mortality events commonly result in the impingement of large numbers of schooling fish on the intake screens. At PNPS, Atlantic menhaden and Atlantic silversides accounted for 15 of the 21 recorded impingement events on record. Table 2 lists the large impingement events (defined as an impingement rate of 20 or more fish per hour and total impingement of 1,000 fish or more over the event) at PNPS from 1973 to 2014. Since 1980, these large impingement events account for 22% of the total number of fish impinged at PNPS. The December 2014 impingement events discussed above were not reported here because the total number of fish impinged did not exceed 1,000.

Table 2. Estimated number of species impinged during large impingement events at PNPS since 1980 (Normandeau 2015).		
Date	Dominant Species	Estimated Number Impinged (All species)
August-September 1973	Clupeids	1,600
August 5, 1976	Alewife	1,900
November 23-28, 1978	Atlantic menhaden	10,200
December 11-29, 1978	Rainbow smelt	6,200
March/April 1979	Atlantic silverside	1,100
September 23-24, 1981	Atlantic silverside	6,000
July 22-25, 1991	Rainbow smelt	4,200
December 15-28, 1993	Atlantic silverside	5,100
November 26-28, 1994	Atlantic silverside	5,800
December 26-28, 1994	Atlantic silverside and Rainbow smelt	11,400
September 8-9, 1995	Alewife	13,100
September 17-18, 1999	Atlantic menhaden	4,910
November 17-20, 2000	Atlantic menhaden	19,900
August/September 2002	Atlantic menhaden	33,300
November 1, 2003	Atlantic menhaden	2,500
November 12-17, 2003	Atlantic menhaden	63,900
November 19-21, 2003	Sand lance and	17,900

	Atlantic menhaden	
November 29, 2003	Atlantic silverside	3,900
August 16-18, 2005	Atlantic menhaden	107,000
September 14-15, 2007	Atlantic menhaden	6,500
July 29, 2010	Alewife	1,061

In addition to adult and juvenile fish, a wide range of invertebrate species, including crustaceans, bivalves, echinoderms, cephalopods, tunicates, gastropods, jellies, worms and sea anemones, are impinged at PNPS. Figure 4 presents invertebrate losses from 1980 to 2014. On average, 31,739 invertebrates per year are impinged, with the lowest number of impingement losses 1997 (4,107) and the highest number in 1981 (251,997). The greatest number of invertebrates were impinged in 1980 and 1981; impingement during these years was dominated by large numbers of blue mussels. Since 1981, impingement of blue mussels has dropped substantially from these previously high values. In 2014, 20,515 invertebrates were impinged including sevenspine bay shrimp and green crab totals that were more than twice the long-term mean. The number of invertebrates impinged over the 34-year data collection was estimated to be 1,099,652. Invertebrate species that experienced the greatest impingement losses included American lobster, blue mussel, the clam worm, green crab, horseshoe crab, lady crab, rock/Jonah crabs, bay shrimp, sea stars and squid.

Figure 4. Thousands of invertebrates impinged annually at PNPS from 1980-2014.



3.3. Adverse Environmental Impacts at PNPS

Section 316(b) of the CWA requires that "the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact." 33 U.S.C. § 1326(b). The withdrawal of cooling water at PNPS removes and kills billions of aquatic organisms, predominantly fish eggs and larvae, but also adult fish, shellfish, crustaceans, and other aquatic life, from Cape Cod Bay. In the Final 316(b) Rule for Existing Facilities, the impacts from aquatic organisms drawn into CWISs are referred to as adverse environmental impact (AEI). *See* 79 Fed. Reg. at 48,303. In addition to these direct impacts, the loss of aquatic organisms due to CWISs can have indirect, ecosystem level effects, including disruption of aquatic food webs, disruption of nutrient cycle and other biochemical processes, alteration of species composition and overall levels of biodiversity, and degradation of the overall aquatic environment. *See* 79 Fed. Reg. at 48,303.

In the discussion above, EPA has documented the primary adverse impacts of impingement and entrainment, which result in the direct mortality of billions of eggs and larvae and thousands of adult and juvenile fish each year. Entrainment mortality has the potential to result in the loss of millions of adult fish each year from the local community in Cape Cod Bay. Through correspondence with EPA Region 1 prior to promulgation of the Final Rule, Entergy has asserted both that (1) "EPA (with DEP's concurrence) has renewed each of PNPS' NPDES permits over this thirty-three year period [since 1975], consistently determining and, as of the Station's recent NPDES permits, expressly stating that PNPS' existing CWIS configuration already constitutes BTA under § 316(b)" and (2) that monitoring data collected by the permittee since 1977 demonstrates "that operation of PNPS' CWIS has not resulted, and was not expected to result, in an adverse environmental impact to the aquatic ecosystem in the vicinity of the Station as a result of impingement or entrainment." See p. 2 of the July 1, 2008 letter from Elise N. Zoli of Goodwin Procter to Damien Houlihan of EPA.

First, since the issuance of PNPS' current permit in 1993, new regulations pertaining to existing facilities (including PNPS) have been promulgated to reduce impingement and entrainment of fish and other aquatic organisms at cooling water intake structures used by existing power generation and manufacturing facilities for the withdrawal of cooling water from waters of the United States. *See* 79 Fed. Reg. 48,300 (Aug. 14, 2014) and the discussion of the application of the Final Rule to PNPS, above. These regulations establish new requirements that reflect the best technology available for minimizing adverse environmental impact that may be, though are not necessarily, different from the consideration of BTA under the current permit and, as such, require that EPA reconsider BTA at PNPS. In fact, as Entergy recognizes, the current NPDES permit specifically requires that "The present design shall be reviewed for conformity to regulations pursuant to Section 316(b) of the Act when such are promulgated." Part I.A.1.i.3 of the current NPDES Permit. With regard to impingement, the new § 316(b) regulations establish nationally-applicable BTA standards without reference to any previous BTA determination for a particular facility. 40 C.F.R. § 125.94(c). For entrainment, the new regulations establish the framework under which a permitting authority must make a site-specific BTA determination and the factors that must be considered in that determination. *Id.* § 125.98(f). Notably, a previous BTA determination for a particular facility does not appear as a factor in that list. *See id.* § 125.98(f)(2). To the contrary, the Final Rule provides that a permitting authority may only determine that "no additional control requirements are necessary beyond what the facility is already doing" if the permitting authority finds that "all technologies considered have social costs not justified by the social benefits, or have unacceptable adverse impacts that cannot be mitigated." *Id.* § 125.98(f)(4).

Second, the preamble to the Final 316(b) Rule for Existing Facilities generally refers to impingement and entrainment mortality associated with the withdrawal of cooling water through a CWIS as an adverse environmental impact. *See, e.g.*, 79 Fed. Reg. at 48,318-21 and 48,328 ("EPA interprets section 316(b) to require the Agency to establish a standard that will best minimize impingement and entrainment—the main adverse effects of cooling water intake structures . . . ."). Thus, the loss of, or injury to, aquatic organisms (including fish eggs and larvae, juvenile and adult fish, and other types of organisms) from being entrained or impinged by a CWIS constitutes adverse environmental impact under CWA § 316(b). EPA Region 1 has established, in the discussion above, that PNPS is responsible for the loss of billions of eggs and larvae, and millions of fish and other aquatic organisms annually as a result of the operation of its CWIS. Consistent with the Final Rule, these losses represent an adverse environmental impact to Cape Cod Bay.

EPA has established that the loss of aquatic life due to impingement and entrainment at PNPS does constitute an adverse environmental impact.[10] That said, EPA does, however, work to assess the scope and import of the adverse impacts as part of its ultimate determination of the BTA in broader ecological context to the extent possible based on the best, reasonably available information. EPA stated in the May 1977 Draft § 316(b) Guidance that "[t]he magnitude of an adverse impact should be estimated" with reference to the following factors: (1) "absolute damage," (2) "percentage damage," (3) absolute and percentage damage to any endangered species, (4) absolute and percentage damage to any "critical aquatic organism," (5) absolute and percentage damage to commercially valuable and/or sport fisheries yield, and (6) "whether the impact would endanger (jeopardize) the protection and propagation of a balanced population of shellfish and fish in and on the body of water from which the cooling water is withdrawn (long-term impact)." EPA considers whether the losses of the various life stages of a particular species can be shown to have, or not to have, an effect on the local population of that species. EPA also considers whether the losses to one or more species might impact the health of the overall community of organisms in the affected ecosystem. The guidance indicates that adverse impacts ought to be evaluated at all these levels, but does not suggest that adverse impacts are insignificant or immaterial if impacts are not able to be demonstrated at the overall population or community level. Of course, the significance or

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[10] This is not a case of a few organisms being entrained and impinged, or even a case of one hundred fish being impinged, or 10,000 eggs and larvae. The data indicate that PNPS's CWIS entrains *billions* of eggs and larvae and impinges hundreds of thousands of juvenile and adult fish. EPA concludes that there is no serious question that entrainment and impingement in this case are sufficient to register as AEI to be appropriately minimized under § 316(b).

magnitude of the impacts may come into play when considering whether the social cost of undertaking particular actions to further reduce impacts is justified by the social benefits.

Of course, in many cases, the Agency will be unable to draw conclusions about these broader effects in light of the limits on available information and the difficulties of the science of fish population dynamics. Ultimately, EPA completes a reasonable assessment of the adverse impacts in light of the reasonably available information and then factors that into its determination of the BTA in each case, including the weighing of the social costs and benefits of different BTA options. EPA's analysis for the Draft Permit is consistent with these principles.

3.3.1. Species-specific Adverse Environmental Impacts at PNPS

It can be challenging to put the cumulative losses from a CWIS in a meaningful context. Historically, power generating facilities have used commercial fish landings as a point of comparison. This point of comparison has not been very meaningful, because the landings come from geographic areas that are substantially larger than just the receiving water of the power generating facility. Entergy, in its 2008 *Adverse Environmental Impact Assessment for Pilgrim Nuclear Power Station*, focuses on "whether water withdrawals at the CWIS have caused an ecologically significant reduction in the abundance of local and regional populations of susceptible fish and macrocrustacean (American lobster) species" (p. 10). In its analysis, local and regional populations extend from Cape Cod Bay to the entire Gulf of Maine. Arguably, an ecologically-relevant scale is to compare the cumulative losses due to impingement and entrainment at PNPS to a discrete population segment. Determining discrete population segments for marine species can be very difficult; however, some species have very high levels of site fidelity to spawning grounds. This means that individuals in that population will spawn in the same location year after year. EPA has attempted to demonstrate potential adverse impacts of the CWIS on distinct population segments by focusing on a few species with high site fidelity.

Winter Flounder

Studies have shown winter flounder to have an extremely high level of site fidelity to natal spawning grounds (Buckley et al. 2008). To assess the potential impacts of entrainment and impingement on winter flounder in Cape Cod Bay, PNPS conducts an annual trawl survey of 106 square miles of western Cape Cod Bay. The annual survey consists of 80+ trawls to derive an estimate of winter flounder density. In calculating a winter flounder density estimate, it is assumed that the net has an efficiency of 50%. The density estimate is extrapolated over a 106-square mile area to derive a population estimate of winter flounder in western Cape Cod Bay.

To estimate the percentage of the population lost to entrainment and impingement at PNPS, Normandeau compares the number of age-3 equivalent winter flounder lost as eggs and larvae with the area swept population estimate in western Cape Cod Bay three years later. (Normandeau 2015 pp. 19-32). From 1997 to 2011, the percentage lost varies annually from less than 1 percent to as high as 26 percent with an annual average of 9 percent of the area swept estimate. The 2014 equivalent age-3 winter flounder lost to impingement and entrainment amounts to 10.6% of the 2014 area swept estimate. *Id*.

River Herring and Rainbow Smelt

The rivers in and around Plymouth Harbor and Duxbury Bay, including the Jones River and Town River, support spawning habitat for several species of anadromous fish, which grow in estuaries and coastal waters and travel to freshwater rivers to spawn, including alewives, blueback herring (together commonly known as river herring) and rainbow smelt. Because these species spawn in freshwater and migrate to estuaries as young-of-the-year, PNPS entrains few early life stages. However, river herring and rainbow smelt are among the most commonly impinged species at PNPS. Based on impingement data collected from 1980 through 2014, mean annual impingement is 2,776 fish and 1,424 fish for river herring and rainbow smelt, respectively. Both rainbow smelt and alewife have experienced high impingement events, with more than 1,000 alewife impinged during a single event in July 2010 and more than 4,200 rainbow smelt impinged during a single event in July 1991 (Normandeau 2015).

Population estimates for river herring (alewives and bluebacks) in the Jones River have been estimated based on the herring run count at the Elm Street fish ladder since 2005 (Table 3).[11] Fish counters count the number of fish that pass in a 10-minute interval based on the recommendations in Nelson (2006). Impingement losses each year between 2005 and 2014 comprise a substantial percentage of the estimated spawning run in most years. In 4 of the 10 years for which river herring spawning population estimates are available, impingement losses exceeded the estimated spawning run in the Jones River. Losses of this magnitude may potentially negatively impact the population of river herring in the Jones River. Impingement of river herring is most common in November – December (61%), when juveniles emigrate from freshwater, followed by March-April (13%) before fish can make it upriver during the annual spawning migration.

Table 3: Population estimate of river herring in the Jones River compared to river herring impingement losses at PNPS.

Year	Jones River population estimate	PNPS river herring impingement losses	Impingement losses compared to population estimates
2005	804	911	113%
2006	1,843	810	44%
2007	2,651	790	30%
2008	560	278	49%

[11] Data obtained from volunteer counts of herring run as reported in Jones River Watershed Association 2015 Annual Progress Report. Available at http://jonesriver.org/getfile/annual-reports/JRWAProgressReport2015.pdf?57c1ac

2009	637	1,291	203%
2010	4,512	12,951	287%
2011	3,597	2,288	64%
2012	1,596	2,218	139%
2013	4,559	309	7%
2014	5,121	2,905	57%
mean	2,588	2,475	96%

At one time, smelt were an abundant species ranging from Virginia to Labrador (Collette and Klein-MacPhee, 2002). For over 100 years, smelt sustained a commercial fishery with a peak take of 162.8 metric tons in 1966. Landings declined to a low of 1.3 metric tons in 1988. Landings increased in the early 1990s back up to 27.1 metric tons in 1992, but they plummeted to 0.1 metric tons in 2001. Substantial population declines have reduced the southern edge of this species range. The population entering the Jones River and nearby rivers currently represents the southern limit of the species range (Chase 2006). In response to the dramatic range contraction and abundance declines, in 2004 the National Oceanic and Atmospheric Administration (NOAA) listed rainbow smelt as a species of concern. This designation highlights NOAA's concern about the species status, but indicates that insufficient information exists to include this species on the Endangered Species List.

PNPS has impinged large numbers of rainbow smelt that are likely associated with the Jones River run. Comparable population estimates described above for river herring are unavailable for rainbow smelt in the Jones River. However, the MassDMF has been assessed spawning run demographics. Chase et al. (2009) found that the Jones River has a truncated age distribution with an abnormally high percentage of age-1 fish and that these age-1 fish were smaller than comparably aged fish from more northern rivers. In response to stress, spawning at an earlier age in short-lived species is believed to be a tactic that may yield higher evolutionary fitness than staying at sea for additional time to gain larger size (Gross 1987). The high percentage of age-1 fish in the Jones River may be an indication of a population under stress.

PNPS is estimated to have impinged 48,054 rainbow smelt from 1980-2013 with an average of 1,413 fish per year. Rainbow smelt is a schooling fish, so losses tend to come in large events, as described above. As a species, rainbow smelt are in serious decline. The continued mortality of thousands of rainbow smelt each year from impingement at PNPS represents a substantial source of additional mortality on the Jones River population that is inconsistent with stopping further declines and promoting the propagation of this species.

Atlantic Cod

Atlantic cod has been a dominant component of the commercial New England fishery for centuries. However, recent declines in stock have led the National Marine Fisheries Service (NMFS) to implement numerous management measures for protection of Gulf of Maine Atlantic cod. In particular, the most recent stock assessment in 2014 indicates that the Gulf of Maine stock is in poor condition. NMFS concludes that the stock is overfished and that overfishing is currently occurring. *See* Gulf of Maine Atlantic Cod 2014 Stock Assessment Update Report (NMFS 2014). Specifically, spawning stock biomass is the lowest ever estimated and is at about 4% of the biomass necessary to maintain the fishery.[12] Fishing mortality remains high despite the fact that catches in 2012 and 2013 are among the lowest since 2004. In addition, recruitment into the fishery from 2009 through 2013 has declined considerably from recruitment during 2004 to 2009. If recent weak recruitment continues, productivity and rebuilding will be less than projected in the stock assessment. The recent stock assessment prompted the NMFS to take drastic measures to protect the stock. Most recently, the NMFS limited multispecies common pool vessels to 25 pounds of Atlantic cod per trip for the remainder of the year (September 15, 2015 to April 15, 2016), which was an increase from the June 2015 temporary prohibition on any take of Atlantic cod for common pool vessels. *See* 80 Fed. Reg. at 55,561 (Sept. 16, 2015).

PNPS' CWIS results is the mortality of an average of more than 6 million Atlantic cod eggs (range 1.2 million to 20.4 million) and 1.1 million larvae (range 0.1 million to 4.2 million) annually based on entrainment data from 1980 through 2014. Normandeau estimates that these losses, on average, equate to almost 1,900 age-2 Atlantic cod (range 228 to 6,707) lost annually. An additional 66 cod (range 0 to 688) are impinged annually, resulting in an average loss of about 54 age-2 fish. Based on commercial and recreational landings and discard data from 1982 to 2013 (NMFS 2014), the weight-at-age of an age-2 Atlantic cod ranges from 1.1 to 3.0 pounds with a mean of 1.9 pounds. Thus, on average PNPS is taking and average of about 3,700 pounds of cod per year. The loss of millions of eggs and larvae each year at PNPS' CWIS is not consistent with preventing further declines and promoting rebuilding of the Gulf of Maine Atlantic cod stock.

Normandeau asserts that the loss of age-2 adult equivalent Atlantic cod lost to impingement and entrainment mortality is relatively low as compared to the average annual commercial landings for NMFS Area 514 (2,216,258 pounds) from 1995 to 2013, and Massachusetts inland and near shore recreational landings (471,162 pounds) from 1995 through 2014. EPA agrees that, at this scale, the loss of 1,000 pounds of Atlantic cod per year comprises a low percentage of regional commercial and recreational landings. However, EPA also considers that the Gulf of Maine Atlantic cod stock is in poor condition, current projections indicate that conditions are not favorable for rebuilding, and recruitment to the fishery is historically low. While losses at PNPS comprise only a percentage of the overall mortality, this additional and unnecessary

[12] In 2013, the Atlantic cod spawning stock biomass was estimated to be 2,063 metric tons (mt) based on model projections with constant mortality at M = 0.2. The spawning stock biomass necessary to produce the maximum sustainable yield (MSY) is 47,184 mt. Fishing mortality is estimated at 1.3, which is nearly 6 times greater than the estimated fishing mortality necessary to for the stock to produce MSY (0.18). MSY is defined in 50 C.F.R. 600.310(e)(1)(i)(A) as "the largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological, environmental conditions and fishery technological characteristics (e.g., gear selectivity), and the distribution of catch among fleets. MSY is the basis for fishery management under the Magnuson-Stevens Act and is used to assess whether a stock or stock complex is overfished or if overfishing has occurred.

cropping of early life stages is likely one of many factors contributing to the inability of the stock to rebuild.

Several studies have demonstrated that Atlantic cod exhibits spawning site fidelity at very fine spatial scales (Robichuad and Rose 2001, Skjæraasen et al. 2011, Svedäng et al. 2007), and that the Gulf of Maine stock forms a metapopulation structure (Kovach et al. 2010). The spawning site fidelity likely limits reproductive connectivity among spawning sites, and may increase the vulnerability of semi-discrete spawning populations to overexploitation and extirpation (Zemeckis et al. 2014). For this reason, assessing the potential population-level impacts of mortality at PNPS only as a percentage of regional landings potentially underestimates the impact that the cropping of early life stages may have on the ability of the local subpopulation of Atlantic cod in Cape Cod Bay to prevent further declines and to promote resiliency of the local population.

3.3.2. Summary

EPA evaluated the entrainment and impingement losses at PNPS in light of the nature of the Cape Cod Bay ecosystem and status of affected local populations above. Although Entergy asserts that impingement and entrainment mortality at PNPS are not of a magnitude to constitute an adverse environmental impact under § 316(b), EPA maintains that adverse impacts have clearly been demonstrated. And while the CWIS at PNPS that results in the death of billions of aquatic organisms each year from Cape Cod Bay may be just one of multiple, cumulative stressors that aquatic life in the bay are experiencing, the collective impacts from degraded habitat, poor water quality, fishing mortality, and others may negatively affect a species' resiliency, or ability to withstand stress.

For example, the cumulative stressors of fishing mortality and habitat degradation have likely contributed to the severe decline in groundfish populations in the Gulf of Maine. In an effort to recover these populations, effective regulations for Northeast Multispecies (groundfish) include large reductions in catch limits for Gulf of Maine cod, Georges Bank winter flounder, and Gulf of Maine winter flounder. *See* the Greater Atlantic Region Bulletin from Apr. 23, 2015 titled *Northeast Multispecies (Groundfish) Fishing Year 2015 Regulations*. Continued rolling closures for the commercial fishery restrict vessels during certain times of year in an effort to protect Gulf of Maine cod, whose stock biomass is severely depleted with current estimates at just 3-4 percent of levels deemed sustainable. These restrictions demonstrate the precarious status of New England fisheries and the lengths that the regulatory agencies have gone to protect existing stocks, even declaring a fishery resource disaster for the Northeast Multispecies Groundfish Fishery in 2013. *See, e.g.*, September 13, 2012 letter from Rebecca Blank, Acting Secretary of Department of Commerce to former Governor of Massachusetts Deval Patrick. The Massachusetts Division of Marine Fisheries (MassDMF) spring trawl surveys for Cape Cod Bay and Massachusetts Bay (Regions 4-5) in the past decade have observed declining biomass levels (measured as stratified mean weight per tow) for winter flounder, yellowtail flounder, windowpane flounder, little skate, winter skate, Atlantic cod, red hake, and ocean pout (MassDMF 2015). For several species, among them winter flounder, windowpane flounder, little skate, and Atlantic cod, biomass levels observed during recent surveys are among the lowest values in the time series (1978-2014). While CWISs, such as that operated by PNPS, are not solely, or even largely, responsible for these declines, the imperiled status of groundfish has motivated NFMS to implement drastic measures in order to protect these stocks. At a minimum, facilities contributing to loss of these stocks should also implement measures to minimize mortality of individuals.

4.0 Assessment of Existing Cooling Water Intake Structure (CWIS) at PNPS

In the previous section, EPA established that PNPS entrains billions of eggs and larvae and impinges tens of thousands of juvenile and adult fish each year, and that the cumulative adverse environmental impacts of the existing CWIS have resulted in the mortality of millions of juvenile, adult, and adult equivalent fish and represent an adverse environmental impact of the CWIS on Cape Cod Bay. This section evaluates PNPS's existing technology to determine if the location, design, construction, and capacity of the CWIS reflects the BTA for minimizing these adverse environmental impacts, as required by CWA § 316(b).

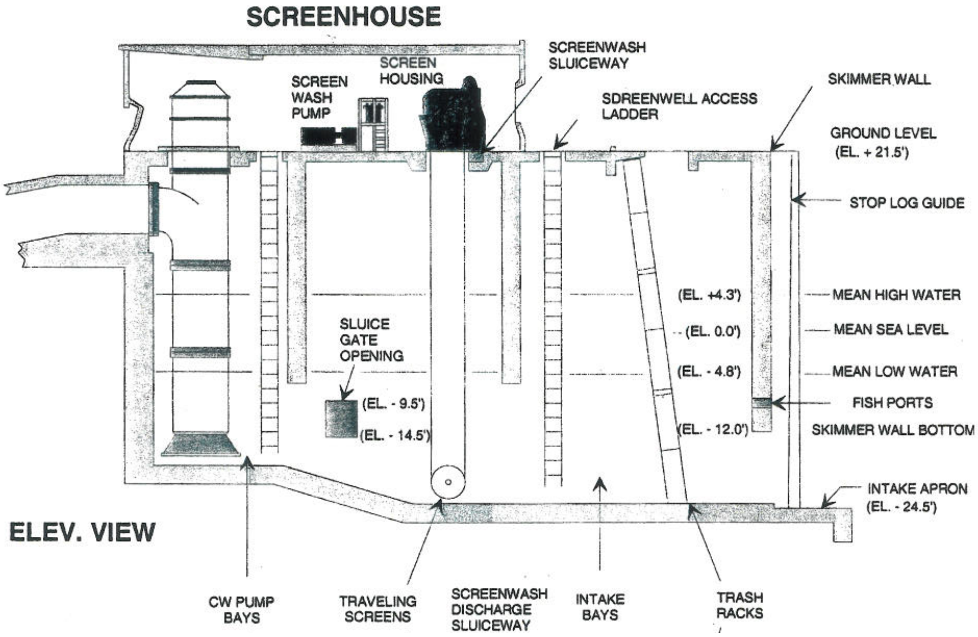
4.1. Existing Cooling Water Intake Structure

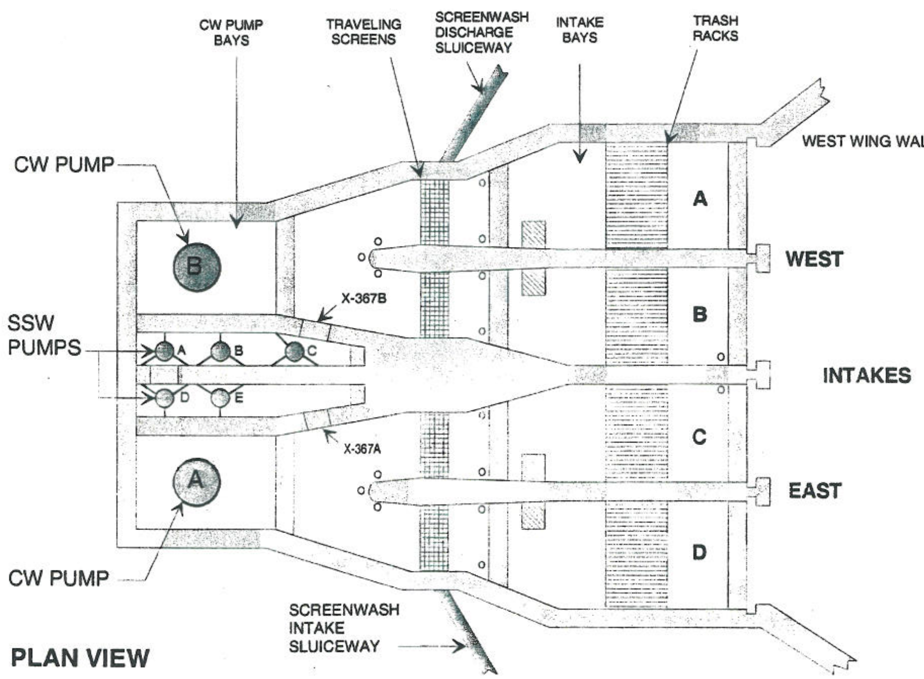
The facility's once-through CWIS is located along the shoreline within a small embayment formed by two protective breakwaters. The average velocity at the embayment opening is 0.05 feet per second (fps) at mid-tide with both pumps operating (Enercon 2008, p.5). Seawater drawn through a dredged intake channel passes through trash racks (3-inch spacing) before reaching four intake bays, each containing a traveling screen. Behind the traveling screens are two condenser cooling water (CW) pumps and five salt service water (SSW) pumps, as well as fire protection system pumps[13] and chlorination equipment. The openings to the intake bays are fully submerged at mean low water with the lowest portion approximately 24 feet below mean sea level (MSL). A skimmer wall extends to a depth of 12 feet below MSL to block floating aquatic life and/or debris at or just below the surface. See Figure 5, below.

PNPS's once-through cooling system is designed to withdraw up to 467 million gallons per day (MGD) (equivalent to 324,500 gallons per minute) of water from the Cape Cod Bay. This design relies on large volumes of water for purposes of condensing steam in the power plant's condensers. The majority (96%) of seawater withdrawn is pumped through the main condenser via the CW pumps to promote the efficient generation of electricity. The objective of the circulating water system is to provide the main condenser with a continuous supply of cooling water for the removal of heat rejected primarily by the turbine exhaust and turbine bypass steam. About 4% of the seawater withdrawn is

[13] Fire protection water is normally supplied by the Town of Plymouth but seawater can be used in an emergency.

Figure 5: Elevation view (top) and plan view (bottom) of the cooling water intake structure at PNPS. (Enercon 2008 Attachment 5).





used by the SSW system as the heat sink for nuclear safety-related systems such as the Reactor Building Closed Cooling Water and Residual Heat Removal (Enercon 2008 p.11).[14] According to PNPS, in 2007 the Institute of Nuclear Power Operations (INPO) issued a "Significant Operating Experience Report" (SOER) mandating that nuclear plants evaluate and address all possible factors that could lead to intake cooling water blockage. PNPS states that the SOER is "expected to cause existing operation and maintenance practices at PNPS to be re-evaluated and may lead to design changes affecting CWIS components." *Id*.

The existing operation of PNPS's CWIS is continuous with the exception of planned refueling outages and unplanned reactor shutdowns. Even during these planned and unplanned outages, at least one SSW pump is kept on to maintain essential cooling of nuclear safety-related systems. Entergy estimates that an annual flow reduction of 5.4% from the design flow of 324,500 gallons per minute (gpm) occurs due to planned and unplanned outages and periods of lower SSW flows caused by reduced cooling demands. During April and May, flow reductions from planned outages can be 13.5% to 26.5% less than design flow (Enercon 2008 p.20).

4.2. Location of CWIS

PNPS is located on the northwest shore of Cape Cod Bay, a large embayment in southeastern Massachusetts enclosed on the south and east by Cape Cod and by the mainland on the west. Cape Cod Bay is designated an Ocean Sanctuary by the Commonwealth of Massachusetts. See M.G.L. c.132A § 13(b). Water depths near PNPS average about 12 feet; the maximum depth (180 ft) occurs at the mouth of Cape Cod Bay. About half the surface area of the bay has depths greater than 100 ft, increasing as the sea floor slopes toward the deepest water at the mouth of the bay (NRC 2006). Within Cape Cod Bay, the prevailing ocean circulation moves water in a counterclockwise pattern. Tidal fluctuations largely control the exchange of water with Massachusetts Bay, where the total bay flushing rate is approximately 7.2% per day (NRC 2006). The average water temperature in Cape Cod Bay ranges from about 35°F in winter to about 72°F during the summer at the near surface and about 37°F (mid-winter) to about 54°F (mid-summer) in the near-bottom water (Libby et al. 2006). Water temperatures fluctuate seasonally and due to upwelling, downwelling, and turbulence. The relatively well-mixed waters during winter gradually shift towards a two-layer stratified temperature gradient present from summer through early fall.

The location of a CWIS in the waterbody is an important factor influencing its adverse environmental impacts. For example, a CWIS located in the productive littoral zone (i.e., light-penetrating) rather than deeper waters could result in greater entrainment impacts;

[14] According to PNPS, "nuclear safety" means conditions, actions, or considerations within the customary or exclusive jurisdiction of the Nuclear Regulatory Commission (NRC) associated with the design, construction, operation, and shut down of NRC-licensed nuclear electric steam generating facilities, including without limitation any and all conditions associated with the modified or altered use of equipment, or changes to facility operations, requiring assessment of a station's NRC licensing basis or operating procedures." (Enercon 2008, p 10).

likewise, a CWIS located in a nearshore marine environment (such as an estuary) has a higher potential for entrainment than an intake located in offshore deeper waters where eggs and larvae are not as prevalent. *See* Technical Development Document for the Phase I Rule (EPA 2001) pp. 5-15 to 16. The environmental impacts of CWISs can be affected by the location in relation to the shoreline (i.e., at the shoreline or offshore) as well as in terms of where they are located in the water column. As an example, the littoral zone (where light penetrates to the bottom) in lakes and reservoirs, as well as the shoreline of rivers, is generally the principal spawning and nursery area for freshwater fish. In nearshore coastal waters and estuaries, which are some of the most biologically productive waters, the distribution and abundance of organisms is influenced by a number of factors including: geographic location, salinity, temperature, oxygen, circulation, and vertical and horizontal stratification.

Impacts of impingement and entrainment can potentially be mitigated by locating CWISs outside of these biologically productive areas (*e.g.*, offshore intakes outside the euphotic zone at depths more than 100 m) (Phase I Rule *Technical Development Document* Chapter 5 pp. 15-16). EPA's *Guidance Document for Best Technology Available for the Location, Design, Construction and Capacity of Cooling Water Intake Structures for Minimizing Adverse Environmental Impact* (EPA 1976) recommends selecting CWIS locations to avoid important spawning areas, juvenile rearing areas, fish migration paths, shellfish beds, or areas of particular importance for aquatic life. The location of a CWIS opening within the water column is another important characteristic that affects the structure's capacity to impinge organisms. Structures that withdraw from mid-water column or surface waters tend to impinge pelagic (i.e., open water) species of fishes, while intakes that withdraw from bottom waters impinge more demersal (i.e., bottom-oriented) species, as well as fish migrating along the shoreline.

Cape Cod Bay is an Ocean Sanctuary and a valuable natural resource that supports a vibrant tourism industry as well as commercial and recreational fisheries. The species composition of finfish in western Cape Cod Bay reflects a transition between the Gulf of Maine and the Mid-Atlantic Bight, serving as the southern-most boundary for several northern Atlantic fish species and the northern-most boundary for several fish species that inhabit the warmer waters south of Cape Cod. This overlap results in a rich and diverse aquatic community, including, but not limited to, a diverse plankton community, 31 species for which essential fish habitat has been designated, and 10 federally-listed threatened and endangered species (at least two life stages of Atlantic sturgeon, 4 species of protected turtles, and 5 species of protected marine mammals). Cape Cod Bay also provides critical habitat for the North Atlantic right whale (*Eubalaena glacialis*), which is among the rarest species of all marine mammals. *See* 59 Fed. Reg. 28,805 (June 3, 1994). The NMFS has recently proposed expanding the designated critical habitat for the right whale to include the entirety of Cape Cod Bay. *See* 80 Fed. Reg. 9,314 (February 20, 2015). Since 1980, 80 species of fish and 39 species of invertebrates have been collected on the PNPS intake screens (Normandeau 2015). As discussed above, fish commonly impinged include winter flounder (*Pseudopleuronectes americanus*), Atlantic menhaden, (*Brevoortia tyrannus*), alewife (*Alosa pseudoharengus*), Atlantic silverside (*Menidia menidia*), blueback herring (*Alosa aestivalis*), cunner (*Tautogolabrus adspersus*), grubby

(*Myoxocephalus aenaeus*), hakes (*Urophysis sp.*), and rainbow smelt (*Osmerus mordax*). Invertebrates commonly impinged include blue mussels (*Mytilus edulis*), Sevenspine bay shrimp (*Crangon septemspinosa*), green crab (*Carcinus maenas*), and rock/Jonah crab (*Cancer sp.*).

Regarding location, PNPS's CWIS is situated on the shore of a productive and ecologically important aquatic community. Its location in a biologically dynamic nearshore environment magnifies the potential for adverse impacts from impingement and entrainment. In fact, as discussed earlier, the CWIS entrains billions of eggs and larvae and impinges tens of thousands of fish each year, resulting in the loss of millions of fish and other aquatic organisms. The preamble to the Final Rule clearly refers to impingement and entrainment as adverse environmental impact, and the magnitude of these adverse environmental impacts in Cape Cod Bay, an Ocean Sanctuary and designated Class SA water providing "excellent habitat" for fish and other aquatic organisms, is undeniable. *See* 79 Fed. Reg. at 48,303 and 48,328.

4.3. Existing Traveling Screen Design and Operation

PNPS's four through-flow traveling screens, two for each condenser water pump, were originally installed in 1970. Screen assemblies were replaced in 2005 (screens C and D) and 2007 (screens A and B). All replacement screens have been functionally equivalent to the original screens (Enercon 2008, p 13). The 10-ft wide screens include ¼-inch wide by ½-inch tall stainless steel screening. Based on the design flow with both condenser pumps running (at 324,500 gpm/4 screens = 81,125 gpm per screen) and a water depth of 19.2 ft at mean low water (MLW), PNPS estimates a through-screen velocity of 1.57 fps. This velocity does not comply with the protective velocity of 0.5 fps identified in the Final Rule. *See* 40 C.F.R. § 125.94(c)(2); (3); 79 Fed. Reg. at 48,373. In addition, because PNPS operates near design flow during most months of the year, the through-screen velocity is unlikely to change substantially whether based on design or actual intake flow.

According to PNPS, the traveling screens are operated "routinely, preemptively, and in response to an alarm" (Enercon 2008, p.6). Six scheduled screen rotations/washes normally occur each week. The screens are rotated continuously to prevent freezing when the ambient air temperature drops below 30°F. A pressure differential between the upstream and downstream sides of the screen assembly can also trigger rotation. The screens use dual spray washing to remove debris and/or aquatic life. A low pressure (15 psi) spray washes organisms from the screen and lifting shelves, after which a high pressure (140 psi) spray removes debris. The screenwash water is dechlorinated with sodium thiosulfate prior to use on the screens.[15]

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[15] Sodium hypochlorite solution is applied to each circulating pump bay alternately at an applied maximum dosage of 0.1 ppm for approximately 1 hour per day for control of slime growth and fouling organisms. Water from the screen wash pump discharge header is used as dilution water and the diluted solution enters the intake bay diffusers located downstream of the trash racks. Two separate pumped hypochlorite systems provide a direct feed to either service water pump bays at a dosage up to a maximum of 0.25 ppm. A Dechlorination System pumps sodium thiosulfate to the screenwash pumps to dechlorinate screen wash

Power plants that utilize once-through cooling typically power spray fish and debris off their traveling screens into some form of fish return system which transports the fish (and in some cases debris as well) back to the aquatic habitat from which they were withdrawn. At PNPS, fish and possibly debris washed from the traveling screens during the low pressure spray wash are directed into a trough where they are transported into epoxy coated, corrugated metal sluiceway. The sluiceway makes several turns that vary from 11° to 27° and includes a sharp slope shortly before emptying into the embayment, 300 feet from the intake. The corrugation provides resistance to flow in order to maintain a design water depth of 6 inches and a design water velocity less than 8 fps in the sluiceway. The sluiceway is covered with screen material to prevent predation by birds. With the existing technology, fish and other living organisms may be subjected to significant stress due to the sharp turns, pipe corrugations, and vertical drop to the water. Furthermore, although fish are returned 300 feet from the intake, these fish are still located in the embayment, near the intake screens. This location may increase the chance of re-impingement and impingement mortality.

In summary, the existing traveling screens have the potential to reduce impingement mortality for some species, primarily through the use of a low pressure spraywash and fish return sluiceway. As discussed above, on a national basis the BTA standard for impingement mortality in the Final Rule is based on a modified traveling screen with a fish-friendly return system. *See* 79 Fed. Reg. at 48,344. The traveling screen in operation at PNPS is consistent with some, but not all, of the aspects of a modified traveling screen as defined in 40 C.F.R. § 125.92(s) (and described at 79 Fed. Reg. 48,374):

> Modified traveling screen means a traveling water screen that incorporates measures protective of fish and shellfish, including but not limited to: screens with collection buckets or equivalent mechanisms designed to minimize turbulence to aquatic life; additional of a guard rail or barrier to prevent loss of fish from the collection system; replacement of screen panel materials with smooth woven mesh, drilled mesh, molded mesh, or similar materials that protect fish from descaling and their abrasive injury, continuous or near continuous rotation of screens and operation of fish collection equipment to ensure any impinged organisms are recovered as soon as practical; a low pressure wash or gentle vacuum to remove fish prior to any high pressure spray to remove debris from the screens, and a fish handing and return system with sufficient water flow to return the fish directly to the source water in a manner that does not promote predation or re-impingement of the fish, or require a large vertical drop.

The CWIS is not operated continuously or near-continuously. Further, it is not clear if the mesh panels adequately protect fish from descaling, if the panels' screen baskets minimize turbulence, or if the fish return system meets the requirement to "return fish directly to the source water in a manner that does not promote predation or re-

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water so that marine life is not impacted when the screens are washed. See FSAR, p.3 in Enercon 2008 Attachment 1.

impingement of the fish, or a large vertical drop." *See* 79 Fed. Reg. at 48,374. Entergy has not demonstrated that the existing traveling screens would meet the impingement mortality performance standard at 40 C.F.R. § 125.94(c)(7). Finally, EPA is concerned about the impingement of large numbers of Atlantic silversides, Atlantic menhaden, rainbow smelt, and river herring. The Final Rule provides for additional measures to protect these fragile species, which are unlikely to survive being impinged on the screens. *See* 40 C.F.R. §125.94(c)(9).

4.4. Seasonal Flow Reductions

The mesh size of the traveling screens at PNPS differs from, though performs comparably to, that commonly used in the industry for CWIS screens (3/8 inch square). This mesh size should be small enough to prevent the entrainment of adult fish and most juvenile fish through the plant's cooling water system, but not younger and smaller life stages (*i.e.*, eggs and larvae). As a result, there is no reduction in entrainment mortality associated with the operation of the existing traveling screens. There is, however, an entrainment reduction associated with reductions from design flow associated with the scheduled maintenance outages. Entergy calculated an annual flow reduction of 5.4% from baseline flow, with the greatest reductions in April and May due to the timing of refueling outages. Entergy estimates an annual entrainment reduction of 8.5% based on the mean monthly equivalent adult entrainment averaged over six years. Based on mean density of ichthyoplankton entrained per month from 2002 through 2007, EPA calculated an annual entrainment reduction of about 3% for eggs and about 9% for larvae. Based on entrainment data from 2002 to 2007, the species most affected by flow reductions in April and May include cunner and Atlantic mackerel eggs, as well as sand lance, winter flounder, and grubby larvae.

4.5. Anticipated Changes in Plant Operation During the Next Permit Cycle

As part of the permit application requirements under the Final Rule, a facility must submit a description of the operational status of each unit for which a CWIS provides water for cooling including, among other things, a description of plans or schedules for decommissioning or replacement of units. *See* 40 C.F.R. § 122.21(r)(8). According to the preamble to the Final Rule, "where the remaining plant life is considerably shorter than the useful life of the technology or where a facility has a planned retirement within the next permit cycle, this information is useful to support a determination regarding that specific entrainment technology." (79 Fed. Reg. at 48,366). On October 13, 2015, during the development of a Draft Permit for PNPS, Entergy announced its intention to close PNPS no later than June 1, 2019. *See* Entergy's October 13, 2015 News Release. Entergy cites poor market conditions, reduced revenues, and increased operational costs as factors in its decision to close the plant. Further, Entergy indicates that the exact timing of the shutdown, which may be sooner than June 1, 2019, will be decided during the first half of 2016.

Based on this announcement, EPA expects that within the next permit cycle, and no later than June 1, 2019, PNPS will, at a minimum, permanently eliminate cooling water withdrawals and discharges for the main condenser. This cooling water volume comprises 96% (311,000 gpm) of the once-through cooling water at the plant. Currently, the remaining 4% (13,500 gpm) is used for cooling water for the safety-related equipment, including shut-down systems. Clearly this change in operation of the plant will have a substantial impact on impingement mortality and entrainment at PNPS. As such, EPA has considered the anticipated closure of PNPS in its BTA determination, as discussed below.

5.0 Assessment of Available Entrainment Technologies

In Sections 3.0 and 4.0 of this fact sheet, EPA demonstrated that PNPS's CWIS likely results in the loss of billions of eggs and larvae to entrainment and tens of thousands of fish to impingement each year and further, that the existing intake location and traveling screen technology are not sufficient to minimize the adverse environmental impacts of impingement and entrainment under the current operation. In the following sections, EPA evaluates the availability of technologies to minimize adverse environmental impacts from entrainment and sets the site-specific entrainment BTA requirements after considering a number of factors, including the remaining useful life of the plant and the costs and benefits of available technologies.

To support this BTA determination, EPA requested that Entergy evaluate the availability of technologies designed to minimize entrainment at PNPS's CWIS, including: traveling screen modifications, screen/barrier technologies, an offshore intake location, various flow reduction options, and closed-cycle cooling. Each of these technologies has advantages and disadvantages, both inherent to the technology and as applied specifically at PNPS, and no one alternative commends itself as perfect, proven, and fully protective of the environment. For this analysis, EPA has considered the permit record, including PNPS's June 2008 Engineering Response to US EPA's CWA § 308(a) information request letter and August 2014 Engineering Response Supplement to US EPA's CWA § 308(a) information request letter, as well as other analyses and literature about the feasibility, cost, and effectiveness of entrainment technologies.

5.1. Closed-Cycle Cooling

At PNPS, the existing once-through cooling water design transfers waste heat directly from the main condenser to the receiving water (Cape Cod Bay), and requires the facility to continuously withdraw up to 467 MGD of cooling water. In contrast, closed-cycle cooling water systems transfer waste energy (as heat) from the main condenser to the atmosphere. Steam electric power plants equipped with closed-cycle cooling systems use substantially less water relative to a once-through cooling system by cooling and then recirculating the previously heated water through the condenser. This recirculation reduces not only the volume of water withdrawn for cooling, but also the discharge of heat to the receiving water.

There are two basic methods of heat rejection for closed-cycle recirculating cooling water systems. The first is to use wet (or evaporative) cooling towers. The second uses cooling ponds or lakes. *See, e.g.*, 79 Fed. Reg. at 48,333 and EPA's Technical Development Document for the Final 316(b) Existing Facilities Rule (TDD) p.6-3 to 6-6. These two methods dramatically reduce cooling water use requiring only a relatively small amount of "makeup" water to replace cooling water lost to evaporation and leaks. A third type of closed-cycle cooling system does not use cooling water at all and, instead, employs "dry cooling towers" (or "air-cooled condensers"). Dry cooling systems are generally regarded to be more expensive and require more space to install than wet cooling tower systems. *See, e.g.*, 79 Fed. Reg. at 48,333-34; Final Rule TDD p. 6-6 to 6-8. EPA is unaware of any current or proposed nuclear power plants designed to employ dry cooling technology (EPRI 2012).

In its 2008 *Engineering Response to EPA's CWA Section 308 Request for Information* (Enercon 2008), Entergy maintains that the lower efficiencies of evaporative ponds, spray ponds, cooling canals, and dry cooling towers are not capable of providing sufficient cooling to support the condenser temperature required by PNPS's turbine design. Entergy concluded that evaporative ("wet") cooling towers are the most appropriate closed-loop technology for PNPS. EPA agrees that wet cooling towers are an appropriate closed-cycle cooling system consistent with the best performing technology for entrainment. Other closed-cycle cooling systems (e.g., dry cooling) are likely to be substantially more expensive, have larger impacts on plant performance, and impose additional constraints as compared to wet cooling towers. For these reasons, dry cooling is less likely to be feasible at nuclear power plants than wet cooling towers (EPRI 2012).

Below, EPA presents its assessment of the feasibility of closed-cycle cooling at PNPS using wet cooling towers. First, EPA discusses the impacts of retrofitting an existing facility with closed-cycle cooling on plant efficiency and power generation generally, followed by a site-specific evaluation of the impacts of wet cooling towers on power generation at PNPS using two different tower designs. Finally, EPA evaluates the feasibility of a third engineering design, which involves replacing the main condenser to optimize plant efficiency with a closed-cycle system.

5.1.1. Design of a Closed-Cycle Cooling System at PNPS

Boiling water reactors, like the one at PNPS, are governed by a set of administrative limits[16] used to ensure reliability and safety. According to Entergy, these administrative

[16] According to Entergy, administrative limits are PNPS-proceduralized limits used to prevent encroachment of NRC licensed limitations which require a documented Limited Condition of Operation when exceeded. The administrative limits include pump net positive suction head requirements, overall plant control characteristics, core thermal power limits, and core thermal-hydraulic stability. NRC defines

limits govern the operation of various equipment in order to prevent the occurrence of a transient (*i.e*., change in the reactor coolant system temperature, pressure, or both) or scram (*i.e*., the sudden shutting down of a nuclear reactor, usually by rapid insertion of control rods). The limiting parameters for a closed-cycle system at PNPS are the steam turbine backpressure and hotwell temperature.[17] At PNPS, the administrative hotwell average temperature limit is 120°F and administrative limit for steam turbine backpressure is 4 in-Hg (Enercon 2008, Enercon 2014, PNPS Procedure 2.2.93 "Main Condenser Vacuum System", PNPS Procedure 2.1.14 "Power Station", and PNPS 2.2.94, Rev.114 "Seawater System Procedure"). Entergy asserts that an operational hotwell temperature limit of 118°F is used to provide an allowance against the administrative limit, and because the steam turbine backpressure meets the administrative limit at a hotwell temperature of 118°F, the hotwell temperature is the bounding limit in its analysis of cooling towers.

Closed-cycle cooling systems use an evaporative process to cool water that was heated in the condenser, discharges the heat to the atmosphere, and then recirculates that water back to the condenser. Converting PNPS to a closed-cycle cooling system would generally result in higher circulating water temperatures as compared to the existing once-through cooling system. The continued loss of condenser cooling efficiency would eventually lead to an exceedence of the hotwell temperature unless thermal power output from the reactor is reduced. According to Entergy, nuclear power plants are designed as base load generating facilities and continuous power loss as part of normal operation may introduce new risks for potential transients, increase the likelihood of operator error, and may challenge previously accepted equipment reliability acceptance criteria (Enercon 2014). Unlike a fossil fuel generating facility that is able to adjust thermal energy output by reducing the amount of fuel fired (e.g. by burning less coal or oil), a nuclear facility has a narrow range within which it can manipulate the energy generated by the reactor. A nuclear generating facility controls the power of the reactor by inserting control rods, which prevent the neutrons from causing further fissions. Generally, routine manipulation of the control rods is not tenable and may result in an increased risk of power oscillations, or transients, which could lead to frequent plant shutdowns (Enercon 2014).

At PNPS, the core operating limits are delineated by the Maximum Extended Load Line Limit Analysis (MELLLA) rod lines, the Exclusion Region, and the Buffer Zone. PNPS is authorized to operate up to the MELLLA boundary, which allows for the highest thermal power output over most core flow rates and is considered the upper limit for power generation. Operation above the MELLA boundary is generally prohibited (PNPS Procedure 2.1.5 Rev. 112 "Controlled Shutdown from Power"). The Exclusion Region is an area within the operating domain where the possibility exists for the occurrence of thermal-hydraulic oscillations. Normal operation is prohibited in the Exclusion Region.

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limiting condition for operation as the section of Technical Specifications that identifies the lowest functional capability or performance level of equipment required for safe operation of the facility. See NRC Glossary at http://www.nrc.gov/reading-rm/basic-ref/glossary.html.

[17] The maximum hotwell temperature ensures the performance and longevity of the condensate demineralizer system, which maintains the quality of the recirculating water in the steam loop. The maximum steam turbine backpressure limit prevents damage to the turbine.

The Buffer Zone is defined as a region in the operating domain with a parallel boundary to the Exclusion Region and adds an additional margin to prevent occurrences of thermal hydraulic instabilities. The intersection of the Buffer Zone and MELLLA boundary represents the theoretical maximum power reduction possible without movement of the control rods to bring down power level in the plant. Based on the current and past fuel cycles, this point is generally located at approximately 80% thermal power (Enercon 2014). In addition, PNPS maintains operations above a specific core mass flow rate (40 million pounds per hour) to reduce the risk of reactor scram due to a transient or inadvertent operation. Together, the core mass flow rate and the MELLLA boundary dictate that the lowest power that can be consistently achieved without rod movement is approximately 80% of thermal power output (Enercon 2014). Enercon used the performance evaluation of power station efficiency (PEPSE) model to estimate the maximum power output at PNPS using closed-cycle cooling with the existing condenser, and then assessed how often power reductions would be required to meet administrative limits, and how often power reductions greater than 20% thermal power would require PNPS to move the control rods to reduce the risk of a reactor scram.

5.1.2. Anticipated Impacts of Closed-Cycle Cooling on Power Generation

In a closed-cycle system, the performance of the cooling tower (in other words, the ability of the tower to transfer heat from the recirculating water to the atmosphere) is defined by the approach to wet bulb temperature, which is a meteorological measurement that incorporates both moisture content and ambient air temperature. The approach to wet bulb temperature describes the number of degrees above the ambient wet bulb temperature by which the cooling tower can be expected to reduce the recirculating cooling water temperature (*i.e.*, the temperature of the water exiting the cooling towers). This value is used in the design phase to determine the size of the cooling tower. Enercon used an approach to wet bulb temperature of 12°F for its initial analysis (Enercon 2008) and, upon EPA's request, submitted an additional analysis with an approach to wet bulb temperature of 9°F (Enercon 2014).[18]

At PNPS, the main condenser was designed and sized to use a continuous, cold supply of Cape Cod Bay water as a heat sink. Using the existing main condenser in a closed-cycle system with an approach to wet bulb temperature of either 9°F or 12°F will result in a higher recirculating water temperature relative to the existing once-through system under most conditions, and thus, will reduce plant performance as compared to the existing once-through system. This loss of efficiency (or "energy penalty") in turn results in lost power output. In addition, the fans and pumps associated with mechanical cooling towers, like those proposed at PNPS, require electricity to run. The loss in power output

[18] Enercon estimated that lowering the approach to wet bulb temperature to 9°F would result in the need for a 25% larger tower compared to the original analysis at 12°F. Enercon used wet bulb temperature data recorded at the National Weather Service observatory at the Plymouth Municipal Airport from 1997-2006 for the 2008 analysis and 2009-2013 for the 2014 analysis. Corresponding inlet water temperatures were supplied by PNPS from data collected for NPDES discharge monitoring reports.

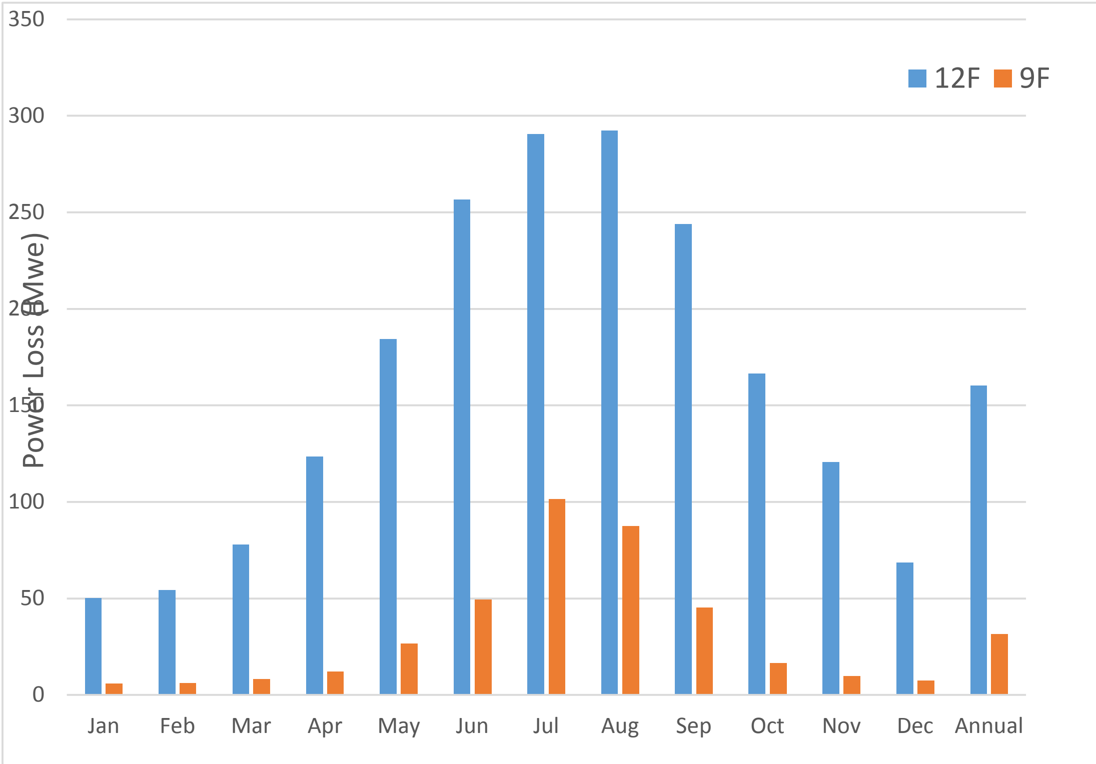
as a result of running the necessary equipment is considered an auxiliary power reduction, or "parasitic loss." At PNPS, Entergy estimates that cooling towers would result in a continuous parasitic loss of 20 megawatts of electric power (MWe), which is about 3% of the total output. EPA considered the loss of output both in terms of the feasibility of installing and operating closed-cycle cooling at PNPS and the additional social costs imposed by the energy penalty.

In its 2008 Engineering Response (Enercon 2008) and 2014 Engineering Response Supplement (Enercon 2014), Entergy provided preliminary engineering evaluations using basic plant operational parameters to calculate the effects of retrofitting PNPS with a closed-cycle cooling system, including the expected power generation loss (*i.e.*, energy penalty). Enercon used the performance evaluation of power station efficiency (PEPSE) modeling software to estimate plant operational parameters and net power generation depending on the cooling water temperature, flow rate, and the approach to wet bulb temperature. The PEPSE model allows for the calculation of system performance and operational conditions while meeting the equipment limitations to ensure reliability and safety of the plant. In its analysis of closed-cycle cooling, Enercon used slightly conservative operational parameters to ensure that the administrative limits, as described above, are not exceeded.

Results

The PEPSE evaluation indicates that retrofitting PNPS with a closed-cycle cooling system would require the plant to operate at less than 80% thermal power (*i.e.*, require movement of control rods) during some periods of the year. Figure 6 illustrates the loss in net power generation (MWe) that would occur over the year based on cooling tower designs with a 12°F or 9°F approach to wet bulb temperature. In both cases, the efficiency of the tower, and therefore the ability to generate power within the existing administrative limits, decreases as ambient air temperatures increase in the spring. Entergy's analysis indicates that cooling towers with a 12°F approach to wet bulb temperature would result in a substantial continuous power loss (greater than 243 MWe including parasitic losses) on 26 to 31 days during each month from June through September (Enercon 2008 Attachment 3, p.3). A larger tower with a 9°F approach to wet bulb temperature improves efficiency of the tower and therefore, increases the ability to generate power within the existing administrative limits. However, Entergy's analysis indicates that this design could still result in a substantial continuous power loss (more than 87 MWe *not* including parasitic losses) on 8 to 14 days during July and August (Enercon 2014 Attachment 1, p.3). An additional, albeit relatively minor, power reduction would occur as a result of operating the 9°F towers.

Figure 6. Annual PNPS Power Reduction with 12°F Approach to Wet Bulb Cooling Tower. (From Enercon 2008 Attachment 3, Section 2, p.3)



The PEPSE model simulation indicates that the power output at PNPS could be substantially impacted by the loss of efficiency with closed-cycle cooling. Power losses at PNPS resulting from closed-cycle cooling could impact operation of the nuclear reactor if net thermal power (MWt) is less than 80% because the facility may be forced to shutdown for safety reasons. Table 4 summarizes the loss of power generation (MWe) and number of days per year that the plant would operate at less than 80% net thermal power (MWt) in order to maintain a hotwell temperature of 118°F with a cooling tower designed with either an approach to wet bulb temperature of 9°F or 12°F. In this analysis, parasitic losses were removed from both sets of data for a direct comparison of gross power generation loss because, according to Enercon, “parasitic losses cannot be precisely estimated without a more detailed design and layout” (Enercon 2014 p.33).

Table 4. Estimated gross power generation loss and net thermal power loss at PNPS for cooling towers with approach to wet bulb temperatures of 9°F and 12°F.		
	Approach to Wet Bulb Temperature	
	9°F	12°F
Average no. days with gross electrical power loss > 20 MWe (3%)	140 days	356 days
Average no. days with gross electrical power loss > 80 MWe (12%)	84 days	308 days
Average no. days with gross electrical power loss > 140 MWe (21%)	41 days	240 days
Annual gross electrical power loss	31.6 MWe	160.4 MWe
Average no. days with net thermal power < 80% MWt	25 days	242.5 days

Enercon estimated that with an approach to wet bulb temperature of 12°F, on average, PNPS would operate for at least one hour at less than 80% net thermal load on 242 calendar days per year. A larger cooling tower, with an approach to wet bulb temperature of 9°F, reduces the risk that PNPS would operate at less than 80% thermal power, but there is still a substantial risk of shutdown during the summer months, particularly during the months of May through September (see Figure 6 and Table 4, above). At this approach to wet bulb temperature, PNPS would experience, on average, 25 days at a net thermal power of less than 80% during the months of June, July, and August (Table 5).

Table 5. Average number of days with operation at less than 80% thermal power (MWt) with closed-cycle cooling at an approach to wetbulb temperature of 9°F.			
Month	<80% MWt	Month	<80% MWt
January	0.0	July	11.8
February	0.0	August	7.2
March	0.0	September	2.8
April	0.0	October	0.2
May	0.6	November	0.0
June	2.4	December	0.0

Entergy states that nuclear power plants operate as baseload plants and are not designed to change the core flow rate on a regular basis. For example, currently the core flow rate is reduced only when the circulating temperature in the plant reaches the ultimate heat sink temperature limit of 75°F, which has occurred three times in the past 14 years. In other words, frequent power loss, in which the core flow rate is decreased to reduce the net thermal heat generated by the plant, is not a normal mode of operation and the long-term impacts on nuclear fuel and plant transients are uncertain. Operating at less than 80% thermal power would require movement of the control rods, and may increase the likelihood of transients and forced shutdowns.

PNPS concluded that conversion to closed-cycle cooling is infeasible because it would substantially impact the capacity of the plant to generate electricity and is generally not consistent with a nuclear power plant designed for baseload generation. However, the

PEPSE results for a 9°F approach to wet bulb tower suggest that that PNPS could operate closed-cycle cooling during the months of November through April without reducing thermal power. In May and October, the simulation indicates that PNPS would have to operate at reduced power for less than one day, on average. From June through September PNPS would either have to maintain the ability to use the existing once-through system or shutdown for a prolonged period when the reduction in plant efficiency requires movement of the control rods.

Finally, EPA is committed foremost to ensuring public safety and will ensure that any BTA determination does not conflict with nuclear safety requirements. The Final Rule expressly considers the impact of any required entrainment technology on nuclear safety at 40 C.F.R. § 125.94(f), which states:

> If the owner or operator of a nuclear facility demonstrates to the Director, upon the Director's consultation with the Nuclear Regulatory Commission, the Department of Energy, or the Naval Nuclear Propulsion Program, that compliance with this subpart would result in a conflict with a safety requirement established by the Commission, the Department, or the Program, the Director must make a site-specific determination of best technology available for minimizing adverse environmental impact that would not result in a conflict with the Commission's, the Department's, or the Program's safety requirement.

Entergy states that because closed-cycle cooling would significantly reduce generating capacity, require substantial periods of active power loss, and would, at times, require the plant to down power, closed-cycle cooling is not available at PNPS. EPA agrees that the PEPSE simulation indicates that maintaining the current administrative limits (the hotwell temperature and turbine backpressure) would likely reduce power output and could lead to plant shutdown during some periods the year. EPA is currently consulting with the Nuclear Regulatory Commission (NRC) to confirm PNPS's statements regarding the potential conflicts with nuclear safety requirements. Any required changes to the plant that could affect operation and safety, including cooling towers, would likely be subject to the NRC's process for changes to an existing operating license at 10 C.F.R. § 50.59.

5.1.3. Optimizing Efficiency by Replacing Condenser

In part, the impacts of closed-cycle cooling on the efficiency of the plant could be alleviated by increasing the size of the condenser. The main condenser at PNPS was designed for the use of a stable and coldwater source of cooling water (i.e., Cape Cod Bay). According to Entergy, increasing the size of the condenser at an operational nuclear power plant is unprecedented. As such, Entergy concludes that the current condenser could not be replaced. The location of the main condenser, central to the turbine building, further complicates any modification to the cooling system. Replacing the condenser would likely require a complete disassembly and modification of the turbine building.

According to Entergy, modification of the turbine building of this size and scope has never been attempted at an operational nuclear power plant, therefore modifying the existing cooling equipment is not feasible. EPA agrees with Entergy's position that a modification of the existing cooling system of this size at a nuclear power plant would likely be unprecedented, although it does not necessarily follow that it is therefore infeasible. Nonetheless, replacing the condenser would be difficult and would involve substantial capital costs and construction downtime costs on top of the already substantial cost of converting to closed-cycle cooling. On top of these capital costs, EPA estimates a construction outage of 24 months.[19] The extended outage would be necessary because, according to Entergy, in order to replace the main condenser, the turbine building would have to be extensively modified, if not demolished and re-built. EPA expects that a minimum of 24 months would be required to replace the main condenser and re-build the turbine building based on the construction outages estimated for other plants.[20]

5.1.4. Entrainment Reduction

EPA estimates that an optimized cooling tower can achieve flow reductions of about 95% or more for salt water sources. *See, e.g.*, 79 Fed. Reg. at 48,333 (Aug. 14, 2014) and *Technical Development Document for the § 316(b) Existing Facilities Final Rule* (Final Rule TDD) p. 6-9. Entrainment mortality, which is directly proportional to the amount of cooling water withdrawn, is therefore reduced by 95% using closed-cycle cooling technology both using the existing condenser or replacing the main condenser. In this case, PNPS circulating water withdrawn for cooling at the main condenser could be reduced by 95%, but the volume of safety service water (SSW) would not change because cooling towers would not be tied into this system. A 95% reduction in circulating water withdrawals combined with the existing SSW withdrawals (19,400 gpm) results in a net reduction in cooling water of 91%. Therefore, PNPS would likely experience at least a 91% reduction in entrainment with closed-cycle cooling (either using the existing condenser or replacing the main condenser). In addition, use of a closed-cycle recirculating system is compliant with the BTA standards for impingement mortality under the Final Rule at 40 C.F.R. § 125.94(c)(1).

EPA considered the potential entrainment reduction that could be achieved with seasonal use of a 9°F wet cooling tower. The inability to rely on closed-cycle cooling during the summer months would require PNPS either to shutdown during the summer, which would result in substantial outage costs, or to operate the existing once-through cooling system during the summer, which would reduce the benefits of closed-cycle cooling to minimize entrainment. If PNPS were to operate the existing once-through cooling system during June through August when the cooling tower is most likely to interfere with

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[19] EPA estimated a minimum capital cost of $311 million ($2009 dollars) for replacement of the condenser by doubling the cost of condenser modification at a nuclear facility from EPRI's 2011 *Closed-Cycle Cooling System Retrofit Study: Capital and Performance Cost Estimates.*

[20] EPRI (2011) estimated construction outage periods ranging from 4 to 22 months for retrofitting a nuclear plant (*Closed-Cycle Cooling System Retrofit Study: Capital and Performance Cost Estimates).* EPA estimated 10 months of outage for retrofitting the existing condenser with cooling towers and extended the outage to 24 months of outage given the challenges presented by the location of the main condenser in the turbine building.

PNPS' ability to meet administrative limits, entrainment reductions would be substantially diminished. The highest densities of eggs, which account for 89% of total annual entrainment, occur during June and July when there would be no entrainment controls present. EPA estimates that operating cooling towers from September through May, while operating the existing once-through system from June through August would result in a 19% reduction in entrainment. This performance is not substantially more than could be achieved with variable frequency drives at far lower cost, and is not as effective as other potentially available entrainment controls. Operating closed-cycle cooling year-round would require PNPS to shutdown for a period of time during the summer (when demand is highest), which would result in significant losses in annual revenue (*i.e.*, private costs) and substantial social costs as a result of the need to generate this lost power from an alternative source.

5.1.5. Cost

Because PNPS concluded that closed-cycle cooling technology is not available, Enercon did not provide any cost estimates for this technology. EPA generated baseline cost estimates for converting PNPS to closed-cycle cooling using Entergy's cost estimates for cooling towers associated with assisted recirculation at PNPS, Entergy's cost estimates for cooling towers at Indian Point Electrical Center Units 2 and 3 (Enercon 2010), and EPRI's 2011 *Closed-Cycle Cooling System Retrofit Study: Capital and Performance Cost Estimates.* EPA acknowledges there is a high level of uncertainty underlying these cost estimates driven by the lack of site-specific information about the design and installation of this technology at PNPS. Nonetheless, EPA believes these estimates are a useful baseline for comparison of costs for the purposes of this BTA determination for entrainment. The social costs of closed-cycle cooling are discussed in detail in Section 5.7, below.

5.1.6. Summary

To summarize, a closed-cycle cooling system at PNPS would likely reduce cooling water withdrawals, and therefore, impingement and entrainment, by 91% or more. However, converting to closed-cycle cooling would negatively affect plant performance and, in some cases, cause the plant to experience routine active power losses over a substantial portion of the year forcing the plant to shut down. Frequently shutting down PNPS by moving the control rods may be in inconsistent with its operating license and would potentially impose substantial social costs for another generator to replace the output from PNPS. A larger cooling tower would reduce the likelihood of shutdowns during most of the year, but not during the summer when electricity demand and entrainment are highest. Optimizing the cooling tower by replacing the existing condenser could alleviate some of these operational issues, but a change of this magnitude is unprecedented at an operational nuclear power plant and would result in substantial additional capital and installation downtime costs. Therefore, closed-cycle cooling does not appear to be technologically infeasible at PNPS, but will impose substantial operational inefficiencies and significant social costs once operational, which, given the extensive construction period, would not be until at least four years from permit issuance.

5.2. Variable Frequency Drives

Single-speed pumps have a constant withdrawal rate at design capacity. The two, single-speed circulating pumps used for condenser cooling at PNPS have a combined design pumping capacity of 311,000 gpm (447.8 MGD). In contrast, variable frequency drives (VFDs), also known as variable speed pumps (VSPs), can be operated with a variable withdrawal rate, which enables a facility to adjust the volume of cooling water withdrawn to better match its actual cooling needs. To make the conversion, the existing pump motors would be replaced and equipped with VFDs, which would control the speed of the motors by varying the frequency and voltage of electric power to the pumps.

5.2.1. Design of Variable Frequency Drives at PNPS

Entergy evaluated the feasibility of replacing the existing, single speed drives with adjustable VFDs on each of the two circulating water pumps in order to reduce once-through cooling water withdrawals at the intake. Enercon estimates that the maximum flow reduction through the condenser would be 45% based on the continuous operating limit for hotwell temperature (118°F) and to ensure condenser performance. Use of VFDs could provide a small benefit to PNPS because VFDs require less power to run than single-speed pumps. Entergy anticipates that, on average, less than 0.1% of net power capacity would be saved at a flow reduction of 45% (Enercon 2008, p. 48).

Entergy used the PEPSE model to estimate possible flow reductions achievable with VFDs with active power losses ranging from 0% to 20% (Enercon 2008). With zero active power loss, flow reductions would be limited to 18% to 34% with an annual average reduction of 28%. At 20% active power loss (the maximum available loss without control rod movement[21]), flow reductions of 36% to 45% could be achieved with an annual average reduction of 42%. Reductions would be highest during the colder months when ambient water temperatures are coldest, and lower during the summer when ambient temperatures (and ichthyoplankton densities) are highest.

5.2.2. Entrainment Reduction

Based on average monthly ichthyoplankton densities from 2002 to 2007, EPA estimates that VFDs with Entergy's predicted maximum monthly flow reductions (at 20% active power loss) could achieve annual entrainment reductions of 41%. However, actual flow reductions and resulting entrainment reductions would be substantially less than predicted in the 2008 Engineering Response. VFDs use less circulating water, which results in a rise in both the discharge temperature (delta T) and maximum temperature.

[21] As described above, the movement of control rods to regulate thermal power increases the likelihood of transients and implicates nuclear safety concerns.

The current NPDES permit limits the temperature rise at the discharge to 32°F and the maximum temperature to 102°F. These limits, which exceed Massachusetts surface water quality standards, have been authorized by the CWA Section 316(a) variance as protective of the balanced, indigenous population. See the discussion in Section 7.0 of the fact sheet. Maximum flow reductions at 20% power loss result in increased thermal impacts, with an annual average rise in temperature of 56.4°F and maximum discharge temperature of 103.9°F. Entergy estimates that reducing flow via VFDs with no power loss results in an annual average discharge temperature rise of 45.3°F, confirming that even at the lower range of flow reductions with no power loss (18% to 34%), PNPS would be unable to meet the current permitted rise in temperature limit of 32°F. In order to achieve the predicted entrainment reduction of 41%, PNPS would exceed the permitted maximum temperature limit and would exceed the permitted delta T limit by nearly 25°F. At this time, Entergy has not demonstrated that the increase in discharge temperature would ensure the protection and propagation of the balanced, indigenous population. To this end, EPA requested that Entergy evaluate the available flow reduction using VFDs within the constraints of the existing thermal discharge limits.

In its 2014 Engineering Response Supplement, Entergy concluded that VFDs are feasible at PNPS from an engineering perspective, but in order to maintain compliance with the current permitted temperature limits, the maximum reduction in flow would be 9% (Enercon 2014, p. 44). This reduction can be attained because PNPS typically operates at a temperature rise of 29°F, which is within the 3°F buffer from the permitted limit of 32°F. The reduction would be less than 9% during the months of July to September unless active power losses occur. As a result, actual flow reductions achievable with VFDs at the current permitted temperature limits would likely be less than 9%. Furthermore, because flow reductions under the current temperature limits are minimal, the through-screen velocity at the traveling screens would continue to exceed 0.5 fps, which is not protective of fragile species that currently experience high mortality at the traveling screens and fish return.

5.2.3. Cost

Of the technologies considered in this determination, VFDs impose the lowest private and social costs. Enercon estimated the total capital cost for conversion of the two circulating water pumps with VFDs is approximately $7 million ($2008). There are no additional operating and maintenance costs associated with VFDs compared to the existing pumps. There is no energy penalty or cost of carbon associated with the operation of VFDs with no active power losses. Entergy proposed achieving greater flow reductions (up to 42%) with a 20% active power loss, which would inflict social costs associated with the loss of output at PNPS. EPA has not considered this option, however, because flow reductions greater than 9% cannot be achieved, regardless of active power losses, without exceeding the current temperature limits. The social costs for this option are discussed in more detail in Section 5.7, below.

5.2.4. Summary

Flow reductions, and therefore entrainment reductions, greater than 9% cannot be achieved with VFDs unless PNPS exceeds both the maximum temperature limit and rise in temperature limit. Entergy concluded that further analysis of VFDs would be required to assess the potential effects of increased discharge temperatures on the balanced, indigenous population. Without fully understanding this trade-off, EPA is not inclined to authorize higher thermal discharge limits at PNPS. Therefore, while VFDs are an available BTA for entrainment at PNPS, this technology would likely result in an entrainment reduction of no more than 9%. In addition, this option provides no additional reduction in impingement mortality beyond the existing traveling screen, which does not improve the survival of fragile species.

5.3. Assisted Recirculation

As discussed above, Entergy determined that converting PNPS to closed-loop cooling is not technologically feasible because the loss in plant efficiency would significantly increase the risk of transients and would likely result in the need to shut down the plant for extended periods of the year. EPA did not determine that closed-loop cooling is infeasible, but concluded that the technology would entail an extensive installation period and would impose substantial social costs resulting from the loss of generating capacity at PNPS. A similar, but alternative option, evaluated here as "assisted recirculation," would be to use cooling towers as part of the existing open-loop system. Similar systems, known as "helper towers" have been used at nuclear plants to reduce cooling water temperatures during hot summer months before discharging the cooling water to the source waterbody (EPRI 2011). Traditional helper towers discharge cooling water from the towers directly to the source waterbody without altering the flow. In contrast, assisted recirculation at PNPS would discharge a portion of the water from the cooling towers back to the intake bay where it would then be mixed with the relatively cooler Cape Cod Bay water and recirculated through the plant. PNPS would supplement the recirculated water from the cooling towers with water that continues to be withdrawn at the CWIS from Cape Cod Bay, but at a lower withdrawal rate than the existing once-through system. The ratio of recirculated water to Cape Cod Bay water could be adjusted as necessary to meet the cooling demands of the condenser, which provides the operational flexibility to overcome many of the limitations of a closed-cycle cooling system without resulting in a loss of generating capacity, while still enabling the plant to reduce cooling water flows and, therefore, entrainment.

In assisted recirculation, circulating water exiting the main condenser is diverted to a cooling tower instead of the discharge canal. A portion of this cooled water is pumped from the cooling tower to the intake where it mixes with water from Cape Cod Bay. The combined Cape Cod Bay and recirculated water is then circulated through the plant via the CW and SSW pumps. The existing CWIS would remain relatively unchanged and would enable PNPS to recirculate a larger volume of the cooled discharge (and reduce once-through cooling water withdrawals) when ambient air and water temperatures are cooler, and increase once-through cooling withdrawals when ambient conditions would cause the plant to operate at or above administrative limits that would result in active power losses with a closed-cycle system (*e.g.*, hotwell temperature). Unlike a closed-cycle cooling retrofit, assisted recirculation would allow PNPS to respond to changing conditions and would not increase the likelihood of transients and scrams. In addition, the reduction in flow through the traveling screens during some periods of the year would reduce the through-screen velocity to less than 0.5 fps, which would likely provide impingement mortality protection for fragile species. *See* 79 Fed. Reg. at 48,336-37.

Assisted recirculation is constrained in a manner similar to closed-loop cooling, in that increasing ambient wet bulb temperatures result in the possible encroachment of PNPS limitations. Unlike a closed-cycle cooling system, assisted recirculation allows PNPS to increase once-through cooling water withdrawals and decrease the volume recirculated through the cooling tower when approaching the administrative limits in order to avoid reducing thermal power and possible shutdown. Under this option, PNPS would likely experience lower flow reductions during summer when ambient temperatures are highest, but would still be able to recirculate a portion of the cooling water. Closed-cycle cooling, in contrast, would require PNPS to either operate the once-through system or shutdown when ambient temperatures are high to avoid transients.

5.3.1. Design of Assisted Recirculation at PNPS

In its evaluation of assisted recirculation, Enercon proposed use of a round hybrid cooling tower located on the western end of the upper parking lot. This location is feasible but would require relocation of the hydrogen storage pad, sewage treatment facility, and sludge dewatering facility. To pump discharge water to the cooling towers, and then to the CWIS to be re-used, a new pump house would be built at the discharge canal. To protect against drawdown, a portion of the discharge canal would have to be made wider and deeper. New pipes would deliver water from the cooling tower to the CWIS. These modifications, on top of the relatively high cost of the hybrid cooling tower, increase capital costs.

Enercon evaluated assisted recirculation with the PEPSE model using the same operational hotwell temperature limit as in the closed-cycle cooling analysis (118°F). In this case, Enercon applied an additional thermal operation limit for the SSW pumps (73°F) because the cooling water recirculated from the tower mixes with the intake water and is used both for the main condenser as well as the SSW system. Enercon predicts that reductions in flow ranging from 35% in August to 92% in January and February can be achieved without a loss in power output. Entergy also evaluated the potential reductions that could be achieved with an active power loss of 5% ranging from a low of 41% in August to a high of 96% in January and February.[22]

[22] The continuous operation limit for the inlet SSW temperature (73°F) sets a static cap on the available flow reduction such that increasing active power loss (MWe) above 5% does not result in additional flow reductions.

5.3.2. Entrainment Reduction

EPA estimated that assisted recirculation without active power loss would result in an annual entrainment reduction of about 52%, while reducing power output by 5% would result in an annual entrainment reduction of about 58%. Using assisted recirculation, Entergy predicts maximum flow reductions greater than 80% in December through April, which coincides with higher abundances of the early life stages of several commercially or recreationally valuable species, including winter flounder and Atlantic cod. In fact, Entergy predicts that flow, and therefore entrainment, can be reduced more than 45% using assisted recirculation in every month except for July, August, and September when flow reductions of 35-43% are possible. These flow reductions can be achieved without any effect on power generation. In addition, because assisted recirculation cools the water prior to discharge, these flow reductions would not result in higher discharge temperatures. In addition, assisted recirculation would result in a through-screen velocity (TSV) less than 0.5 fps from November through May, which would provide impingement mortality controls for fragile species. The TSV would increase as once-through withdrawals increase during warmer months and would range from 0.62 fps in October to a maximum of 1.1 fps in August, compared to a TSV of 1.57 fps using the existing traveling screens at the current flow rate.

5.3.3. Cost

Entergy estimated that the capital cost for assisted recirculation is $364.5 million ($2007) with an annual operational cost of $211,000. Entergy also estimates that the maintenance costs are likely to vary over a 30-year period and include the costs for replacement of components (e.g., pump impellers, motors, or entire assemblies). Entergy estimates annual maintenance costs (in $2007) of $632,000 for the first 5 years, $1,083,000 for years 6 to 15, and $1,978,000 for years 16 to 30. Enercon estimates loss of electrical output of the plant as a result of operating the cooling tower ("parasitic losses") vary approximately linearly as a function of input flow rate. However, because PNPS could adjust the amount of recirculating water based on ambient conditions, there is no energy penalty, resulting from the loss of efficiency, associated with assisted recirculation. The social costs of this option are discussed in more detail in Section 5.7, below.

5.3.4. Summary

Entergy concluded that assisted recirculation is feasible at PNPS, but that this technological approach is unprecedented at nuclear power stations in the United States. While EPA is not aware of any existing nuclear facilities that use cooling towers in a once-through cooling system to reduce water withdrawals, there are similar "helper tower" configurations in operation at several nuclear plants in the U.S. (EPRI 2011). The only difference between that technology and assisted recirculation is that at PNPS the cooled water would be discharged back to the intake and mixed with cold seawater, rather than being discharged to the source water. Consequently, EPA concludes that assisted recirculation is an available technology for minimizing entrainment.

In its 2008 Engineering Response, Entergy concludes that the theoretical performance of assisted recirculation is similar to that of VFDs, but at an increase in cost by more than fifty-fold. EPA disagrees that the performance of these two technologies is comparable. First, according to Entergy, the maximum flow reduction available using VFDs is 45% and that includes a 20% active power loss. Assisted recirculation does not have the same limitation because this technology would not increase discharge temperatures like VFDs. In fact, because discharge water goes through the cooling tower prior to being discharged, the temperature at the outfall would decrease compared to existing conditions. According to Entergy, the maximum flow reduction that can be achieved through VFDs within the existing thermal discharge limitations is 9%, which is substantially less than the anticipated flow reductions achieved with assisted recirculation.

5.4. Offshore Intake Location

Even over the relatively small scale of Cape Cod Bay, densities of adult and juvenile fish, as well as eggs and larvae, exhibit spatial variation with both distance from shore and depth in the water column. As a result of this variation, the location of a CWIS can influence entrainment. Nearshore coastal waters are typically the most biologically productive areas; therefore, moving an intake for a coastal facility offshore may reduce entrainment relative to an onshore intake (TDD to Final Rule p.6-56 to 6-58). Deeper waters are generally considered less biologically productive, although the site-specific biological community is an important consideration in siting an offshore intake.[23] Offshore intakes can also be fitted with velocity caps[24] or cylindrical wedgewire screens, which can be designed with a sufficiently low velocity to allow fish to avoid impingement. An added benefit of an offshore intake may result from the withdrawal of colder water, which increases the efficiency of the facility and may lower the discharge temperature.

Offshore intakes have been used at nuclear and fossil fuel facilities in coastal locations and on the Great Lakes. Seabrook Nuclear Power Station, which is located about 65 miles north of PNPS, uses an intake that is about 1.3 miles offshore at a depth of about 60 ft (the velocity cap is located 18 ft below the surface). Most offshore intakes, such as the one at Seabrook, were constructed at the same time as the plants rather than retrofit.[25]

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[23] During development of the Phase III Rule, EPA examination of data on densities of ichthyoplankton in the Gulf of Mexico indicated that ichthyoplankton densities at stations less than 50 m deep are more than 4 times the average densities at stations 150 m deep, and can be more than 18 times the average densities at stations greater than 150 m deep. See the Preamble to the Phase III Rule 71 Fed. Reg. 35013 (June 16, 2006) and OW-2004-0002-951.

[24] Velocity caps convert flow from a vertical direction to a horizontal one at the entrance to the intake, which provides a physiological trigger to induce an avoidance response in fish. Velocity caps are also configured with supports and bar spacing designed to prevent larger aquatic organisms from entering the intake pipe and swimming to the forebay. See Technical Development Document for the Final 316(b) Existing Facilities Rule p. 6-59.

[25] In the Technical Development Document for the Final 316(b) Existing Facilities Rule (p. 6-59), EPA recognizes that selecting an appropriate intake location is best considered when siting a new intake or

However, the Oak Creek Power Plant on Lake Michigan completed a retrofit of an offshore intake in 2010 that could serve as a model. A new intake was constructed located 6,000 feet offshore and fitted with 24 cylindrical wedgewire screens with 3/8-inch mesh. Total withdrawals at the intake are 2,200 MGD, which serves both the existing Oak Creek facility plus the new Elm Road Generating Station. The total cost of the retrofit, including modifications to the existing shoreline intake, the intake tunnel, and wedgewire screens was $121 million (We-engeries 2014b).

5.4.1. Design of an Offshore Intake at PNPS

An alternative intake location was examined during the original licensing of PNPS in the early 1970s for construction of Unit 2 but was never built. PNPS proposed an intake located approximately 2800 feet offshore at a depth of 35-40 ft. In 2000, another analysis of intake technologies prepared for PNPS by ENSR suggested an offshore intake could be located about one mile offshore at a depth of 36 feet. A velocity cap was included in the proposed design to minimize impingement by reducing the horizontal design flow to a maximum of 0.5 fps. ENSR concluded that installation of a submerged intake was feasible for PNPS and did not present any safety concerns. However, ENSR raised concerns about the effectiveness of an offshore intake. In particular, ENSR was uncertain if an offshore intake would effectively minimize entrainment of larval winter flounder because larvae of this species may be concentrated at the bottom of the water column. Additionally, the Permittee stated that an offshore intake may impede navigation and would likely disrupt the benthic environment during construction. *See* 316 Demonstration Report – Pilgrim Nuclear Power Station (Redacted) p.6-5 to 6 (ENSR 2000).

In its 2008 Engineering Response, Entergy concluded that an offshore intake at PNPS may be feasible, but site-specific biological data to assess potential entrainment reductions is lacking (Enercon 2008). Entergy states that "[d]etailed field studies of ichthyoplankton and local fish distribution are required to establish whether an offshore location is preferable and what that location would be." Similarly, in its 2014 Engineering Response Supplement, Entergy states that site-specific data are unavailable either to identify potential offshore intake locations or evaluate potential reductions in entrainment compared to the current CWIS (Enercon 2014). Entergy also maintains that an extensive, multi-year field study would be required to determine the optimal location and depth to minimize entrainment.

An offshore intake is feasible, although Entergy did not identify any potential locations for the intake. At EPA's request, Tetra Tech evaluated whether an offshore intake location is available at PNPS and proposed select design parameters and capital costs for an offshore intake at PNPS. *See* Memo dated November 10, 2014 from John Sunda and Kelly Meadows (Tetra Tech) to Damien Houlihan and Jennifer Chan (EPA) titled *Engineering Analysis of Adding a Submerged Offshore Intake at Pilgrim Station* and

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facility, and that changing the intake location is both limited to facilities with available space and often one of the most expensive technologies considered.

Memo dated November 10, 2014 from Ann Roseberry Lincoln and Blaine Snyder (Tetra Tech) to Damien Houlihan and Jennifer Chan (EPA) titled *Pilgrim Station Cooling Water Intake Location Analysis*. Based on the total pump capacity, Tetra Tech proposes a design with two intake riser shafts each with an inner diameter of 9 feet. To avoid extensive impacts to benthic habitat, Tetra Tech suggests using the shaft and deep tunnel design employed at Seabrook and at Oak Creek Stations, instead of excavating, laying, and covering the intake pipe on the ocean bottom.

The PNPS intake design must consider the safety-related system requirements specific to a nuclear facility, including ensuring that the salt service water (SSW) pumps operate with a reliable water supply for the reactor under all conditions, the ability to keep the water elevation at the pumps from dropping below the required pump submergence elevation (and damaging the SSW pumps), and issues related to excavation of the intake tunnel near a nuclear reactor. To ensure that the SSW pump water supply is available under all conditions, Tetra Tech proposes a supplementary intake system design similar to the one at Oak Creek. *See* Memo dated November 10, 2014 from John Sunda and Kelly Meadows (Tetra Tech) to Damien Houlihan and Jennifer Chan (EPA) titled *Engineering Analysis of Adding a Submerged Offshore Intake at Pilgrim Station*. The Oak Creek design provides the option of alternating between the new offshore location and the existing shoreline intake. A similar design would allow PNPS to bypass the offshore intake during emergency conditions to ensure a steady supply of cooling water for the SSW pumps and avoid safety-related issues. Using low-head lift pumps between the intake tunnel outlet basin and the existing intake eliminates the need to modify the existing cooling equipment to compensate for increased head loss and allows for continued use of the existing intake during construction. The low-head lift pumps would provide sufficient pump submergence during normal operations. Finally, because of the potential effect of blasting on the safety and integrity of the reactor, Tetra Tech suggests an alternative method of mechanical shaft boring for construction of the intake tunnel at PNPS.

Tetra Tech investigated suitable offshore locations for a submerged intake by analyzing information on depth, distance offshore, and locational data on sensitive, special, or unique resources (including shellfish suitability areas defined by MassFisheries, core habitat for whales, popular underwater recreational diving sites, presence of eelgrass, and hard or complex seafloor habitat). *See* Memo dated November 10, 2014 from Ann Roseberry Lincoln and Blaine Snyder (Tetra Tech) to Damien Houlihan and Jennifer Chan (EPA) titled *Pilgrim Station Cooling Water Intake Location Analysis*. Based on this evaluation, at least one suitable area for an offshore intake is located between 5,000 and 15,000 ft offshore at a depth of 15 to 20 m, which overlaps with North Atlantic right whale core habitat. The presence of a submerged offshore intake with a low intake velocity may not directly affect right whales, who generally spend the majority of their time in Cape Cod Bay in the upper 5 m of the water column (Parks et al. 2012), but it may indirectly impact right whales by entraining zooplankton species that are the preferred prey in Cape Cod Bay (the copepods, *Centrophages* spp., *Pseudocalanus* spp, and *Calanus finmarchicus*). The patterns of right whale residency and distribution in Cape Cod Bay are closely tied to the distribution of zooplankton. Copepod densities from

January through March are typically concentrated in the water column and whales exhibit bottom feeding. *Pseudocalanus* spp., which are common during late winter and early spring, form dense bottom layers and exhibit diel vertical migrations with concentrations forming at the surface at night. In April, surface concentrations of *C. finmarchicus* often peak in April with and whales are likely to exhibit more skimming and surface feeding. *See*, for example, Leeney et al. 2009. It is possible that a submerged offshore intake may affect North Atlantic right whales if the abundance of preferred prey in Cape Cod Bay is impacted by entrainment. Further evaluation of the potential impacts on right whales must be performed if an offshore intake is considered an available technology at PNPS.

5.4.2. Entrainment Reduction

Offshore intakes can potentially reduce entrainment compared to shoreline intakes by withdrawing water from depths at which the biological productivity (and therefore, density of fish eggs and larvae) is relatively low. The Final Rule recognizes that an offshore intake located in a less biologically productive area may experience a reduction in entrainment, but maintains that these reductions are dependent on the distance from the shoreline, the intake depth, and the site-specific aquatic community at the proposed location (79 Fed. Reg. at 48,331). Because the species found will change as a function of distance, relocating an intake may shift the impacts to a different set of species, rather than reducing entrainment. During development of the Phase III rule and the Final Rule, EPA evaluated available data on the spatial distribution of ichthyoplankton in the Gulf of Mexico, along the western coast of the U.S, and in the Gulf of Maine (see Final 316(b) Rule Docket Reference DCN12-6703 *"SEAMAP and Other Data Applicability to Other Coastal Settings"*). In this study, ichthyoplankton densities tend to decline with depth and distance from shore, and densities are lowest at depths greater than 100 m. Data from the Gulf of Maine suggests that mean ichthyoplankton densities decline dramatically at depths greater than 60 m.

To EPA's knowledge, site-specific studies of the spatial distribution of eggs and larvae are not available to estimate the potential entrainment reductions that may be realized at PNPS by relocating the intake offshore. However, Seabrook Station, located about 65 miles north of PNPS, operates an offshore intake that may serve as a proxy for the performance of this technology at PNPS. Seabrook Station calculated the similarity in the entrainment communities based on biological data collected at Pilgrim and at Seabrook Stations from 2002 to 2006 (Seabrook 2008 PIC). Estimated similarity in the entrainment communities ranged from 61 to 69 for eggs (where 100 represents complete similarity) and from 64 to 78 for larvae. These estimates suggest that PNPS and Seabrook Station entrain similar species and that a comparison of the two intakes may be an adequate representation of the potential entrainment reduction that could be realized at PNPS with an offshore intake. In its 2008 Proposal for Information Collection under the remanded Phase II Rule, Seabrook Station estimated the reductions in entrainment due to the existing offshore intake by comparing entrainment losses at Seabrook to the entrainment losses at PNPS measured as the density of eggs and larvae collected during biological monitoring at each station from 2002 to 2006. On average, the density of ichthyoplankton collected at Seabrook Station was 25% lower than the densities collected at PNPS. Adding the additional reduction in cooling water flow at Seabrook Station resulting from the withdrawal of colder, deeper water resulted in an estimated 31% reduction in entrainment at Seabrook's design flow compared to PNPS's shoreline intake. Based on the analysis of the offshore intake at Seabrook Station, entrainment reductions between 25 to 31% may be possible with an offshore intake at PNPS.

Saila et al. (1997) compared annual equivalent adult losses of winter flounder due to entrainment at Seabrook and Pilgrim Stations during the years 1990 to 1995 and found that PNPS experienced greater losses of adult equivalents in all years despite withdrawing less cooling water. Reductions in equivalent adult winter flounder ranged from 11% to 77% with an average reduction of 58.6%.

Entergy, in its 2008 and 2014 Engineering Responses, maintains that biological data is not available to evaluate potential reductions in entrainment compared to the existing shoreline CWIS. In its review of available biological data, Normandeau suggests that an offshore intake may reduce entrainment of Atlantic menhaden and winter flounder eggs and larvae compared to the existing shoreline location, depending on the depth and location of the intake, but that an offshore intake may increase entrainment of cunner eggs and larvae[26] and American lobster larvae compared to the current location (Normandeau 2008). Meanwhile, Scherer (1984) observed winter flounder larvae throughout the water column (to a depth of 20 m) in the main channel leading to Plymouth Harbor-Duxbury Bay, but found that larvae were more abundant near the bottom than at the surface on 3 of 4 sampling dates. The results of this study demonstrate that withdrawing water from a depth of 15 to 20 m (the preferred depth in Tetra Tech's evaluation of an offshore intake for PNPS) may not reduce entrainment of winter flounder larvae in all locations and highlights the necessity of more site-specific biological data from potential offshore locations at PNPS.

Finally, in an attachment to Entergy's 2014 Engineering Response Supplement, Normandeau discusses potential impacts to species in Cape Cod Bay during construction of an offshore intake, including: increased probability of ship strikes with marine mammals and sea turtles due to increased vessel traffic, interference with communication and prey detection as a result of vessel and construction-related noise, disturbance to benthic habitat, and increased turbidity (Normandeau 2014). Normandeau also identifies the potential for increased entrainment of select forage species, including phytoplankton and zooplankton, as well as the potential for sea turtles to become entrapped at an offshore intake fitted with a velocity cap. EPA acknowledges that the potential for

[26] Normandeau indicates that cunner entrainment may increase with an offshore intake location; however, a comparison of entrainment and impingement at PNPS and Seabrook Nuclear Power Station during development of the (remanded) Phase II Rule indicates that 1) cunner in Cape Cod Bay typically spawn closer to shore and 2) the mean annual number of cunner eggs and larvae (as estimated by the facility) entrained at Seabrook was only 13% of the mean annual entrainment at PNPS. The mean entrainment data collected at PNPS in the 1990's and reported during the development of the Phase II Rule is consistent with the more recent data evaluated for this BTA determination and lends uncertainty to the statement that cunner entrainment would increase at an offshore location as compared to the existing shoreline intake.

impacts to the aquatic community both during construction of an offshore intake and due to its operation in a new location would need to be addressed during the design phase.

5.4.3. Cost

In its most recent Engineering Response, Entergy maintains that because a specific location for a potential offshore intake cannot be determined, capital and operation and maintenance costs for an offshore intake cannot be accurately estimated (Enercon 2014). In its 2008 Engineering Response, Entergy estimated the capital cost of an offshore intake to be $36.4 million based on the costs estimated for the original offshore intake design from 1980 updated to 2007 dollars. In 2014 dollars, this cost would be $45 million.

This cost is based on construction of a new intake and does not include retrofit costs. The cost of retrofitting PNPS with a submerged offshore intake will depend on the location and the final design, including whether the intake will be equipped with CWW screens or a velocity cap. As a baseline estimate, Tetra Tech evaluated the cost of the retrofit at Oak Creek Station on Lake Michigan. After considering the regional construction cost difference, contingency to account for differences in plant and waterbody type, and inflation, Tetra Tech estimated a comparable cost for a project at PNPS and adjusted the costs for differences in design flow and tunnel length. Tetra Tech estimates capital costs ranging from $56 million to $121 million dollars, depending on the distance offshore and the technology employed (velocity cap or coarse-mesh wedgewire screens). Tetra Tech's estimate is generally consistent with the capital cost of $80.9 million (2000 dollars) and annual O&M costs of $148,000 estimated in Entergy's evaluation of impingement and entrainment technologies from 2000 (ENSR 2000). After evaluating the costs and the preferred location, EPA considers $81 million in capital costs (for intake with velocity cap at a distance 10,000 ft offshore) and $253,000 in annual O&M costs to be representative of the retrofit costs for an offshore intake at PNPS.

5.4.4. Summary

EPA acknowledges that the performance of an offshore intake is subject to a number of site-specific factors and that the available data appear insufficient to assess potential entrainment reductions at PNPS. Still, while a site-specific intake design and precise estimate of the entrainment benefit of relocating the intake offshore cannot be accurately determined at this time, neither EPA nor Entergy have determined that this technology is not feasible at PNPS nor that it would definitively not reduce entrainment losses at PNPS compared to the existing system. EPA does not propose an offshore intake location as the BTA for entrainment at PNPS in this determination because of the uncertainty regarding the feasibility, location, cost, and the inability to estimate the expected biological performance of this technology as compared to other available technologies.

5.5. Cylindrical Wedgewire Screens

A cylindrical wedgewire (CWW) screen uses a "v" or wedge-shaped, cross-section wire welded to a framing system to form a slotted screening element. Wedgewire screens can potentially reduce both entrainment and impingement by physically excluding organisms from being drawn into the CWIS and by operating at a sufficiently low through-screen velocity to allow fish to swim away from the screens (Taft 2000). Typically, CWW screens are designed with a through-screen velocity of no greater than 0.5 fps, which would likely protect even fragile species from impingement mortality. Whether this technology may be effective or not to reduce entrainment at a particular facility depends on a variety of factors, including the screen slot size, water depths, local hydrodynamics, the relative sizes of the screen mesh and the local organisms, and water withdrawal volumes and velocities. The performance of CWW screens relative to entrainment losses depends on, among other things, the presence of sufficient ambient current to sweep eggs and larvae past the intake screens rather than being drawn into or onto them. *See* TDD for Final Section 316(b) Phase II Rule, p. A-13 (Feb. 12, 2004).

Both coarse-mesh and, to a lesser extent, fine-mesh screens have been used at power plants and manufacturing facilities across the U.S. The largest current installation of CWW screens is at Oak Creek Power Plant on Lake Michigan. As described above, this facility employs an offshore intake (located about 6,000 ft offshore) in combination with 24 coarse-mesh wedgewire screens to minimize impingement and entrainment. The original shoreline intake at Oak Creek remains operational and ensures a reliable source of intake flow even in the event that flow from the offshore intake and CWW screens is not available or reduced.

5.5.1. Design of Cylindrical Wedgewire Screens at PNPS

Entergy considered the availability of CWW screens at the PNPS intake, as well as in combination with a new, offshore intake location (Enercon 2008 and 2014). According to Entergy, installation of CWW screens at PNPS is technologically infeasible because the potential for the screens to become dislodged, damaged, or clogged and thereby cut off cooling water supply for the SSW pumps (required for safe shutdown of the plant) presents a nuclear safety concern (Enercon 2008, p. 42). The safety design bases of the SSW system are: (1) no single system component failure can prevent the SSW system from providing a heat sink for the Reactor Building Closed Cooling Water; and (2) the SSW system continuously supplies adequate cooling water to the Reactor Building Closed Cooling Water heat exchangers during transient and accident conditions. Therefore, the permittee maintains that any potential technology that introduces new failure modes into the SSW system, or that could interfere with SSW cooling water supply, would implicate nuclear safety concerns and should be judged as technologically infeasible (Enercon 2008 Response p.24). Entergy indicates that operation of this technology would require PNPS to isolate the SSW supply, which would require extensive modification to the existing CWIS or construction of a new CWIS and result in an extended forced outage (Enercon 2008, p. 42).

As described above, Entergy concluded that CWW screens are unavailable at PNPS due to concerns for nuclear safety related to a reliable cooling water source for the SSW pumps. In its 2014 Engineering Response Supplement, Entergy re-evaluated this technology in response to EPA's request for further consideration of CWW screens as part of an offshore intake configuration (Enercon 2014). Entergy concluded that the engineering feasibility of wedgewire screens cannot be determined with existing information and that further study, including a pilot test, would be required to determine if this technology is available at PNPS. Entergy again highlighted the potential safety-related problems due to clogging and provided documentation of periodic heavy debris loading events that occur at the Station and that could pose a problem if CWW screens are used at the intake. Entergy also raised concerns about the feasibility of an automatic burst system (ABS) to maintain screen performance at an offshore location 1,000 ft or greater from shore, which Entergy states exceeds the limits of known ABS designs.

In response to Entergy's position that CWW screens are not available at PNPS due to nuclear safety concerns related to SSW intake, EPA proposes that there is at least one possible solution to address Entergy's safety-related concerns and ensure a continuous supply of cooling water for the SSW pumps. In its 2000 Demonstration for PNPS, ENSR[27] proposed a design for wedgewire screens for 15 "T"-shaped cylindrical screens of 1 mm slot size located outside the embayment at the end of a 1500-ft tunnel (ENSR 2000, p. 6-7 to 6-8). ENSR specifically considered the potential safety concerns related to clogging of the screens, and included keeping the existing intake structure intact and functional as a backup for the wedgewire screen system in the design to alleviate safety concerns.

Enercon proposed a similar design for CWW screens (*i.e.*, using the existing intake structure as backup for a wedgewire system) for the Indian Point Electric Center (IPEC), on the Hudson River (Enercon 2010). Like PNPS, IPEC withdraws cooling water for the safety service water pumps from the same intake as the circulating water pumps. For IPEC, Enercon proposed circumventing the safety-related issues with the SSW pumps by connecting the CWW screens to the CWISs downstream of the existing traveling screens and maintaining operability of the existing screens. In this way, stop logs and isolation valves would enable the CWW screen arrays to be isolated for maintenance, repair, seasonal operation, or to ensure a reliable supply of cooling water for safety while cooling water supply continues uninterrupted from the existing intake bays (Enercon 2010). The CWW design for IPEC requires that the existing intake pump pits be excavated by approximately 6 feet to ensure the submergence margin and water level would prevent air entrainment (cavitation) in the circulating water pumps that could lead

[27] In 2000, ENSR Corporation, under contract to Entergy, prepared a 316 Demonstration Report for Pilgrim Nuclear Power Station (Redacted Version) which assessed the impacts of thermal discharges and the CWIS on a select set of species in Cape Cod Bay. In 2008 and 2014, Entergy contracted Enercon to provide an assessment of the impacts from the CWIS in response to EPA's information requests under Section 308 of the CWA.

to shutdown. Thus, it does not necessarily follow that, since CWW screens could become dislodged, damaged, or clogged, they are technologically infeasible at PNPS.

At an intake flow of 324,500 gpm and maximum design flow of 0.5 fps per screen, PNPS could possibly require 28 or more CWW screens depending on the size of the screens and the slot size.[28] Enercon does propose the use of an airburst mechanism to clear debris from the screens at IPEC. An airburst mechanism would likely be unavailable at PNPS because the screens would be located too far offshore for the system to be functional. The lack of an airburst mechanism could lead to more fouling issues at PNPS, which highlights the importance of maintaining operability of the existing traveling screens in the event that the CWW screens become clogged and cooling water supply is reduced. Maintaining the existing intake may also minimize unplanned shutdowns related to water elevation, because the alternative, existing intake could be used to raise the water elevation in the intake and prevent air intrusion and cavitation of the pumps.

5.5.2. Entrainment Reduction

When appropriate physical conditions are met (e.g., adequate depth, optimal screen orientation, and sufficient ambient crossflow) and the slot size is small enough to exclude egg and larval life stages, CWW screens can potentially achieve substantial entrainment reductions. To prevent eggs and larvae from passing through the screen, the slot size must be small enough relative to the size of entrained organism to prevent their being pulled through the screens.[29] CWW screens are also designed with a low through screen velocity (no greater than 0.5 fps) which, due the cylindrical shape of the screens, quickly dissipates, thus creating a relatively small flow field in the waterbody. Coupled with optimal screen orientation, this small flow field results in a small profile that minimizes the potential for contact between susceptible organisms and the screen. Finally, the ambient current crossflow (or "sweeping flow") carries free-floating organisms past the screen. When the sweeping flow is dominant over the intake velocity, the hydrodynamic properties of the screens may reduce entrainment. *See* Final Rule TDD p. 6-42. To EPA's knowledge, the performance of CWW screens has not been studied in a nearshore coastal setting like PNPS. However, a study of 0.5 mm slot CWW screens conducted in an estuary in Narragansett Bay, Rhode Island with similar species to PNPS observed entrainment reductions of 92.5% to 99.9% for eggs and 48.8% to 93.3% for larvae, depending on the species and length class (EPRI 2004). This study indicates that under the right conditions and with a sufficiently small slot size, PNPS could experience substantial reductions in entrainment with CWW screens. Site-specific studies would be

[28] Based on the flow and size of the CWW screens at IPEC, PNPS would need 28, 1.0-mm screens that are 7 ft in diameter and 25 ft long. ENSR proposed a design for PNPS with 15, 1.0 mm slot CWW screens but did not specify a design through-screen velocity in its evaluation. Enercon did not evaluate CWW screens with slot sizes less than 1.0 mm for IPEC, but it is likely that more than 28 screens would be required if the slot size is less than 1.0 mm.

[29] The critical measurement for eggs is diameter. For larvae, the critical measurement is not their length, but their head capsule width. This is because even if a larva is longer than a particular screen opening, it can be pulled through that opening if the head capsule is narrower than the opening.

required to determine the optimal design for screens at PNPS, including, but not limited to screen size, slot size, orientation, depth, location, and sweeping flow.

While the literature suggests that PNPS could reduce *entrainment* by operating CWW screens at the intake, it is not certain that excluding eggs and larvae from being entrained would directly reduce *entrainment mortality* at PNPS. In other words, eggs and larvae that would otherwise have been entrained through the existing screens would be excluded with fine-mesh CWW screens, but could be killed or suffer trauma by contacting the screens or becoming impinged. At present, EPA has insufficient information that directly assesses egg and larval survival after contacting a fine-mesh wedgewire screen. 79 Fed. Reg. at 48,331, 48,335-36, and 48,435. Studying egg and larval survival after contact with a wedgewire screen would be difficult. Indeed, larvae in particular can be so fragile that they are killed merely by the process of trying to collect them for analysis. *See id.*at 48,323; TDD 2014, p. 11-10.

That said, EPA has collected and reviewed some information from the scientific literature concerning the survival of eggs and larvae after being impinged against a fine-mesh traveling screen. While not the same technology, traveling screens are also designed to exclude organisms from entrainment by relying, at least in part, on a small screen mesh size relative to the size of the otherwise entrainable organisms. *See* the 316(b) Existing Facilities Rule Technical Development Document p.6-46 to 52. These data suggest that, under some circumstances (*e.g.*, low intake velocity), the eggs of some fish species, as well as crustacean larvae, may be capable of surviving contact with a fine-mesh wedgewire screen. Given the manner in which wedgewire screens are intended to take advantage of passing currents to move organisms, EPA would expect fish eggs to do equally well or better after contact with a wedgewire screen as with a traveling screen. The literature also suggests, however, that fish larvae are unlikely, or at least are much less likely, to survive contact with a fine-mesh screen. Region 1 discussed this information in some detail in its Fact Sheet (see pp. 27-29) for the Draft NPDES Permit for the GE Aviation facility in Lynn, MA (NPDES Permit No. 0003905). *See also* 76 Fed. Reg. 22,186 (Apr. 20, 2011). Similar to GE Aviation, entrainment at PNPS is dominated by eggs and therefore may realize substantial reductions in entrainment mortality if the eggs survive potential impact with wedgewire screens. Still, the intake volume at PNPS is much larger than GE Aviation and there is significant uncertainty in the physical design and location available for installation of CWW screens at PNPS.

5.5.3. <u>Cost</u>

Because it concluded that CWW screens were not feasible, Entergy did not provide a cost estimate for this technology. ENSR estimated a capital cost of $39.1 million (2000 dollars) and annual O&M cost of $142,000. Tetra Tech estimated capital costs for CWW screens located 2,800 ft offshore would be approximately $62 million, with an estimated $175,000 to $350,000 in annual O&M costs (Tetra Tech Nov 2014 Memo). Tetra Tech based this estimate on the cost for the Oak Creek offshore intake retrofit project, which also includes wedgewire screens. Tetra Tech scaled the costs to account for the differences in intake flow, location, and fuel type (nuclear versus fossil fuel). Additional costs could be incurred depending on the slot size and costs related to any modifications to the existing intake system, including any losses in revenue if PNPS would experience a shutdown (e.g., if the circulating water pump pits need to be excavated).

5.5.4. Summary

In sum, under certain environmental conditions, narrow slot wedgewire screen technology may be capable of substantial reductions in entrainment mortality at facilities with certain characteristics. EPA disagrees with Entergy's position that CWW screens would be unavailable at PNPS due to nuclear safety-concerns related to a reliable source of cooling water for the SSW pumps, in part because Entergy has proposed a compatible CWW installation at another of its own nuclear energy facilities with a combined circulating and safety water intake system, and because a similar design was proposed for PNPS by ENSR in 2000. EPA concludes, therefore, that CWW screens may be available to reduce entrainment at PNPS. However, a substantial level of uncertainty remains, including identifying a preferred location that has sufficient sweeping flow, the design of the installation, the optimum slot size, the biological effectiveness of the screens to reduce mortality of eggs and larvae, and the potential that debris and clogging could be sufficiently removed to ensure performance of the screens under most conditions. EPA does not consider CWW screens to be the BTA for entrainment at PNPS based on uncertainty with the design and performance of this technology, as compared to other available technologies.

5.6. Potential Options for the BTA for Entrainment at PNPS

Entergy has evaluated several possible technologies to reduce entrainment of eggs and larvae at PNPS. In its own evaluation of technologies, Entergy concluded that "most of the customary range of technologies, including closed-cycle cooling, is not technologically feasible (including as a matter of nuclear safety) on a site-specific basis." *See* July 1, 2008 letter from E. Zoli of Goodwin Procter to D. Houlihan of EPA. Entergy further concluded that "certain theoretical technologies" were unprecedented and, because they had never been demonstrated through operation at a comparable facility, may not reasonably be considered commercially available.

EPA concludes that there are three potential BTA options for entrainment: closed-cycle cooling, assisted recirculation, and VFDs. Although EPA disagrees with Entergy's elimination of CWW screens for PNPS due to conflicts with nuclear safety requirements,[30] the available information for both an offshore intake and CWW screens is not sufficient to support selection of either as the BTA for entrainment at this time. EPA agrees with Entergy's assessment that assisted recirculation and VFDs are available technologies for the BTA for entrainment at PNPS. EPA does not agree that, based on

[30] As explained earlier, designs proposed by Entergy for the installation of CWW screens at its Indian Point Electric Center suggest that CWW screens could likewise be designed and ultimately installed at PNPS to guarantee that sufficient cooling water is available for the safety service water pumps.

technical feasibility, closed-cycle cooling is not an available technology at PNPS. That being said, retrofitting PNPS with closed-cycle cooling is expected to impose significant costs, either as a result of the reduction in the facility's ability to generate power within its administrative limits using the existing condenser or the large capital and downtime expenses associated with replacing the main condenser.

5.7. Calculation of Social Costs for Available Technologies

The preamble to the Final Rule (79 Fed. Reg. at 48,370) states "[I]n deciding what technology to require a permittee to install to address entrainment, the Director may undertake an evaluation of social costs and benefits of implementing such requirements." Accordingly, the Final Rule indicates that this analysis will be based on information supplied by the applicant, any third parties, and additional information as determined appropriate by the Director. This section presents the calculation of social cost for each of the available technologies: closed-cycle cooling, assisted recirculation, and variable frequency drives. The social cost represents the total burden imposed on the economy and is the sum of all opportunity costs incurred. *See* Chapter 8 of EPA's *Guidelines for Preparing Economic Analyses* (EPA 2010, updated in 2014). Social benefits are considered in Section 6.3.

5.7.1. Regulatory Background

As noted above, pursuant to EPA's Final 316(b) Rule, the permitting authority generally must establish site-specific entrainment requirements reflecting its determination of the "maximum reduction in entrainment warranted after consideration" of a number factors, including "[q]uantified and qualitative social benefits and costs of available entrainment technologies when such information on both benefits and costs is of sufficient rigor to make a decision."[31] 40 C.F.R. § 125.98(f)(2). Additionally, the regulations specify that the permitting authority "may reject an otherwise available technology as a BTA standard for entrainment if the social costs are not justified by the social benefits." *Id.* § 125.98(f)(4).

"Social costs" are defined in the new regulations as:

> costs estimated from the viewpoint of society, rather than individual stakeholders. Social cost represents the total burden imposed on the economy; it is the sum of all opportunity costs incurred associated with taking actions. These opportunity costs consist of the value lost to society of all the goods and services that will not be produced and consumed as a facility complies with permit requirements, and

[31] Because this particular permitting proceeding began prior to October 14, 2014, the Region is not *required* by the new rule to consider social costs in the BTA determination for entrainment for this permit. *See* 40 C.F.R. § 125.98(g) ("In the case of permitting proceedings begun prior to October 14, 2014 . . . [t]he [permitting authority's] BTA determination *may* be based on *some* or all of the factors in paragraphs (f)(2) and (3) of this section." (emphases added). The Region has nonetheless decided to consider social costs in its entrainment BTA determination for PNPS.

> society reallocates resources away from other production activities and towards minimizing adverse environmental impacts.

Id. § 125.92(y). This definition highlights that the permitting authority's evaluation analyzes the costs to society as a whole from the reductions in entrainment that would result from the installation of a particular entrainment technology, rather than costs and benefits that would accrue to limited parties. 79 Fed. Reg. at 48,370.

5.7.1. Methodology

For this BTA determination, EPA retained Abt Associates, Inc. (Abt), working under subcontract to Tetra Tech, Inc., to assist EPA in calculating the social costs of entrainment technologies. Abt developed a cost tool to estimate total social and private cost (the net present value of compliance over time) and the annualized social and private cost of compliance technology alternatives. The analysis of site-specific social costs using the cost tool for PNPS is consistent with the requirements for consideration of cost in the Final Rule. *See* 40 C.F.R. § 122.21(r)(10)(iii).

The preamble to the Final Rule describes a number of cost elements that should be accounted for in assessing the social cost of entrainment technologies, including: capital costs, installation downtime, energy penalty, annual operation and maintenance costs, and administrative expenses. *See* 79 Fed. Reg. at 48,370. Each of these costs is described briefly below and discussed in more detail as it applies to specific technologies in the following sections.

Capital cost. The costs for initial outlay including the capital costs for the technology and any downtime (or outage) associated with the installation of the technology.

Installation downtime: The cost that society must pay for alternative generating units to replace the electricity that would have otherwise been generated at PNPS during any downtime (*i.e*., outage) incurred for installation of the compliance technology. Downtime costs do not include costs associated with lost production if the installation period incorporates routine maintenance outages.

Energy penalty: The cost incurred due to the turbine efficiency loss associated with the conversion of once-through to closed-cycle cooling. At PNPS, which cannot increase fuel consumption to make up the loss, the energy penalty results in a reduction in the electricity generated. In the Final Rule, EPA considers the social cost of the energy penalty as the cost for another facility to generate electricity no longer available for consumption because of the energy penalty. At PNPS, another facility must compensate for the lost electricity at PNPS as a result of the energy penalty. EPA assumes the replacement electricity is supplied by the lowest production cost generating unit available to make up the lost generation at PNPS. *See Economic Analysis for the Final 316(b) Existing Facilities Rule* Appendix I: Energy Effects p. 3-5.

Annual operation and maintenance costs: Annual cost to operate and maintain the equipment, which includes the cost of replacing the output lost as a result of operating the cooling tower fans and additional pumps, or “auxiliary power requirement,” as this power is no longer available for consumption. Like the energy penalty, the social cost of the auxiliary power requirement is estimated as the cost incurred by society for another facility to generate the lost power.

Administrative expenses: Social cost of additional permitting or reporting expenses incurred by the facility and EPA.

The Final Rule directs EPA to “consider the costs from the perspective of society as a whole, rather than the costs accruing to limited parties (e.g., very local populations or the permittee, which presents a limited set of information to the Director). *See* 79 Fed. Reg. at 48,370. Social costs differ from private costs (*i.e.*, compliance costs incurred by the facility) in several key ways:

- The compliance costs used to estimate social costs are considered without accounting for any tax effects. Social costs are the full value of the resources used, whether they are paid for by PNPS or by all taxpayers in the form of lost tax revenue.
- The cost to society accounting for installation downtime, energy penalty, and auxiliary energy requirement is the increase in electricity production costs, including any increase in CO_2 emissions, from other generators needing to supply the electricity otherwise produced by PNPS. The lost generation at PNPS must be made up by another generating unit because PNPS, as a baseline nuclear facility, is unable to compensate for lost power generation by, for example, burning more fuel.

Costs are tallied over the expected life of the technology or the remaining life of the facility and presented both as net present value and annualized values using an appropriate social discount rate. For the analysis of social costs, EPA had to assume a capital outlay schedule for each of the available technologies. EPA assumed that installation of cooling towers, both for closed-cycle cooling or assisted recirculation, would begin in 2016 and would take four years, which is consistent with the assumption used to estimate social costs under the Final Rule. *See* Chapter 7 (Total Social Costs) in *Economic Analysis for Final 316(b) Existing Facilities Rule* (p. 7-2). EPA assumed that installation of variable frequency drives would begin in 2016 and take 12 months to install. The majority of the funds (87%) would be expended in the first 6 months of installation, based on the division of procurement costs compared to implementation costs provided by Entergy in the work scope for variable frequency drives (2008 Engineering Response Attachment 3, p.3). EPA also assumed that facilities would continue to incur O&M costs, auxiliary energy requirement, energy penalty, and administrative costs through one cycle of useful technology life (30 years for cooling towers and 15 years for variable frequency drives). In other words, after the initial capital outlay, EPA assumed annual social costs would be incurred through 2031 for variable frequency drives and 2050 for assisted recirculation and closed-cycle cooling.

EPA uses available indices to adjust values from the year in which the cost components are reported to a common dollar year (in $2015), and then to the year in which they are incurred: the McGraw Hill Construction Cost Index (CCI) (for technology costs), the Bureau of Labor Statistics Employment Cost Index (ECI) (for administrative costs), and the Gross Domestic Product (GDP) deflator index published by the U.S. Bureau of Economic Analysis (for general inflation). EPA used the *Annual Energy Outlook 2014* electricity price projections published by the Energy Information Administration (EIA) of the U.S. Department of Energy for construction outage and energy effects that are accounted for as reduced electricity sales.

EPA accounts for the fact that benefits and costs do not always take place in the same time period using an appropriate social discount rate. The Office of Management and Budget (OMB) regulatory analysis guidance Circular A-4 (OMB 2003) recommends discounting future impacts because benefits or costs that occur sooner are more valuable. The further in the future the costs or benefits are expected to occur, the more they should be discounted. OMB's basic guidance (OMB 2003 p. 33-34) indicates that real discount rates of 3 percent and 7 percent should be used in regulatory analysis. After developing the year-explicit schedule of total social costs and adjusting them for predicted real change to the year of their incurrence, EPA calculated the present value of these cost outlays as of the anticipated year that costs will first be incurred by discounting the cost in each year back to $2015 using both the 3 percent and 7 percent discount rates.

5.7.2. <u>Cost of Technology</u>

As described above, EPA used the cost tool developed by Abt Associates to estimate the social costs resulting from installing and operating each of the potentially available technologies (closed-cycle cooling, assisted recirculation, and variable frequency drives). Social costs include the capital cost, fixed and variable operation and maintenance (O&M) cost, auxiliary energy requirement, energy penalty, cost associated with installation downtime, and administrative cost to implement the BTA. In calculating social costs, administrative cost applies both to the permitting authority (in this case, EPA) and to the permittee. Table 6 presents the social costs for each of the potentially available technologies.

At annualized costs ranging from $229 million to $243 million (at a 7% and 3% discount rate, respectively), closed-cycle cooling with a cooling tower designed with a 12°F approach to wet bulb temperature is by far the most expensive option to minimize entrainment at PNPS. The energy penalty resulting from the loss in turbine efficiency due to converting from once-through to closed-cycle at PNPS causes the plant to shut down for some periods of the year in order to meet the administrative limits, which results in a severe loss of power output. Because generating units are dispatched in order of increasing production costs, and because PNPS is a nuclear baseload generator with relatively low production costs, the cost of regional replacement generation will be greater than PNPS.[32] A tower with an approach to wet bulb temperature of 9°F, or replacing the condenser with one sized more appropriately for the conversion, reduces the energy-related social costs, but still imposes substantial social costs of about $100 million per year. Although assisted recirculation imposes far lower energy-related social costs than closed-cycle cooling with the existing condenser, the relatively high cost of cooling towers results in annualized costs ranging from $35 million to $45 million (at a 3% and 7% discount rate, respectively). VFDs, at an annualized cost of less than $1 million, are far less expensive than the other available technologies because they impose a relatively low capital expense and have no energy-related social costs. EPA discusses the basis for the social cost estimates presented in Table 6 in the following sections.

[32] The cost tool estimates the cost of regional replacement generation as the non-baseload generation-weighted average of all non-baseload generating units with a fuel cost of production greater than or equal to PNPS.

Table 6. Present Value and Annualized Social Cost of Available Technologies for Entrainment Controls at PNPS with Energy Effects Valued as Cost of Regional Generation Increase (presented as $millions in 2015 dollars).

($millions)	Present Value at 3.0% Discount Rate					Present Value at 7.0% Discount Rate				
	CCC 12°F	**CCC 9°F**	**CCC New**	**AR**	**VFD**	**CCC 12°F**	**CCC 9°F**	**CCC New**	**AR**	**VFD**
Present Value										
Capital Outlay	$472.7	$472.7	$1,104.0	$459.8	$8.7	$451.2	$451.2	$1,043.9	$438.9	$8.7
Construction Outage Cost	$214.6	$214.6	$583.3	$0	$0	$214.6	$214.6	$583.3	$0	$0
Total Initial Cost	$687.3	$687.3	$1,687.3	$459.8	$8.7	$665.8	$665.8	$1,627.2	$438.9	$8.7
Annual O&M	$43.8	$43.8	$43.1	$45.7	$0	$21.5	$21.5	$20.4	$22.4	$0
Reg. Generation Increase	$4,029.4	$1,159.3	$253.2	$174.0	$0	$2,177.3	$626.4	$131.9	$94.0	$0
Totaled Annual Costs	$4,073.3	$1,203.1	$296.3	$219.7	$0	$2,198.9	$647.9	$152.3	$116.5	$0
Administrative Expenses	$0.17	$0.17	$0.17	$0.13	$0.16	$0.10	$0.10	$0.09	$0.07	$0.12
Present Value, Total Cost	$4,760.8	$1,890.6	$1,986.7	$679.7	$8.8	$2,864.8	$1,313.9	$1,779.6	$555.4	$8.8
Annual Equivalent Cost	$242.9	$96.5	$101.2	$34.7	$0.74	$229.0	$104.0	$136.8	$44.8	$0.97

CCC 12°F = Closed-cycle Cooling with Existing Condenser and 12°F Cooling Tower
CCC 9°F = Closed-cycle Cooling with Existing Condenser and 9°F Cooling Tower
CCC New = Closed-cycle Cooling with New Condenser
AR = Assisted Recirculation
VFD = Variable Frequency Drives
Useful life of technology: 30 years for cooling towers (CCC and AR) and 15 years for VFDs.
"Totaled Annual Costs" is the sum of costs incurred annually (e.g., maintenance, regional generation replacement costs) over life of the technology. "Annual Equivalent Cost" is the equivalent cost per year each year the technology is in operation. Depreciation period is 20 years for cooling towers and 15 years for VFDs. Analysis assumes PNPS would renew its operating license with the NRC and continue operation after its current license expires in 2032.

Capital Outlay (Including Installation Downtime)

EPA used capital costs provided by Entergy for assisted recirculation and variable frequency drives (Enercon 2008, Attachment 1 p. 16 and Attachment 3, p.3). Using the cost calculator, EPA estimated that the capital cost (in $2015) for assisted recirculation ranges from $438.9 to $459.8 million (at a social discount rate of 7% and 3%, respectively) and the capital cost for conversion of the two circulating water pumps with VFDs is approximately $8.7 million. EPA assumed that the final installation for both technologies could be achieved during the scheduled, 3-week refueling outage and therefore neither compliance technology would incur costs associated with installation downtime.

Entergy did not provide any cost estimate for closed-cycle cooling, either using the existing condenser or with replacement of the main condenser, because Entergy concluded that closed-cycle cooling was not technically feasible at PNPS. Therefore, EPA estimated capital costs for closed-cycle cooling at PNPS using cost estimates provided by Enercon (2010) for the conversion to closed-cycle cooling of Unit 2 at Indian Point Energy Center (IPEC), which is a large nuclear facility owned by Entergy on the Hudson River. For this facility, Enercon estimated the costs of a nuclear retrofit using a round hybrid cooling tower with fairly substantial site preparation and modification requirements. Enercon also estimated the cost of the conversion of IPEC Unit 3, but EPA chose to use the IPEC Unit 2 costs as a proxy for closed-cycle cooling at PNPS, because the estimate for Unit 3 included additional costs to relocate a natural gas pipeline that are not relevant to PNPS. EPA then scaled the costs from IPEC Unit 2 (1078 MW) to PNPS (670 MW) using the ratio of capacity factor to estimate capital costs for PNPS with the existing condenser. This capital cost was used to for both the analysis of a 12°F tower and a 9°F tower, although EPA notes that it is likely a 9°F tower, being larger than a 12°F tower, would be more expensive. For this reason, the social costs for the 9°F tower may be underestimated to some degree.

To estimate the capital cost of closed-cycle cooling with a new condenser, EPA started with cost estimates provided in EPRI 2011 for substantial condenser modifications associated with a closed-cycle cooling retrofit at a nuclear facility located in an estuary. EPA then doubled the cost estimate for this modification to approximate the cost of a new condenser at PNPS and added it to the capital costs described above from IPEC Unit 2.

EPA estimated that closed-cycle cooling would take 4 years to install using the existing condenser and 5 years if the main condenser were replaced. The installation downtime for the existing condenser was assumed to be 10 months (40 weeks) minus the regular 3 week refueling outage. EPA assumed a conservative estimate of 24 months (104 weeks) of downtime (minus one 3-week refueling outage) to replace the main condenser, considering that the turbine building would have to be taken offline and likely dismantled and rebuilt. Installation downtime requires a one-time, temporary shutdown for the facility that will impose both private costs (through loss of revenue from electricity sales) and social costs (for replacing electricity not generated at PNPS at another generating unit). In the Final Rule, EPA estimates the social cost of installation downtime as the increase in energy production costs from using alternative generating units to supply electricity compared to the cost that would have been incurred if regulated units remained in service, *not* the loss in net income to PNPS. *See Economic Analysis for the Final 316(b) Existing Facilities Rule* Appendix I: Energy Effects p. 9-11. Production costs for electricity generation at nuclear facilities are relatively low; therefore, replacing the lost generation at PNPS from alternative units would likely result in an increase in energy production costs.

EPA acknowledges that these estimates are not site-specific and are only an approximation of the costs that may be required for the conversion of PNPS to a closed-cycle cooling system. Still, these capital costs are based on real estimates for conversions of nuclear power facilities to closed-cycle cooling and the cost elements (*e.g.*, round hybrid cooling tower, design and engineering costs) are comparable to the costs provided by Entergy for assisted recirculation. Using the cost calculator, EPA estimated that the capital cost, including installation downtime costs, for cooling towers at PNPS (in $2015) could range from a low of about $666 million for a retrofit using the existing equipment to nearly $1.7 billion for optimizing the cooling towers by replacing the main condenser.

Energy-Related Costs

Closed-cycle cooling systems use an evaporative process to cool water exiting the condenser. This heat is discharged to the atmosphere, and the cooled water recirculated back to the condenser. Converting a cooling system from once-through to closed-cycle reduces the turbine efficiency compared to once-through cooling, which reduces the amount of power a plant can generate using the same amount of fuel. At a nuclear facility like PNPS, which cannot compensate for this loss by burning more fuel, the loss of output must be replaced by another generating unit in that region. EPA assesses this reduction in plant efficiency as an “energy penalty.” *See, e.g.*, 79 Fed. Reg. at 48,333 and *Economic Analysis for the Final 316(b) Existing Facilities Rule*, Appendix I: Energy Effects. Depending on the loss of efficiency, the energy penalty can result in substantial additional costs to the facility (in loss of electrical sales as a result of the reduction in power output) and social costs (in this case, assessed as the additional cost to replace this power by an alternative regional generator). The cost of generating the replacement electricity is assumed to be supplied by the lowest production cost generating unit available to make up the lost generation at PNPS. *See Economic Analysis for the Final 316(b) Existing Facilities Rule* Appendix I: Energy Effects pp. 3-5 and 9-11. Production costs for electricity generation at nuclear facilities are relatively low; therefore, replacing the lost generation at PNPS from alternative units would likely result in an increase in energy production costs.

In this analysis, only closed-cycle cooling with the existing condenser has an energy penalty (lost output due to loss of thermal efficiency). Neither assisted recirculation nor variable frequency drives results in a loss of thermal efficiency because PNPS can shift towards using more once-through cooling water from Cape Cod Bay when necessary.

Closed-cycle cooling with a new condenser can be optimized to eliminate impacts from thermal efficiency loss.

EPA used the cost tool to estimate the social costs (in terms of the cost of replacing that power using an alternative generating unit in the region) of the energy penalty for closed-cycle cooling using Entergy's estimates of the average daily reduction in power output per month for a cooling tower with a 12°F and 9°F approach to wet bulb temperature. Using Entergy's estimates of average daily lost power output (in MWe), EPA estimated the lost generation as a result of converting to closed-cycle cooling without re-optimizing the main condenser. Safe operation of the reactor requires that PNPS maintain thermal power at levels greater than 80%. For the 12°F tower, EPA assumed that the plant would operate at less than 80% power and have to shutdown (*i.e.*, loss of 670 MW) when estimated power output losses would be greater than 240 MWe, which occurs every day during the months of June through September. The frequent need to shut down the plant results in an energy penalty of 49%, an annual cost which, summed over the 30-year life of the cooling towers, results in an estimated total social cost (including cost to replace the electricity in the region) ranging from $2 billion (at 7% discount rate) to $4 billion (at 3% discount rate). For a 9°F tower, the average daily output losses are lower and the plant would likely shutdown for only 25 days per year, which EPA assumed would occur in July. This penalty reduces output by almost 12% and results in a total social cost of about $648 million (at 7% discount rate) to about $1.2 billion (at 3% discount rate) over the life of the technology (30 years).

In its 2008 Engineering Response, Entergy provided an estimate of the auxiliary power requirements (or "parasitic loss") from operating the cooling tower (Attachment 2 Table 3, p. 13). Entergy estimated that the electricity required to operate the fans and pumps associated with cooling towers would result in a continuous parasitic loss of 20 megawatts of electric power (MWe). Using these values to estimate the annual cost associated with the auxiliary power requirement for closed-cycle cooling results in a loss of about 3% of total plant generation. For the existing condenser, the social cost for replacement of the generation lost to the auxiliary energy requirement is combined with the thermal energy penalty costs presented in Table 6 as regional generation increase (ranging from $626 million over the life of the technology for a 9°F tower at 7% discount rate to $4 billion for a 12°F tower at a 3% discount rate). The social cost of regional generation increase with a new main condenser is limited to the auxiliary energy requirement ($132 million to $253 million over the life of the technology at 7% and 3% discount rate, respectively).

Entergy's 2008 Engineering Report included an estimate of the average parasitic loss with assisted recirculation (Enercon 2008 Attachment 2 p. 13). The energy requirements for assisted recirculation, which average about 13.6 MWe, are less than the requirements for closed-cycle cooling because when recirculating flows are reduced (*i.e.*, when ambient temperatures require that PNPS rely more on Cape Cod Bay water), the towers require less electricity to operate. Using these values to estimate the annual cost associated with the auxiliary power requirement for assisted recirculation results in a loss of about 2% of total plant generation. Because assisted recirculation has no energy penalty, the social cost for regional generation increase is solely due to the replacement of this output from another generator over the life of the cooling tower, which ranges from about $94 million (at 7% discount rate) to $174 million (at 3% discount rate). Variable frequency drives require no additional electricity to operation and therefore impose no auxiliary energy requirements; in fact, VFDs require are slightly more efficient that the existing single speed pumps and would result in a minor cost savings for PNPS.

Annual Operation and Maintenance

Mechanical draft cooling towers require annual maintenance to ensure optimal operation, which imposes an annual cost primarily as labor and materials. In addition, mechanical draft cooling towers require energy to run the recirculating pumps and evaporative fans, which imparts an annual cost for this electricity, which would otherwise have been available for consumption. *See* 79 Fed. Reg. at 48,386. Estimating the cost of this auxiliary energy requirement follows the same procedures as those outlined above for the energy penalty. In other words, the loss of generation resulting from the electricity requirement for cooling towers at PNPS would impart a social cost to replace that power at another generating unit.

Entergy's 2008 Engineering Report included an estimate of the annual operation and maintenance requirements for cooling towers for the assisted recirculation technology option (Enercon 2008 Attachment 2 p 14-15), which EPA used to estimate annual costs for operating cooling towers with both closed-cycle cooling and assisted recirculation. Entergy projected that cooling towers would impose an annual operational cost of $211,000 ($2007). Entergy estimates that the maintenance costs are likely to vary over a 30 year period and include the costs ($2007) for replacement of components (e.g., pump impellers, motors, or entire assemblies): $632,000 per year for the first 5 years, $1,083,000 per year for years 6 to 15, and $1,978,000 per year for years 16 to 30. Variable frequency drives have no annual operation and maintenance requirements beyond the expenditures for the existing CWIS and related system.

Administrative Expenses

Administrative costs include the initial permitting costs for the facility and the permitting authority as well as annual costs for compliance monitoring and recordkeeping. In this case, EPA assumed no costs for initial permitting, since this determination is based on information already submitted to EPA by the permittee during development of the draft permit. EPA assumed annual compliance monitoring consistent with the compliance alternatives analyzed and recordkeeping costs for the permittee and the permitting authority.

5.7.3. <u>Sensitivity Analysis</u>

The costs presented in Table 6 and discussed above are EPA's best estimate of the actual cost of the compliance technologies based on the best available information. Nonetheless, EPA acknowledges that these costs are estimated and rely on a number of assumptions regarding the construction schedule, installation downtime, capital costs, and associated costs for replacement energy and carbon emissions. However, in order to determine how uncertainty over any one of the assumptions in the input data affect the total social cost, EPA conducted a sensitivity analysis by varying each assumption individually and recalculating the social costs. This analysis enables EPA to assess the robustness of the results to changes in the input data.

The results of the analysis indicate that Entergy's estimated capital cost for cooling towers for assisted recirculation is relatively high compared to other estimates and that the social costs based on Entergy's assisted recirculation estimate may be overestimated by about 15%. However, EPA assumed that assisted recirculation could be tied in during a scheduled maintenance outage with no additional outage period. A construction outage of up to 6 months would increase the total and annualized cost of assisted recirculation by about 15% to 20% due to the costs associated with a prolonged outage.

For closed-cycle cooling, again, EPA's estimated capital costs were as much as 23 to 50% higher than other retrofit estimates, including estimated costs for other nuclear facilities. However, because the total social costs for retrofitting closed-cycle cooling with the existing condenser are dominated by energy penalty (i.e., cost of replacement generation and social cost of carbon) associated with the loss of efficiency, adjusting the capital costs only resulted in an increase in total social cost of 2% to 8%.

EPA assessed the total social costs of closed-cycle cooling over a range of energy effects, from a minimum of 2.5% of output to a maximum of 60% of output. Even at a penalty of 10% of output, which, based on the PEPSE analysis and current administrative limits would likely be a conservative penalty for PNPS, the total social cost of closed-cycle cooling would exceed $1 billion dollars.

Of the technologies considered in this determination, VFDs impose the lowest private and social costs. Enercon estimated the total capital cost for conversion of the two circulating water pumps with VFDs to be approximately $7 million (2008 dollars). There are no additional operating and maintenance costs associated with VFDs compared to the existing pumps. Entergy proposed achieving greater flow reductions (up to 42%) with a 20% active power loss, which would inflict social costs associated with the loss of output at PNPS. EPA has not considered this proposed option in its analysis, however, because flow reductions greater than 9% cannot be achieved, regardless of active power losses, without exceeding the current temperature limits.

5.7.1. Summary

As shown in Table 6 and discussed above, the social cost of VFDs is minimal and primarily consists of capital outlay for the purchase of pumps and associated equipment. On the other hand, the social cost of closed-cycle cooling is substantial and includes not only significant capital outlay to construct cooling towers, but imposes high social costs associated with the cost of replacing the lost output at PNPS with production from another generating unit in the region. The social cost for assisted recirculation falls between these two available technologies; the capital cost for assisted recirculation is considerably greater than for VFDs, but the energy-related costs are much lower than with closed-cycle cooling.

The total social cost of cooling towers using the assisted recirculation compliance option ranges from about $555 million (annualized to $44.8 million per year) at a 7% discount rate to $680 million (annualized to $34.7 million per year) at a 3% discount rate. These costs are substantially less expensive than any of the closed-cycle cooling options. Replacing the main condenser or converting to closed-cycle cooling using the existing condenser and a 9°F cooling tower is almost 3 times more expensive than assisted recirculation. Converting to closed-cycle cooling using the existing condenser and a 12°F cooling tower is about 5 to 7 times more expensive (at 7% and 3% discount rate, respectively) than assisted recirculation. The annualized cost for the incremental gain (per percentage increase in entrainment reduction) from assisted recirculation (at 54% annual reduction) versus closed-cycle cooling (at 91% annual reduction) ranges from about $1.7 million per percent reduction between assisted recirculation and closed-cycle cooling with new condenser or 9°F cooling tower to $5.6 million per percent reduction in entrainment between assisted recirculation and closed-cycle cooling with a 12°F tower. The additional benefit associated with reducing entrainment by 91% compared to 54% would have to be considerable to justify the additional expenditure of $62 million to $208 million per year for closed-cycle cooling over assisted recirculation. In Section 6.0, EPA considers the social costs of the available technologies in relation to the estimated benefits as one of the factors in determining the site-specific entrainment requirements for PNPS.

6.0 Consideration of Factors for Site-Specific Entrainment Requirements

As described above in the discussion of EPA's approach to this re-issuance under the Final Rule (Section 2.0), EPA is making a BTA determination based on the information submitted to date, which it has determined is sufficient for such a determination pursuant to 40 C.F.R. § 125.98(g). Also described in Section 2.0, under the ongoing permit proceedings provision of the Final Rule, the BTA determination "may be based on some or all of the factors" in § 125.98(f)(2). Having said that, EPA's analysis is necessarily informed by the Final Rule, which is currently in effect at the time of this writing, and EPA intends that its determination is consistent with the requirements of the rule, including consideration of the factors listed at § 125.98(f)(2): (i) the numbers and types of organisms entrained; (ii) impact of changes in particulate emissions or other pollutants associated with entrainment technologies; (iii) land availability; (iv) remaining useful plant life; and (v) quantified and qualitative social benefits and costs of available technologies when such information is of sufficient rigor to make a decision and § 125.98(f)(3): (i) entrainment impacts on the waterbody; (ii) thermal discharge impacts; (iii) credit for reductions in flow associated with the retirement of units occurring within the ten years preceding October 14, 2014 (the effective date of the rule); (iv) impacts on the reliability of energy delivery within the immediate area; (v) impacts on water consumption; and (vi) availability of process water, gray water, waste water, reclaimed water, or other waters of appropriate quantity and quality for reuse as cooling water.

In Section 5.0, EPA presented its assessment of Entergy's evaluation of available technologies to reduce entrainment at PNPS, and concluded that closed-cycle cooling, assisted recirculation, and VFDs are potentially available as the BTA for entrainment. In this section, EPA presents its analysis of factors in § 125.98(f) as listed above that could affect determination of the BTA for entrainment in the absence of Entergy's decision to close the plant. EPA also explains both its determination of the maximum reduction in entrainment warranted after consideration of these factors and, in compliance with § 125.98(f)(1), its rejection of any entrainment control technologies or measures that perform better than the selected technologies or measures. Finally, Section 7.0 summarizes the permit conditions related to the BTA in the Draft Permit and presents EPA's determination for impingement mortality under § 125.98(g) that is consistent with the BTA standards for impingement mortality at § 125.94(c).

6.1. Consideration of § 125.98(f)(2) factors for site-specific entrainment controls

Cooling towers, either in a closed-cycle cooling system or for assisted recirculation, and variable frequency drives are potentially available as the BTA for entrainment at PNPS. In the discussion above, EPA established that an alternative source of cooling water is unavailable and the potential for increased thermal impacts limit the use of VFDs for reducing entrainment. EPA turns now to the factors listed at 40 C.F.R. § 125.98(f)(2) to be considered in a site-specific BTA determination for entrainment under the Final Rule, including the numbers and types of organisms entrained, change in particulate and other air emissions, land availability, and remaining useful plant life. The social costs and benefits of available technologies are discussed in Section 6.3, below. The regulations provide that "the weight given to each [of the above] factor is within the [permitting authority's] discretion based upon the circumstances of each facility." 40 C.F.R. 125.98(f)(2).

6.1.1. Remaining Useful Plant Life

In the *Technical Development Document for the Final 316(b) Rule*, EPA states "[m]aking major structural and operational changes (such as retrofitting to closed-cycle cooling) to a facility may not be an appropriate response for a facility or unit that will not be operating in the near future" (Chapter 6: Technologies and Control Measures p.12). In other words, retrofitting with a sophisticated and potentially expensive technology to reduce entrainment at a plant that is nearing the end of its useful life may not result in sufficient benefits to warrant the cost of the technology. In the preamble to the Final Rule, EPA states, for example, "retrofitting to a closed-cycle cooling system at a facility that is scheduled to close in three years will result in little entrainment reduction as compared to retrofitting at a facility that will continue to operate for a significantly longer period." 79 Fed. Reg. at 48,342. For this reason, the Final Rule requires that remaining useful plant life be considered when determining the site-specific entrainment requirements. *See* 40 C.F.R. § 125.98(f)(2)(iv).

As part of the permit application requirements under the Final Rule, a facility must submit a description of the operational status of each unit for which a CWIS provides water for cooling, including, among other things, a description of plans or schedules for decommissioning or replacement of units. 40 C.F.R. § 122.21(r)(8). According to the preamble to the Final Rule, "where the remaining plant life is considerably shorter than the useful life of the technology or where a facility has a planned retirement within the next permit cycle, this information is useful to support a determination regarding that specific entrainment technology." 79 Fed. Reg. at 48,366. During the later stages of EPA's development of a Draft Permit for PNPS, Entergy announced its intention to close PNPS no later than June 1, 2019. *See* Press Release, Entergy, Entergy to Close Pilgrim Nuclear Power Station in Massachusetts No Later than June 1, 2019 (Oct. 13, 2015). Entergy cites poor market conditions, reduced revenues, and increased operational costs as factors in its decision to close the plant. *Id.* Further, Entergy indicates that the exact timing of the shutdown, which may be sooner than June 1, 2019, will be decided during the first half of 2016. *Id.* ISO New England Inc. (ISO-NE) reviewed Entergy's Non-Price Retirement request pursuant to ISO-NE Planning Procedure No. 10 (Planning Procedure to Support the Forward Capacity Market) and determined there is not a local reliability need for this resource, and accordingly the NPR request has been accepted. *See* December 18, 2015 letter from Stephen J. Rourke (ISO NE system Planning) to Marc Potkin (Entergy Nuclear Power Marketing).

PNPS has indicated that it will effectively eliminate seawater withdrawals for the main condenser by June 1, 2019, which falls within the next permit cycle. This cooling water volume comprises 96% (311,000 gpm) of the once-through cooling water at the plant while the remaining 4% (13,500 gpm) is used for cooling water for the safety-related equipment, including shut-down systems. After terminating generation of electricity, a safety-related cooling water will continue to be withdrawn, in addition to a limited volume of seawater to support other decommissioning activities. Entergy anticipates operating no more than four SSW pumps at any time plus limited use of a single circulating water pump not to exceed 5% of the time on a monthly basis. Based on use of the SSW pumps and limited use of the circulating water pump for seawater intake following shutdown, PNPS will reduce intake flows by about 96% on an average monthly basis.

In the evaluation of the potential BTA options, EPA concluded that variable frequency drives (VFDs) and cooling towers (either as a closed-cycle system or used to cool and recirculate cooling water in a flexible, assisted recirculation system) are available as the BTA for entrainment. However, based on the available information submitted by Entergy, cooling towers are likely to take a minimum of 4 years to construct. In other words, if constructed, cooling towers would not be operational before the plant would otherwise already decrease its cooling water withdrawals by approximately 96%, which is an even greater reduction than would be achieved through the use of cooling towers. Thus, no reduction in entrainment would be realized with either closed-cycle cooling or assisted recirculation before the plant shuts down. For this reason, EPA considers that neither closed-cycle cooling nor assisted recirculation are available as the BTA within the remaining useful life of the plant. Because neither technology would be operational before the scheduled closure, EPA does not consider them further in this determination. EPA determined that VFDs, however, could be installed and operational within one year from the effective date of the permit and are an otherwise available technology that could achieve entrainment reductions prior to shutdown of the plant in 2019.

6.1.2. Numbers and Types of Organisms Entrained, Land Availability, and Increased Air Emissions

EPA presented a detailed analysis of the numbers of organisms lost to entrainment at PNPS in Section 3.1 and examined the potential impacts of entrainment on the waterbody in Section 3.3. EPA established that PNPS entrains billions of eggs and larvae each year, and that the adverse environmental impacts of the existing CWIS have resulted in the mortality of millions of juvenile, adult, and adult equivalent fish. EPA concluded that the number of eggs and larvae entrained, and the estimated numbers of equivalent age-1 adult fish lost as a result of this entrainment, constitutes an adverse environmental impact from PNPS's CWIS.

The use of VFDs to reduce flow at PNPS would require a modification to the existing single-speed circulating water pumps, but would not result in the use of any additional land area. Nor would the use of VFDs result in increased air emissions, but may actually result in decreased air emissions by a very minor amount, since, at times, VFDs would require less power to operate.

6.2. Consideration of § 125.98(f)(3) factors for site-specific entrainment controls

In determining site-specific entrainment requirements for a facility, the Final Rule allows that the permitting authority *may* consider several factors specified in 40 C.F.R. § 125.98(f)(3), including flow reduction credits, impacts on water consumption, alternative sources of cooling water, energy reliability, impacts on thermal discharges, and entrainment impacts on the waterbody. EPA is not bound by the regulations to consider these factors, either under the requirements for entrainment BTA determinations at § 125.98(f) or by the ongoing permit proceeding provision at § 125.98(g), but, to the extent that any of these factors affect the availability of VFDs, EPA considers them here.

Entergy evaluated the use of treated recycled water (*e.g.*, grey water) to augment the use of seawater in the plants cooling systems. If all of the wastewater generated in the Plymouth County area (7 municipal wastewater treatment plants) were routed to PNPS, it could supplant only 7.8% of the cooling water flow needed by the Station for condenser cooling and may require up to 166 miles of pipeline (Enercon 2008, p. 55). EPA agrees with Entergy that "[d]ue to the limited sources of grey water in the vicinity of PNPS, grey water is not considered a technologically feasible means of significantly reducing impingement mortality and entrainment" (*Id*., p. 55).

The use of VFDs to reduce entrainment at PNPS could potentially increase thermal impacts through the discharge of warmer water. In fact, Entergy has demonstrated that substantial reductions in entrainment could not be achieved without exceeding the current maximum temperature and rise in temperature limits and concluded that further analysis would be required to assess the potential effects of increased discharge temperatures on the balanced, indigenous population (BIP) (Enercon 2008 and 2014). Attachments B and C to the Fact Sheet provide the Agencies' analysis of Entergy's initial 1316(a) variance request which is consistent with the current permit limits. The analysis determined that the requested limits remain protective of the BIP in Cape Cod Bay. Entergy has neither requested nor have the Agencies' considered the impacts of a higher thermal variance on the BIP. Further, it is unlikely that a study of the potential impacts of increasing the temperature limits, followed by installation of VFDs, could be completed before PNPS is scheduled to shutdown, after which the facility will achieve a 96% reduction in flow. Without fully exploring the trade-off between a higher thermal variance in exchange for a reduction in entrainment, EPA is not inclined to authorize higher thermal discharge limits at PNPS, which limits the maximum entrainment reduction from VFDs to 9%.

6.3. Analysis of Social Costs and Benefits of VFDs

As noted above, pursuant to EPA's Final Rule, the permitting authority must establish site-specific entrainment requirements reflecting its determination of the "maximum reduction in entrainment warranted after consideration" of a number factors, including "[q]uantified and qualitative social benefits and costs of available entrainment technologies when such information on both benefits and costs is of sufficient rigor to make a decision." 40 C.F.R. § 125.98(f)(2). Additionally, the regulations specify that the permitting authority "may reject an otherwise available technology as a BTA standard for entrainment if the social costs are not justified by the social benefits." *Id.* § 125.98(f)(4). Based on the evaluation of technologies and factors described above, EPA has concluded that VFDs are the only available technology that could be installed and deliver any reduction in entrainment within the limited remaining useful life of the plant. Therefore, EPA provides only an evaluation of whether the social costs of VFDs are justified by the social benefits. Had Entergy not made the decision to close PNPS within this permit cycle, EPA may have considered the costs and benefits for other available technologies, including closed-cycle cooling and assisted recirculation.

EPA's analysis of the social costs of VFDs was presented in Section 5.7, above. In this section, EPA highlights the qualitative and quantitative benefits of VFDs, and considers the benefits that would accrue over the remaining life of the plant (*i.e.*, through June 2019) relative to the expenditure for installation and operation of the technology. As discussed above, the Final Rule at 40 C.F.R. § 125.98(f)(2)(v) directs the permitting authority to consider the quantified and qualitative social benefits and costs of available entrainment technologies in establishing site-specific entrainment requirements for BTA.

6.3.1. Social Benefits

The Final Rule defines "social benefits" as:

> the increase in social welfare that results from taking an action. Social benefits include private benefits and those benefits not taken into consideration by private decision makers in the actions they choose to take, including effects occurring in the future. Benefits valuation involves measuring the physical and biological effects on the environment from the actions taken. Benefits are generally treated one or more of three ways: A narrative containing a qualitative discussion of environmental effects, a quantified analysis expressed in physical or biological units, and a monetized benefits analysis in which dollar values are applied to quantified physical or biological units. The dollar values in a social benefits analysis are based on the principle of willingness-to-pay (WTP), which captures monetary benefits by measuring what individuals are willing to forgo in order to enjoy a particular benefit. Willingness-to-pay for nonuse values can be measured using benefits transfer or a stated preference survey.

40 C.F.R. § 125.92(x). This definition highlights that the analysis is focused on the benefits to society as a whole from the reductions in entrainment that would result from the installation of a particular entrainment technology, rather than costs and benefits that would accrue to limited parties. *See* 79 Fed. Reg. at 48,370. In this analysis, EPA focuses on the first two types of benefits valuation described in the definition of social benefits above: a narrative containing a qualitative discussion of environmental effects and a quantified analysis expressed in physical or biological units (in this case, number of organisms saved).

The *Benefits Analysis for the Final 316(b) Existing Facilities Rule* (Chapter 4: Economic Benefits Categories) (EPA 2014) provides a detailed explanation of the types of benefits that can result from reductions in entrainment and impingement mortality. The predominant benefits include market (*e.g.*, the price, quantity, and/or quality of commercial fish harvest), non-market (*e.g.*, higher catch rates for recreational fishing), and non-use benefits. Both market and non-market benefits may be direct (*e.g.*, increased commercial or recreational landings), or indirect (*e.g.*, improvements resulting as an indirect consequence of fishery or habitat improvements, such as increase in bait and tackle sales). Non-use benefits accrue where individuals value improved environmental quality without any past, present, or anticipated future use of the resource in question. Individuals may gain value from knowing that a particular resource is protected (i.e., existence value) or from knowing that the resource is available for future generations (i.e., bequest value). Non-use benefits may include population resilience and support, nutrient cycling, natural species assemblages, and ecosystem health and integrity. Nonuse values include improving the survival probability of a threatened or endangered species. Monetizing non-use benefits (i.e., assigning a dollar value to quantified physical or biological units) is particularly difficult for several reasons. *See* 79 Fed. Reg. at 48,371. First, non-use values are not associated with easily observable behavior. Second, these values may be held by both users and non-users of a resource, which may have different familiarity with the services provided by the resource and therefore, may value the resource differently. Third, methods to estimate non-use benefits are often time- and resource-intensive and may be subject to certain biases. Finally, efforts to disaggregate total value into use and non-use components can be difficult. That being said, recent economic literature provides substantial support for the hypothesis that economic value of non-use benefits are greater than zero (*e.g.*, Freeman et al. 2003, Turner et al. 2003, Zhao et al. 2013). When a substantial fraction of the population holds even small per capita nonuse values, these values can be very large in the aggregate. Both EPA's *Guidelines for Preparing Economic Analyses* (EPA 2010) and the Office of Management and Budget's (OMB) Circular A-4 governing regulatory analysis (OMB 2003) support the need to assess non-use values. Excluding non-use values from consideration is likely to understate substantially total social value.

Generally accepted techniques for estimating non-use values include stated preference methods or benefit transfer analysis based on stated preference studies (OMB 2003, EPA 2010, EPA 2014). Stated preference methods rely on carefully designed surveys to estimate a household's willingness to pay (WTP) for ecological improvements from which values are estimated by statistical analysis of survey responses. EPA developed an original stated preference survey to assess public values for reductions in impingement mortality and entrainment for the Final Rule. *See* Chapter 11 in *Benefits Analysis for the Final 316(b) Rule for Existing Facilities*. EPA did not rely on the results of that study for estimating the benefits of the Final Rule. *See* 79 Fed. Reg. at 48,407-09. For this site-specific BTA determination, developing and implementing a stated preference survey to elicit total use and non-use value resulting from compliance is not practical.

Benefits transfer involves adapting research (*e.g.*, data on stated preference) conducted for another purpose to address policy questions at hand. Boyle and Bergstrom (1992) define benefit transfer as "the transfer of existing estimates of nonmarket values to a new study which is different from the study for which the values were originally estimated." For the Final Rule, EPA used a benefit transfer approach to estimate recreational angling benefits and non-use benefits based on revealed and stated preference data in the North Atlantic and Mid-Atlantic Regions. See 79 Fed. Reg. at 48,405, 4840708, and *Benefits Analysis for the Final 316(b) Rule for Existing Facilities* Chapter 8: Nonuse Benefit Transfer Approach. For the North Atlantic, EPA used a Bio-indicator based Stated Preference Valuation (BSPV) method which addressed Rhode Island residents' preferences for the restoration of migratory fish passage over dams in the Pawtuxet watershed (Johnston et al. 2012, Zhao et al. 2013).

EPA has not endeavored to produce a monetized estimate of benefits – such as by undertaking a stated preference study to estimate non-use benefits – because EPA decided that doing so would be prohibitively difficult, time-consuming and expensive for this permit. Although estimating the commercial use value of fish that would be saved by a particular option can be fairly straightforward, commercial use values are not expected to be significant in this case. Recreational use values are likely to be more significant in this case, but estimating such values can be complex, costly and time-consuming. Moreover, the largest component of the total benefit of saving fish in this case, is likely to be found in the ecological benefits and non-use values arising from saving those organisms. Yet, attempting to develop a monetized estimate of such ecological and non-use values is even more challenging than addressing recreational use values. In both cases, specialized expertise in natural resource economics and modeling is not readily accessible on a permit-by-permit basis. It could take years to develop this type of complete monetized benefits estimate and it could cost hundreds of thousands of dollars in contractor support. EPA currently does not have such resources to apply to this permit. In any event, EPA concluded that the available information is adequate for assessing the available technology in this case. At the same time, EPA recognizes the importance of considering benefits that have not been quantified, but are potentially significant, and also recognizes that where relevant benefits have not been quantified, it is appropriate to consider them qualitatively. *See, e.g., EPA Guidelines for Preparing Economic Analyses* (EPA 2000a). A complete analysis of ecological benefits should attempt to consider, if not monetize, the non-use values. As EPA states on p. 23 of the *Framework for Assessment of Ecological Benefits* (2000):

> Many ecological services are not provided through markets or are not readily associated with market transactions. As a result, it may be more difficult or impossible to provide a dependable monetized measure of the benefits associated with many ecological changes. For those benefits that are not monetized, a qualitative, and when possible, quantitative, assessment of the economic value of the changes provides a measure of the service's importance and the degree of change, even when a dollar value cannot be assigned to that change.

The preamble to the Final 316(b) Rule specifically directs the permitting authority to consider non-quantified benefits:

> In evaluating benefits, the Director should not ignore benefits that cannot be monetized or quantified or consider only the impingement and entrainment reductions that can be counted. To result in appropriate decisions from society's standpoint, the assessment of benefits must take into account all benefits, including categories such as recreational, commercial, and other use benefits, benefits associated with reduced thermal discharges; reduced losses to threatened and endangered species; altered food webs; benefits accruing non-locally due to migration of fish; nutrient cycling effects; and other nonuse benefits…Merely because it is difficult to put a price tag on those benefits does not mean that they are not valuable and should not be included at least qualitatively in any assessment.

79 Fed. Reg. at 48,351. Elsewhere, the preamble states, "[a]bsent the availability of stated preference surveys, non-use values should be evaluated quantitatively and/or qualitatively." 79 Fed. Reg. at 48,371. Similarly, Circular A-4, OMB's guidance on cost-benefit analysis, states "[a] complete regulatory analysis includes a discussion of non-quantified as well as quantified benefits and costs. A non-quantified outcome is a benefit

or cost that has not been quantified or monetized in the analysis. Where there are important non-monetary values at stake, you should also identify them in your analysis so policymakers can compare them with the monetary benefits and costs" (OMB 2003 p. 3).

Therefore, in this case, EPA has qualitatively considered the value of the Cape Cod Bay ecosystem and the organisms that occupy it and the quantitative benefits (measured as number of organisms saved) that may result from the implementation of VFDs at PNPS's CWIS. As part of a qualitative evaluation, EPA seeks to compare the cost of VFDs with "the magnitude of the estimated environmental gains (including the attainment of the objectives of the Act and § 316(b))." *In re Central Hudson Gas and Electric Corp.*, EPA Decision of the General Counsel, NPDES Permits, No. 63, at p. 381 (July 29, 1977). The relevant "objectives of the Act and § 316(b)" include minimizing adverse environmental impacts from cooling water intake structures, restoring and maintaining the physical and biological integrity of the Nation's waters, and achieving, wherever attainable, water quality providing for the protection and propagation of fish, shellfish and wildlife, and providing for recreation, in and on the water. 33 U.S.C. §§ 1251(a)(1) and (2), 1326(b).

6.3.2. Benefits Valuation

As presented in detail above, EPA has concluded that the CWIS at PNPS has caused adverse environmental impacts from impingement and entrainment of fish and shellfish. These adverse impacts include the loss of billions of individual organisms and millions of adult fish, including vast numbers of several commercially and recreationally important species, forage species critical to the biological community in Cape Cod Bay, and several species that have experienced significant population declines in recent decades. EPA believes that these losses have contributed to adverse effects in Cape Cod Bay and may be partly inhibiting or preventing the recovery of several fish stocks.

Massachusetts has classified Cape Cod Bay as a Class SA water, 314 CMR 4.06 Figure X, which is the most protective classification provided for coastal and marine waters in the state's Water Quality Standards. *See* 314 CMR 4.05(4). As such, SA waters are to provide "excellent habitat" for fish and other aquatic life and wildlife as a designated use. 314 C.M.R. 4.05(4)(a). The water quality standards also specify that, "in the case of a cooling water intake structure (CWIS) regulated by EPA under 33 U.S.C. § 1251 (FWPCA § 316(b)), the Department has the authority under 33 U.S.C. § 1251 (FWPCA § 410), M.G.L. c. 21, §§ 26 through 53 and 314 CMR 3.00 to condition the CWIS to assure compliance with narrative and numerical criteria and protection of existing and designated uses." 314 C.M.R. 4.05(4)(a)(2)(d); *see also Entergy Nuclear Generation Co. v. Dep't of Envtl. Prot.*, 944 N.E.2d 1027 (Mass. 2011) (upholding 314 CMR 4.05(4)(a)(2)(d), among other provisions, as a "valid exercise of the authority vested in the Department of Environmental Protection by the Clean Waters Act").

In addition, Cape Cod Bay is a designated Ocean Sanctuary under the Massachusetts Ocean Sanctuaries Act, M.G.L. ch. 132A, §§ 12A-16K, 18, and associated regulations, 302 CMR 5.00. Pursuant to the Ocean Sanctuaries Act, all ocean sanctuaries "shall be protected from any exploitation, development, or activity that would significantly alter or otherwise endanger the ecology or the appearance of the ocean, the seabed, or subsoil thereof….” M.G.L. ch. 132A, § 14. While the Act and its associated regulations permit the “operation and maintenance of industrial liquid coolant discharge and intake systems and all other activities, uses and facilities associated with the generation . . . of electrical power” as “allowed activities” in the Cape Cod Bay sanctuary, they specify that such activities shall be in compliance with applicable general or special statutes, rules, regulations, and orders. M.G.L. ch. 132A, § 16; *see also* 302 CMR 5.08(1). The regulations further provide that state environmental policy shall include, among other things, “[s]upporting the attainment of the national water quality goals for all waters within the ocean sanctuaries through coordination with existing water quality planning and management activities” and “ensuring that all activities in the ocean sanctuaries . . . are consistent with federal and state effluent limitations and water quality standards.” 302 CMR 5.05(1)(c). The state regulations under the Ocean Sanctuaries Act also “form a part of the Commonwealth's Coastal Zone Management Program,” 302 CMR 5.02(2), established pursuant to the federal Coastal Zone Management Act, *see* 16 U.S.C. §§ 1451-1466.

Finally, Cape Cod Bay is included as part of the designated Massachusetts Bay National Estuary under the National Estuary Program established under Section 320 of the 1987 CWA Amendments. Congress established the National Estuary Program because the “Nation’s estuaries are of great importance for fish and wildlife resources and recreation and economic opportunity…[and,] maintaining the health and ecological integrity of these estuaries is in the national interest…” Water Quality Act of 1987, Pub. L. No. 100-4, § 317(a)(1)(A) and (B), 101 Stat. 7, 61 (adding § 320 to the CWA, 33 U.S.C. § 1330). In addition, Congress has found, among other things, that “the concerted efforts of all levels of Government, the private sector, and the public at large will be necessary to protect and enhance the environmental integrity of Massachusetts Bay.” Massachusetts Bay Protection Act of 1988, Pub. L. No. 100-653, § 1003(a)(8), 102 Stat. 3825, 3835-36. As a result of the designation, substantial federal and state resources have been directed to the Massachusetts Bay Estuary Program to enhance knowledge about, and the conservation of, Massachusetts Bay, including Cape Cod Bay.

Although difficult to monetize, the judgment by the Commonwealth or Congress that Cape Cod Bay should provide “excellent habitat” for fish and other aquatic life, that it must be protected from “activity that would significantly alter or otherwise endanger” its ecological integrity as an Ocean Sanctuary, or that it is part of an estuary of national significance demonstrate that lawmakers and, by extension, citizens, place significant value on the benefits provided by the bay.

Changes in the operation of the CWIS at PNPS in compliance with the use of VFDs as BTA would be expected to directly increase the number of commercial, recreational, and forage fish (eggs, larvae, juveniles and adults), as well as other types of aquatic organisms (e.g., invertebrates). The more that entrainment is reduced, the more likely it is that those reductions will contribute to increased populations of juvenile and adult fish. But reducing the loss of eggs and larvae is valuable in and of itself because of the role they play at the base of the food web and other benefits that they provide, such as contributing to species' compensatory reserve. Beyond these direct benefits to aquatic life, reducing entrainment will also likely result in additional indirect benefits to the ecosystem and the public's use and enjoyment of it. Examples of such indirect benefits include increasing recreational and educational opportunities, increasing or maintaining biological diversity, and increasing populations of resident and migratory birds and other terrestrial wildlife dependent on the resource for food.

Ultimately, Entergy's decision to close PNPS will provide the greatest benefit to the aquatic community in Cape Cod Bay and to the public's use and enjoyment of this natural resource by removing the CWIS as a significant source of mortality. A comparatively small amount of cooling water withdrawals will continue to be necessary for the spent fuel rods for a period of time after the plant ceases operation. While the precise cooling water requirements after June 1, 2019 are not definite, PNPS anticipates that four of the facility's five SSW pumps would continue to operate with a maximum daily cooling volume of 15.6 MGD (10,800 gpm), which is a reduction of more than 96% as compared to the current seawater withdrawal. PNPS anticipates that this cooling water requirement would extend about 5 years after shutdown until the spent fuel will be ready for dry cask storage, at which time all cooling water withdrawals would be eliminated. Based on the mean number of eggs and larvae entrained each year, shutting down the plant in 2019 and reducing cooling water withdrawals by 96% for five years after ceasing operations will save nearly 38 billion eggs and larvae through the current operating license (2032) compared to operating the existing CWIS.

EPA has concluded that the anticipated reduced operation of the CWIS during decommissioning of the plant will result in a reduction of cooling water withdrawals better than could be achieved with closed-cycle cooling, which is widely regarded to be the best performing entrainment technology in the industry. Following decommissioning, PNPS will cease to withdraw cooling water from Cape Cod Bay and eliminate any adverse environmental impacts from the CWIS. Therefore, this BTA determination focuses instead on any action warranted to minimize the impacts of the CWIS during the period beginning with the issuance of a final permit decision until the scheduled closing date, in June 2019 and potentially continuing through the decommissioning period, which may extend for 5 years from the date of shutdown. During this period, VFDs are available but, because of the administrative and existing thermal limits described above, are likely to reduce entrainment by a maximum of 9%. To quantify the benefits of VFDs for the interim period between permit issuance and shutdown, EPA assumed VFDs would begin operating in June 2017 (*i.e.*, installed within the first year of operation following issuance of a final decision). Compared to the existing CWIS, the addition of VFDs would be expected to save an additional 406 million eggs and larvae, which is a total reduction of 4.2% over 3 years (from June 2016 through June 2019).

6.3.3. Comparison of Costs and Benefits of Technology

EPA's analysis of the social costs of variable frequency drives (VFDs) was presented in Section 5.7, above. For the comparison of costs and benefits, EPA used Abt's cost tool to recalculate the net present value and annualized cost of VFDs through the year 2019, rather than over the life of the technology (15 years). In this case, total capital outlay (in $2015) is estimated to be $8.5 million at a 3% discount rate and $8.2 million at a 7% discount rate with no additional costs for operation and maintenance or energy-related effects. The annualized cost through 2019 is about $4.5 million dollars (at both 3% and 7% discount rates). Based on the quantitative analysis of the entrainment benefits above, installing VFDs on the circulating pumps would impose a social cost of about $8.5 million for a 4.2% reduction in entrainment over the operating period, which is about $2 million per percent reduction in entrainment. By far the highest density of ichthyoplankton, on average, occurs in the month of June. The likely timeline of final permit issuance and technology installation would likely push operation of VFDs past June 2017, which means that June 2018 would be the only month during the remaining useful life of the plant in which VFDs on the circulating pumps would provide these maximum entrainment benefits. Given the relatively high cost of VFDs and that only minor benefits would accrue for an extremely limited operating period, EPA does not believe the cost of VFDs is justified by the benefits in this case.

6.4. BTA Selection

The Final Rule requires that the permitting authority establish site-specific requirements for entrainment that:

> …reflect the determination of the maximum reduction in entrainment warranted after consideration of factors relevant for determining the best technology available for minimizing adverse environmental impact at each facility. These entrainment requirements may also reflect any control measures to reduce entrainment of Federally-listed threatened and endangered species and designated critical habitat (e.g., prey base).

40 C.F.R. § 125.98(f). The Final Rule further specifies that the "Director must provide a written explanation of the proposed entrainment determination in the fact sheet or statement of basis for the proposed permit under 40 CFR 124.7 or 124.8. The written explanation must describe why the Director has rejected any entrainment control technologies or measures that perform better than the selected technologies or measures, and must reflect consideration of all reasonable attempts to mitigate any adverse impacts of otherwise available better performing entrainment technologies." *Id.* § 125.98(f)(1).

EPA's evaluation of the technologies determined that three options were potentially available at PNPS: closed-cycle cooling, assisted recirculation, and variable frequency drives. Neither closed-cycle cooling nor assisted recirculation, however, could be installed and made operational within the remaining useful life of the plant, which is scheduled to close no later than June 1, 2019. And, as explained above, the social cost of VFDs is not justified by the social benefits that would be provided over the extremely limited period during which they would operate. For these reasons, EPA proposes that, considering the applicable factors at § 125.98(f)(2) and (3) and in light of Entergy's announcement to shut down the facility thereby drastically reducing its cooling water intake, instituting no additional entrainment control requirements prior to the earlier of the cessation of electricity generation or June 1, 2019 and, thereafter, eliminating water withdrawals for the main condenser and reducing other cooling water and other miscellaneous water withdrawals, resulting in a 96% reduction in flow, represents the best technology available for minimizing entrainment at PNPS. This conclusion is predicated on the closure of PNPS no later than June 1, 2019. Should the plant operate beyond June 2019, EPA would have to reconsider not only the cost-benefit comparison for installation of VFDs but also the potential availability of other, better performing technologies (*e.g*., assisted recirculation) which have been eliminated from this analysis due to the limited remaining useful life of the plant.

7.0 Site Specific BTA Requirements to Minimize Impingement at PNPS

In the Final Rule for existing facilities, the BTA for minimizing the adverse impacts of impingement mortality is modified traveling screens with a fish-friendly return. *See* 40 C.F.R. § 125.94(c)(5); 79 Fed. Reg. at 48,337. In addition, the Final Rule provides six alternative methods of compliance. Briefly, these alternative compliance methods include:

1) Operate a closed-cycle recirculating system;
2) Operate a cooling water intake structure with a maximum through-screen design intake velocity of 0.5 fps;
3) Operate a cooling water intake structure with a maximum through-screen actual intake velocity of 0.5 fps;
4) Operate an offshore velocity cap (installed prior to October 14, 2014);
5) Operate any other combination of technologies, management practices, and operational measures that the Director determines is BTA for impingement reduction; or
6) Achieve a 12-month impingement mortality performance standard of all life stages of fish and shellfish of no more than 24 percent mortality.

40 C.F.R. § 125.94(c). The Final Rule also provides the permitting authority with discretion to require a permittee to comply with additional measures to protect shellfish and fragile species from impingement mortality. *See* 40 C.F.R. § 125.94(c)(8), (9).

EPA has made a site-specific BTA determination for entrainment mortality under 40 C.F.R. § 125.98(g) in consideration of the factors at 40 C.F.R. § 125.98(f)(2) and (3). Section 125.98(g) also authorizes EPA to proceed with a determination of BTA standards for impingement mortality that may be based on the BTA standards for impingement mortality at 40 C.F.R. § 125.94(c). Today's determination proceeds under § 125.98(g) and is based on information sufficiently similar to the information required by the Final Rule at 40 C.F.R. § 122.21(r) and which has been provided by the permittee in response to EPA's requests under § 308 of the CWA as well as supplemental biological information provided by the permittee.

7.1. BTA for Impingement Mortality

In its evaluation of the BTA for entrainment, EPA described Entergy's decision to shutdown PNPS no later than June 1, 2019 and, as of that date, reduce cooling water needs at the facility to the minimum required to support decommissioning activities. Entergy anticipates that PNPS would continue cooling water withdrawals for the salt service water (SSW) pumps, at a maximum daily intake of 15.6 MGD, which represents a reduction in cooling water flow of about 96%, which surpasses the flow reduction that PNPS would likely achieve through the use of closed-cycle cooling. Limited use of the circulating water pumps may be required to support decommissioning activities, which Entergy indicates would not exceed 5% of the time.

In addition, at a maximum daily intake volume of 15.6 MGD, the through-screen actual velocity at the traveling screens would be 0.06 fps, which is well below, and therefore consistent with, the BTA standard for impingement mortality at 40 C.F.R. § 125.94(c)(3) (*i.e.*, ≤ 0.5 fps). At PNPS this intake velocity will likely provide greater reductions in impingement mortality than traveling screens because it would allow fish to avoid being impinged on the screens in the first instance, which offers more protection for fragile species (e.g., rainbow smelt and river herring) that are unlikely to survive impingement. Swim speed studies suggest that an intake velocity of 0.5 fps or less will result in 96 percent or better reductions in impingement mortality for most species. *See* 79 Fed. Reg. at 48,337. Therefore, the BTA for impingement mortality during decommissioning activities beginning no later than June 1, 2019 will be met by maintaining a through-screen actual intake velocity no greater than 0.5 fps.

The following sections present EPA's interim BTA determination for impingement mortality during the period from the effective date of the permit until June 1, 2019 (or when PNPS terminates power generation if that should occur before June 1, 2019).

7.2. Interim BTA for Impingement Mortality

In light of, among other things, the current design, location, and operation of the CWIS at PNPS, Entergy's announcement to shut the facility down by June 1, 2019, and EPA's BTA determination for entrainment discussed in Section 6 above, it will be impracticable, if not impossible, for Entergy to comply with certain alternative BTA standards for impingement mortality at 40 C.F.R. § 125.94(c) within the period prior to shutdown. For instance, as discussed in Section 6 above, construction of a closed-cycle recirculating system would be expected to take at least 4 years. *See* 40 C.F.R. § 125.94(c)(1). Similarly, PNPS does not currently have a maximum through-screen design velocity of 0.5 fps or a velocity cap. *See id.* § 125.94(c)(2), (4). While Entergy has announced a drastic reduction in flow that will enable PNPS to comply with the 0.5 fps standard at

§ 125.94(c)(3) by June 1, 2019, compliance with this standard prior to shutdown would require a substantial reduction in cooling water flow, which the facility could not achieve without a significant impact on the production of electricity. Section 5.1 of this fact sheet describes how the administrative limits (*e.g.*, hotwell temperature) and safety buffers (e.g., MELLA boundary and use of control rods) together determine the cooling requirements and generation of electricity at the facility. Here, EPA considers the three remaining compliance alternatives in more detail to determine appropriate interim control requirements for impingement mortality at PNPS.

7.2.1. Modified Traveling Screens

One of the remaining compliance options for impingement mortality in the Final Rule is to operate a modified traveling screen that the owner or operator demonstrates is or will be optimized to minimize impingement mortality of all non-fragile species. *See id.* § 125.94(c)(5).

The Final Rule defines "modified traveling screen" as

> a traveling water screen that incorporates measures protective of fish and shellfish, including but not limited to: screens with collection buckets or equivalent mechanism designed to minimize turbulence to aquatic life; addition of a guard rail or barrier to prevent loss of fish from the collection system; replacement of screen panel materials with smooth woven mesh, drilled mesh, molded mesh, or similar materials that protect fish from descaling and other abrasive injury; continuous or near continuous rotation of screens and operation of fish collection equipment to ensure any impinged organisms are recovered as soon as practicable; a low pressure wash or gentle vacuum to remove fish prior to any high pressure spray to remove debris from the screens; and a fish handling and return system with sufficient water flow to return the fish directly to the source water in a manner that does not promote predation or re-impingement of the fish, or require a large vertical drop.

Id.. § 125.92(s). Examples of modified traveling screens in the definition include modified Ristroph screens with a fish handling and return system, dual flow screens with smooth mesh, and rotary screens with fish returns or vacuum returns. *Id.*

In Section 4.3 of this determination, EPA presents several reasons why the existing traveling screens at PNPS are not consistent with the definition of modified traveling screens at § 125.92(s) as required to meet the BTA standard for impingement mortality at § 125.94(c)(5). The existing screens are comprised of stainless steel screening, rather than alternative materials that would protect fish from abrasive injury, and rotate just six times per week (or when triggered by loading or temperature), rather than continuously or near-continuously as directed by the rule. In addition, the narrow shelves (2–3 inches wide) that carry debris and fish as the screen rotates are designed primarily for moving debris, not fish and are not similar to the fish buckets associated with modified traveling screens because they do not minimize turbulence or prevent loss of fish from the collection system. Finally, the primary sluiceway returns fish to the embayment just 300 feet to the east of the CWIS, and the secondary sluiceway (used when debris loading is unusually high) empties into the discharge canal where the water temperature can be up to 32°F above ambient.

Ideally, the primary sluiceway would return fish to Cape Cod Bay outside of the embayment to minimize the potential for organisms to be re-impinged, and the secondary sluiceway would return fish to a location where they would not be exposed to dramatic increases in temperature that could potentially result in acute mortality. EPA requested that Entergy evaluate the availability and cost of an upgraded fish return sluiceway that maximizes survivability and returns fish outside of the intake embayment. Entergy proposed two possible modifications to the fish return sluiceway in its 2014 Engineering Response, while maintaining that the current sluiceway configuration already promotes high survival rates as demonstrated in the MRI 1984 survival study and a that modified sluiceway is not likely to improve survivability.

The first option that Enercon evaluated routes the fish sluiceway along the existing debris return trough on the west side of the intake structure and along the embankment to the west side of the discharge canal before emptying into Cape Cod Bay west of the discharge plume approximately 300 ft offshore at a depth of 10 ft. The modified sluiceway would be a closed 16-inch pipe with smooth material, long radius bends (to prevent abrasion), a minimum water depth of 6 inches, and velocity of 4.6-8.4 fps.[33] Enercon estimates the cost of this sluiceway configuration (including total construction and engineering cost) is $2,880,000 (2014 dollars). This estimate does not include engineering site support or staff support during construction.

The second option that Enercon evaluated modifies the existing fish sluiceway that travels on the eastern side of the intake structure and extends the outlet of the sluiceway outside of the east breakwater of the embayment. A new pipe would extend about 2000 ft under the embayment and east breakwater and return fish outside of the embayment. This option would require PNPS to dig a new trench under the embayment using horizontal directional drilling. The modified sluiceway would be made of smooth material (including replacing the existing section of corrugated pipe) with a minimum water depth of 3.2 inches. Enercon estimates the cost of this sluiceway configuration (including total construction and engineering cost) is $3,020,000 (2014 dollars). This estimate does not include engineering site support or staff support during construction, nor does it consider the costs of additional geotechnical investigations that may be required beyond the initial investigation to determine bore path selection for the drill.

For the reasons described above, the existing traveling screens at PNPS lack specific measures for the protection of fish and, as such, are not consistent with modified traveling screens as defined in the Final Rule. 40 C.F.R. § 125.92(s). In order to meet the definition of modified traveling screens under the BTA standard for impingement mortality at 40 C.F.R. § 125.94(c)(5), PNPS would likely have to retrofit the screens to

[33] The modified sluiceway would be comprised of three separate piping configurations each with a different construction methodology and a unique water depth, pipe diameter, and flow velocity.

include smooth mesh (or a similar screening material that decreases abrasion) and fish collection buckets to reduce turbulence. In addition, PNPS would have to initiate continuous (or near-continuous) rotation. PNPS may also have to alter the existing fish return system if the current outlet is not sufficiently far from the CWIS to minimize the potential for re-impingement. Even if the permittee were to make these specific changes, however, compliance with this alternative is demonstrated through a two-year impingement technology performance optimization study after the technology is installed. 79 Fed. Reg. at 48,347. The upgrades themselves would likely require additional time to design, install, and begin operating. Thus, PNPS may not complete the necessary upgrades and two-year study before the facility would comply with the actual through-screen velocity BTA simply by virtue of the significant reduction in flow associated with shutdown expected by June 1, 2019. Or at best, the improvements to the traveling screen and fish return and the accompanying performance study necessary to satisfy § 125.94(c)(5) might be in place for only a very limited period prior to shutdown. Moreover, such improvements to the traveling screen and fish return are not expected to provide as great a reduction in impingement mortality as that associated with shutdown, which is expected to decrease the actual through-screen velocity to 0.06 fps, as discussed in section 7.1. As such, any investments to improve the traveling screen and fish return would shortly be rendered obsolete. In light of these considerations, EPA has decided not to mandate upgrades to PNPS' existing screens and fish return systems in this case. Had Entergy not decided to shutter the facility by June 2019, EPA's analysis here may have been different.

7.2.2. System of Technologies

Another option to comply with the BTA standards for impingement mortality under the Final Rule that could be applicable as an interim BTA at PNPS is "a system of technologies, management practices, and operational measures, that, after review of the information required in the impingement technology performance optimization study at 40 C.F.R. 122.21(r)(6)(ii), the Director determines is the best technology available for impingement reduction at your cooling water intake structures." 40 C.F.R. § 125.94(c)(6). PNPS would comply with this option by performing the necessary study and demonstrating that its system of technologies, including the existing traveling screens and maintenance outage flow reduction, has been optimized to minimize impingement of all non-fragile species, including Atlantic silversides. Under this option, the permitting authority's BTA determination is to be informed by comparing the total system performance to the impingement mortality performance standard at § 125.94(c)(7) – that is, no more than 24 percent mortality, including latent mortality, for all non-fragile species together. *Id.* § 125.94(c)(6).

However, complying with this alternative during the interim period between the effective date of the permit and plant shutdown presents a challenge, because, as with the option to upgrade the traveling screens, the permittee must submit a study including two years of biological data collection demonstrating that the operation of the system has been optimized to minimize impingement mortality for non-fragile species. Given the anticipated closure of the plant in June 2019 and the timeline for a final permit decision, the permittee is expected to achieve an actual through-screen velocity of 0.5 fps or less close to or by the time the optimization study is completed.

7.2.3. Impingement Mortality Performance Standard

Finally, facilities may meet the BTA standards for impingement mortality in the Final Rule by achieving a 12-month impingement mortality performance standard of all life stages of fish and shellfish of no more than 24 percent mortality, including latent mortality, for all non-fragile species together that are collected or retained in a sieve with a maximum opening dimension of 0.56 inches and kept for a holding period of 18 to 96 hours. *Id.* § 124.94(c)(7). Under this compliance alternative, a facility must conduct biological monitoring at a minimum frequency of monthly to demonstrate the impingement mortality performance. *Id.* The 12-month impingement mortality performance is the total number of fish killed divided by the total number of fish impinged over the course of the previous 12 months. *Id.*

The BTA standards for impingement mortality in § 125.94(c)(5) and (7) both distinguish between non-fragile and fragile species, specifically applying only to the former (*e.g.*, "the owner or operator of the facility must demonstrate the technology is or will be optimized to minimize impingement mortality of all non-fragile species." *Id.* § 125.94(c)(5)). *See also id.* § 125.92(m) (defining "fragile species"). For the purposes of evaluating impingement data as the basis of the standard in the Final Rule, EPA excluded data for fragile species because the observed mortality data from fragile species might, in large part, reflect conditions other than technology performance. *See* Chapter 11 of the § 316(b) Existing Facilities Rule Technical Development Document p.11-3.

On average, nine species account for more than 94% of annual impingement at PNPS from 1980 to 2013: Atlantic menhaden (53.4%), Atlantic silversides (23.3%), alewife (4.7%), rainbow smelt (3.3%), sand lance (2.2%), winter flounder (2.2%), Atlantic herring (2.1%), blueback herring (1.7%), and grubby (1.3%). Of these nine species, the Final Rule defines five (Atlantic menhaden, alewife, rainbow smelt, Atlantic herring, and blueback herring) as "fragile" species, meaning that the impingement survival rate is less than 30 percent even when the BTA technology of modified traveling screens are in operation. *Id.* § 125.92(m); *see also* 79 Fed. Reg. at 48,364. Exhibit 11-2 in the Technical Development Document for the Final Rule classifies Atlantic silversides, sand lance, winter flounder, and grubby as non-fragile species for the basis of the impingement mortality limitation at 40 C.F.R. § 125.94(c)(7).

Entergy considers Atlantic silversides a fragile species for the purposes of its evaluation of its modified traveling screen (see, for example, Appendix A Table 5 in the 2008 Entrainment and Impingement Report). A site-specific study conducted from 1980-1983 at PNPS (MRI 1984) observed generally low initial and latent survival of impinged Atlantic silversides (0 to 20%); a 2005 study performed by Normandeau (Normandeau 2005) observed initial survival up to 62% with continuous screen rotation. Based on EPA's analysis of impingement data for the Final Rule, however, Atlantic silversides could experience survival rates higher than 70% and are considered non-fragile, meaning that this species would be included in the calculation of impingement performance. It is not clear why the survival of silversides at PNPS would be lower than at other facilities, but in this case, the lower survival of this species may prevent PNPS from achieving the mortality standard because silversides comprise a large percentage of impingement on an annual basis. As an example, in April 2014, PNPS impinged 2,647 fish classified as non-fragile species, including 2,479 Atlantic silversides (Normandeau 2015). In order to comply with the 24% latent mortality standard, survival of silversides would have to exceed 76%.

Given the existing data at PNPS, a survival rate of 76% for Atlantic silversides is unlikely with the existing equipment. Further, it is not certain that improving the traveling screens consistent with the definition of modified traveling screens described in Section 7.2.1 would improve survival of Atlantic silversides at PNPS. For example, replacing the screen material with smooth mesh, or altering the location of the fish return, may not improve survival of this species. EPA demonstrated in the sections above that PNPS is expected to achieve an actual through-screen velocity of 0.5 fps no later than June 1, 2019, which is likely to occur before the permittee could invest in equipment upgrades that may not be effective. An actual through-screen velocity of less than 0.5 fps is a more protective technology than modifying the screens for a species that, at least in this case, experiences relatively high impingement mortality. For these reasons, EPA is not requiring PNPS to invest in improvements that will likely not be operational and effective before the permittee can comply with a more protective BTA standard and may not benefit Atlantic silversides.

7.2.4. Determination of Interim BTA for Impingement Mortality

EPA is making this BTA determination under the ongoing permitting proceedings provision of the Final Rule at 40 C.F.R. § 125.98(g), which states

> The Director's BTA determination may be based on some or all of the factors in paragraphs (f)(2) and (3) of this section and the BTA standards for impingement mortality at § 125.95(c).[34]

Therefore, the Final Rule authorizes, but does not require, EPA to use the BTA standards under the Final Rule in setting permit conditions for an ongoing permit proceeding such as this one. Still, EPA has determined that the BTA for impingement mortality at PNPS will be to comply with an actual through-screen intake velocity of no more than 0.5 fps at the existing traveling screens consistent with 40 C.F.R. § 125.94(c)(3). Compliance with the alternative shall be no later than June 1, 2019, at the same time as compliance with the entrainment requirements established in this determination.

Compliance with the impingement mortality BTA standard at the same time as compliance with the site-specific entrainment requirements is consistent with the Final Rule. In particular, the Final Rule provides that, "[a]fter issuance of a final permit that establishes the entrainment requirements under § 125.94(d), the owner or operator of an existing facility must comply with the impingement mortality standard in § 125.94(c) *as*

[34] So in original. Should be § 125.9<u>4</u>(c).

soon as practicable" and that EPA "may establish interim compliance milestones in the permit." 40 C.F.R. § 125.94(b)(1) (emphasis added). The preamble explains that EPA revised the impingement mortality compliance requirements in this way in the Final Rule in response to comments received on the proposed rule and "synchronized decision making about technology requirements, avoiding situations where investments in [impingement mortality] would later be rendered obsolete by entrainment control requirements." 79 Fed. Reg. at 48,356.

Where there will be some period of time necessary to comply with the BTA standards for impingement mortality and entrainment, such as in this case where the facility will not comply until shutdown (no later than June 1, 2019), the Final Rule at 40 C.F.R. § 125.94(h) authorizes EPA to consider site-specific interim BTA measures:

> An owner or operator of a facility may be subject to interim BTA requirements established by the Director in the permit on a site-specific basis.

The existing technology to minimize impingement mortality at PNPS consists of coarse mesh traveling screens equipped with a low pressure spraywash to rinse organisms from the screen and a sluiceway to return organisms to the receiving water. EPA evaluated whether use of this technology, either as it exists or with upgrades, would meet one of the other compliance alternatives, namely, the protection of non-fragile species using the existing technology under 40 C.F.R. §§ 125.94(c)(5), (6), or (7), during the interim period before the facility shuts down. As described above, EPA has concluded that PNPS is not likely to comply with any of these BTA standards for impingement mortality under the Final Rule in the interim period because the necessary upgrades and studies are not likely to be completed before the facility shuts down, and because the site-specific impingement survival studies submitted by the permittee indicate that, without significant upgrades that might only be in place for a brief period (and even then, the benefit for Atlantic silversides is uncertain), PNPS would be unlikely to achieve a 12-month impingement mortality performance standard of all life stages of fish and shellfish of no more than 24 percent mortality, including latent mortality, for all non-fragile species.

While PNPS is not likely to meet any of the alternative compliance options under 40 C.F.R. § 125.94(c) during the interim period between the effective date of the permit and the cessation of electricity generation, it will be able to comply with the BTA standard for impingement mortality of a maximum through-screen actual velocity of 0.5 fps (*i.e.*, § 125.94(c)(3)) by reducing it to roughly 0.06 fps for the period following cessation of electricity generation but preceding complete cessation of cooling water withdrawals. Moreover, EPA has chosen to synchronize the deadlines for compliance with the impingement mortality and entrainment mortality standards, because the improvements necessary to comply with the alternative impingement control technologies during the interim period are likely to result in situations where the investments would be rendered obsolete, in some cases even before, and in others only a short time after, they are operational. Accordingly, EPA finds that compliance with the BTA for impingement mortality shall be required on June 1, 2019 or when the facility ceases electricity generation. That said, it may be feasible for PNPS to implement some steps as an interim BTA to improve the survival of impinged fish using the existing technology.

Laboratory studies, field studies, and site-specific data collected at PNPS indicate that, for some species, impingement survival is likely to be greater than zero. A site-specific study conducted from 1980-1983 at PNPS (MRI 1984) indicates that the element that was observed to have the greatest impact on impingement survival for all species was continuous rotation, which PNPS does not currently employ at its existing traveling screens. Fragile species, including rainbow smelt and menhaden, experienced high mortality in both 8-hour and continuous wash cycles, supporting the conclusion that these species are not likely to survive impingement regardless of screen rotation parameters. On the other hand, survival of less fragile species was observed to be substantially higher during continuous rotation cycles. For example, initial survival of grubby – which the rule expressly considers a non-fragile species, *see* Exhibit 11B-1 in Chapter 11 Appendix B of the § 316(b) Existing Facilities Final Rule Technical Development Document (EPA 2014) – increased from 37.5% with 8-hour washes to nearly 78% with continuous wash cycles. For all species combined (including fragile species), initial survival increased from 8.9% under the 8-hour wash cycle to 29.6% under the continuous wash cycle. For non-fragile species, initial survival increased from 13% under the 8-hour wash cycle to 47% under the continuous wash cycle. In addition to grubby, initial survival of winter flounder, pollock, and northern pipefish was substantially greater with continuous rotation. Similarly, PNPS' 2005 Impingement Monitoring Report (Normandeau 2006) evaluated initial survival with continuous and static rotation and indicated that initial survival for all impinged species combined was greater when traveling screens were continuously rotated (34%) than when screens were rotated once every 8 hours (19%). In particular, Normandeau (2006) indicated that the higher initial survival of Atlantic silversides with continuous rotation (62%) compared to static rotation (15%) attributed to the overall greater survivability with continuous rotation. The site-specific Normandeau and MRI studies, as well as other laboratory studies (EPRI 2003), supports the conclusion that continuous wash cycles are likely to improve survival of many impinged fish. EPA concludes that as an interim BTA condition, PNPS should implement continuous or near-continuous rotation of the existing traveling screens to minimize impingement mortality for non-fragile species.

8.0 PERMIT REQUIREMENTS BASED ON BTA DETERMINATION

For this permit, EPA is making a 316(b) determination for this facility under the ongoing permitting provision of the Final Rule at 40 C.F.R. § 125.98(g) in consideration of the factors at 40 C.F.R. § 125.98(f)(2) and (3). EPA has considered the design, construction, and capacity of the existing CWIS, the schedule for shutdown proposed by Entergy, and available technologies to minimize impingement mortality and entrainment and determined that the following measures represent BTA:

1. Upon termination of generation of electricity or no later than June 1, 2019, the permittee shall:

    a. Operate the traveling screens with a maximum through-screen intake velocity no greater than 0.5 feet per second. Limited exceedances of the maximum through-screen velocity are authorized for the purposes of maintaining the CWIS and when the circulating water pumps are required to withdraw water to support decommissioning activities not to exceed five (5) percent of the time on a monthly basis.

    b. Monitor the through-screen velocity at the screen at a minimum frequency of daily. Alternatively, the permittee shall calculate the daily maximum through-screen velocity using water flow, depth, and screen open area. For this purpose, the maximum intake velocity shall be calculated during minimum ambient source water surface elevations and periods of maximum head loss across the screens. The average monthly and maximum daily through-screen intake velocity shall be reported each month on the DMR. See Part I.B.1. of this permit.

    c. Cease cooling water withdrawals for the main condenser and reduce total cooling water withdrawals to an average monthly rate of 7.8 MGD. Cooling water withdrawals at the salt service water pumps shall be limited to a maximum daily flow of 15.6 MGD.

    d. Withdrawal of seawater using a single circulating water pump not to exceed five (5) percent of the time on a monthly basis is authorized to support decommissioning activities.

    e. Continuously rotate the traveling screens when operating the circulating water pumps.

2. From the effective date of the permit until termination of generation of electricity, no later than June 1, 2019, the permittee shall continuously rotate the traveling screens.

3. Any change in the location, design, or capacity of any CWIS, except as expressed in the above requirements, must be approved in advance and in writing by the EPA and MassDEP.

Attachment E
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MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION
COMMONWEALTH OF MASSACHUSETTS
1 WINTER STREET
BOSTON, MASSACHUSETTS 02108

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF ECOSYSTEM PROTECTION
REGION I
BOSTON, MASSACHUSETTS 02109

JOINT PUBLIC NOTICE OF A DRAFT NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT TO DISCHARGE INTO THE WATERS OF THE UNITED STATES UNDER SECTION 301, 316(a), AND 402 OF THE CLEAN WATER ACT (THE "ACT"), AS AMENDED, AND REQUEST FOR STATE CERTIFICATION UNDER SECTION 401 OF THE ACT.

PUBLIC NOTICE PERIOD: May 18, 2016 – July 18, 2016

PERMIT NUMBER: **MA0003557**

PUBLIC NOTICE NUMBER: MA-010-16

NAME AND MAILING ADDRESS OF PERMITTEE:

Entergy Nuclear Generation Company
Pilgrim Nuclear Power Station
600 Rocky Hill Road
Plymouth, MA 02360

NAME AND ADDRESS OF THE FACILITY WHERE DISCHARGE OCCURS:

Pilgrim Nuclear Power Station
600 Rocky Hill Road
Plymouth, MA 02360

RECEIVING WATER: **Cape Cod Bay, Class SA water**

PREPARATION OF THE DRAFT PERMIT:

The U.S. Environmental Protection Agency ("EPA") and the Massachusetts Department of Environmental Protection ("MassDEP") have cooperated in the development of a draft permit for the above identified facility. The effluent limits and permit conditions imposed have been drafted to assure compliance with the Clean Water Act ("CWA"), 33 U.S.C. sections 1251 et seq.,, the Massachusetts Clean Waters Act, G.L. c. 21, §§ 26-53, 314 CMR 3.00 and State Surface Water Quality Standards ("WQS") at 314 CMR 4.00. In addition, the draft permit includes thermal effluent limitations for temperature and rise in temperature, or "delta T." The thermal component of the facility's discharge is subject to effluent limitations under CWA § 301, 33 U.S.C. § 1311, and WQS that provide that temperature of a class SA water "[s]hall not exceed 85°F (29.4°C) nor a maximum daily mean of 80°F (26.7°C), and the rise in temperature due to a discharge shall not exceed 1.5°F (0.8°C)." 314 CMR 4.05(4)(a)(2)(a).

The permittee has filed a request for alternative, less stringent effluent limitations for the thermal component of the discharge. Consistent with CWA § 316(a) and 314 CMR 4.05(4)(a)(2)(c), the draft permit contains some thermal limits that are less stringent than WQS, but which EPA and MassDEP have determined nonetheless assure the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife in and on the water body receiving the thermal discharge. These effluent limits are an effluent temperature of 102°F and delta Ts of 32 °F pre-shutdown and 3°F post-shutdown for Outfall 001 (cooling water) and an effluent temperature of 115°F for Outfall 002 (thermal backwash water). These limits are described in Sections 6.1.4 and 6.2.4 of the fact sheet. EPA has formally requested that the State certify this draft permit pursuant to Section 401 of the Clean Water Act and expects that the draft permit will be certified.

INFORMATION ABOUT THE DRAFT PERMIT:

A fact sheet or a statement of basis (describing the type of facility; type and quantities of wastes; a brief summary of the basis for the draft permit conditions; and significant factual, legal and policy questions considered in preparing this draft permit) and the draft permit may be obtained at no cost at: http://www.epa.gov/region1/npdes/draft_permits_listing_ma.html or by writing or calling EPA's contact person named below:

George Papadopoulos, US EPA
5 Post Office Square
Suite 100 (OEP 06-1)
Boston, MA 02109-3912
Telephone: (617) 918-1579

The administrative record containing all documents relating to this draft permit is on file and may be inspected at the EPA Boston office mentioned above between 9:00 a.m. and 5:00 p.m., Monday through Friday, except holidays.

PUBLIC COMMENT AND REQUEST FOR PUBLIC HEARING:

All persons, including applicants, who believe any condition of this draft permit is inappropriate, must raise all issues and submit all available arguments and all supporting material for their arguments in full by **July 18, 2016**, to the U.S. EPA, George Papadopoulos, 5 Post Office Square, Suite 100, Mailcode OEP 06-1, Boston, Massachusetts 02109-3912. Any person, prior to such date, may submit a request in writing to EPA and the MassDEP for a public hearing to consider this draft permit. Such requests shall state the nature of the issues proposed to be raised in the hearing. A public hearing may be held after at least thirty (30) days public notice whenever the Regional Administrator finds that response to this notice indicates significant public interest. In reaching a final decision on this draft permit the Regional Administrator will respond to all significant comments and make the responses available to the public at EPA's Boston office.

FINAL PERMIT DECISION AND APPEALS:

Following the close of the comment period, and after a public hearing, if such hearing is held, the Regional Administrator will issue a final permit decision and forward a copy of the final decision to the applicant and each person who has submitted written comments or requested notice. Within 30 days following the notice of the final permit decision any interested person may submit petition to the Environmental Appeals Board to reconsider or contest the final decision.

David Ferris, Director
MASSACHUSETTS WASTE WATER PROGRAM
MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION

Ken Moraff, Director
OFFICE OF ECOSYSTEM PROTECTION
ENVIRONMENTAL PROTECTION AGENCY

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION
COMMONWEALTH OF MASSACHUSETTS
1 WINTER STREET
BOSTON, MASSACHUSETTS 02108

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF ECOSYSTEM PROTECTION
REGION I
BOSTON, MASSACHUSETTS 02109

JOINT **EXTENSION OF PUBLIC COMMENT PERIOD** AND PUBLIC NOTICE OF A **PUBLIC HEARING** PERTAINING TO THE ISSUANCE OF A **DRAFT NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT** TO DISCHARGE INTO THE WATERS OF THE UNITED STATES UNDER SECTIONS 301 AND 402 OF THE CLEAN WATER ACT, AS AMENDED, AND UNDER SECTIONS 27 AND 43 OF THE MASSACHUSETTS CLEAN WATERS ACT, AS AMENDED.

DATE OF ORIGINAL NOTICE PERIOD: May 18, 2016 – July 18, 2016

PUBLIC NOTICE EXTENDED TO: July 25, 2016

REASON FOR EXTENSION: The public notice is hereby extended (40 CFR §124.10) in response to a request for a public hearing.

PERMIT NUMBER: MA0003557

PUBLIC NOTICE NUMBER: MA-012-16

NAME AND MAILING ADDRESS OF APPLICANT:

Entergy Nuclear Generation Company
Pilgrim Nuclear Power Station
600 Rocky Hill Road
Plymouth, MA 02360

NAME AND ADDRESS OF THE FACILITY WHERE DISCHARGE OCCURS:

Pilgrim Nuclear Power Station
600 Rocky Hill Road
Plymouth, MA 02360

RECEIVING WATER: Cape Cod Bay – Class SA water

PREPARATION OF THE DRAFT PERMIT:

The U.S. Environmental Protection Agency (EPA) and the Massachusetts Department of Environmental Protection (MassDEP) have cooperated in the development of a draft permit for the above identified facility. The effluent limits and permit conditions imposed have been drafted to assure compliance with the Clean Water Act, 33 U.S.C. sections 1251 et seq., the Massachusetts Clean Waters Act, M.G.L. c. 21, §§ 26-53, 314 CMR 3.00 and State Surface Water Quality Standards at 314 CMR 4.00. EPA has formally requested that the State certify this draft permit pursuant to Section 401 of the Clean Water Act and expects that the draft permit will be certified.

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION
COMMONWEALTH OF MASSACHUSETTS
1 WINTER STREET
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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF ECOSYSTEM PROTECTION
REGION I
BOSTON, MASSACHUSETTS 02109

JOINT **CORRECTION TO PUBLIC HEARING INFORMATION** PERTAINING TO THE ISSUANCE OF A **DRAFT NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT** TO DISCHARGE INTO THE WATERS OF THE UNITED STATES UNDER SECTIONS 301 AND 402 OF THE CLEAN WATER ACT, AS AMENDED, AND UNDER SECTIONS 27 AND 43 OF THE MASSACHUSETTS CLEAN WATERS ACT, AS AMENDED.

REASON FOR CORRECTION: Original public notice of public hearing listed the incorrect street address for the Plymouth Public Library (public hearing location).

PERMIT NUMBER: MA0003557

NAME AND ADDRESS OF THE FACILITY WHERE DISCHARGE OCCURS:

Pilgrim Nuclear Power Station
600 Rocky Hill Road
Plymouth, MA 02360

PUBLIC HEARING:

The Regional Administrator has determined, pursuant to 40 C.F.R. § 124.12, that a significant degree of public interest exists on the proposed permit and that a public hearing should be held to consider this draft permit.

A public hearing and meeting (information session) will be held on the following date and time:

DATE: Thursday, July 21, 2016

MEETING TIME: 6:15 p.m. - 7:00p.m.

HEARING TIME: 7:15pm

LOCATION: Plymouth Public Library (side door entrance)
132 South Street
Plymouth, MA 02360

MEETING ROOM: Otto Fehlow Meeting Room

In accordance with 40 C.F.R. § 124.12, the following is a summary of the procedures that shall be followed at the public hearing:

a. The Presiding Officer shall have the authority to open and conclude the hearing and to maintain order; and
b. Any person appearing at such a hearing may submit oral or written statements and data concerning the draft permit.

INFORMATION ABOUT THE DRAFT PERMIT:

A fact sheet (describing the type of facility; type and quantities of wastes; a brief summary of the basis for the draft permit conditions; and significant factual, legal and policy questions considered in preparing this draft permit) and the draft permit may be obtained at no cost at http://www.epa.gov/region1/npdes/draft_permits_listing_ma.html or by writing or calling EPA's contact person named below:

George Papadopoulos
U.S. Environmental Protection Agency – Region 1
5 Post Office Square, Suite 100 (OEP06-1)
Boston, MA 02109-3912
Telephone: (617) 918-1579
Papadopoulos.george@epa.gov

The administrative record containing all documents relating to this draft permit is on file and may be inspected at the EPA Boston office mentioned above between 9:00 a.m. and 5:00 p.m., Monday through Friday, except holidays.

DAVID FERRIS, DIRECTOR
MASSACHUSETTS WASTEWATER
MANAGEMENT PROGRAM
DEPARTMENT OF ENVIRONMENTAL
PROTECTION

KEN MORAFF, DIRECTOR
OFFICE OF ECOSYSTEM PROTECTION
ENVIRONMENTAL PROTECTION
AGENCY – REGION 1

Public notice of this draft permit was provided in the *Old Colony Memorial* newspaper (Plymouth, MA) and sent to the permittee and other interested parties by mail and electronic mail on May 18, 2016. While that original public notice indicated that at least thirty (30) days' advance notice would be provided for any public hearing, in accordance with 40 C.F.R. § 124.10(b)(2), the version of the notice mistakenly posted to EPA's website on May 18, 2016 erroneously noted that at least sixty (60) days' notice would be provided. The version posted on EPA's website has since been replaced with the original notice. Accordingly, this public hearing notice provides at least a thirty (30) day notice prior to the scheduled hearing.

INFORMATION ABOUT THE DRAFT PERMIT:

A fact sheet (describing the type of facility; type and quantities of wastes; a brief summary of the basis for the draft permit conditions; and significant factual, legal and policy questions considered in preparing this draft permit) and the draft permit may be obtained at no cost at http://www.epa.gov/region1/npdes/draft_permits_listing_ma.html or by writing or calling EPA's contact person named below:

George Papadopoulos
U.S. Environmental Protection Agency – Region 1
5 Post Office Square, Suite 100 (OEP06-1)
Boston, MA 02109-3912
Telephone: (617) 918-1579
Papadopoulos.george@epa.gov

The administrative record containing all documents relating to this draft permit is on file and may be inspected at the EPA Boston office mentioned above between 9:00 a.m. and 5:00 p.m., Monday through Friday, except holidays.

PUBLIC HEARING**:**

The Regional Administrator has determined, pursuant to 40 C.F.R. § 124.12, that a significant degree of public interest exists in this proposed permit and that a public hearing should be held to consider this draft permit.

A public hearing and meeting (information session) will be held on the following date and time:

DATE:	Thursday, July 21, 2016
MEETING TIME:	6:15 p.m. - 7:00p.m.
HEARING TIME:	7:15pm
LOCATION:	Plymouth Public Library (side door entrance) ~~120 Central Street~~ **132 South Street** Plymouth, MA 02360
MEETING ROOM:	Otto Fehlow Meeting Room

In accordance with 40 C.F.R. § 124.12, the following is a summary of the procedures that shall be followed at the public hearing:

a. The Presiding Officer shall have the authority to open and conclude the hearing and to maintain order; and
b. Any person appearing at such a hearing may submit oral or written statements and data concerning the draft permit.

EXTENSION OF PUBLIC COMMENT PERIOD:

All persons, including applicants, who believe any condition of this draft permit is inappropriate, must raise all issues and submit all available arguments and all supporting material for their arguments in full by midnight **July 25, 2016**, to:

George Papadopoulos
U.S. Environmental Protection Agency – Region 1
5 Post Office Square, Suite 100 (OEP06-1)
Boston, MA 02109-3912
Papadopoulos.george@epa.gov

FINAL PERMIT DECISION:

Following the close of the comment period, and after the public hearing, the Regional Administrator will respond to all significant comments and will issue a final permit decision and forward a copy of the final decision to the applicant and each person who has submitted written comments or requested notice.

DAVID FERRIS, DIRECTOR
MASSACHUSETTS WASTEWATER MANAGEMENT PROGRAM
DEPARTMENT OF ENVIRONMENTAL PROTECTION

KEN MORAFF, DIRECTOR
OFFICE OF ECOSYSTEM PROTECTION
ENVIRONMENTAL PROTECTION AGENCY – REGION 1