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10 CFR 50
10 CFR 51
10 CFR 54

January 7, 2019

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Peach Bottom Atomic Power Station, Units 2 and 3
Renewed Facility Operating License Nos. DPR-44 and DPR-56
NRC Docket Nos. 50-277 and 50-278

Subject: Response to Request dated December 7, 2018 for Docketing of Additional Documents to Support NRC's Environmental Review of the Peach Bottom Atomic Power Station, Units 2 and 3, Subsequent License Renewal Application

References:

1. Letter from Michael P. Gallagher, Exelon Generation Company, LLC (Exelon), to U.S. Nuclear Regulatory Commission (NRC) Document Control Desk, "Application for Subsequent Renewed Operating Licenses," dated July 10, 2018
2. Email from Barbara Hayes, NRC, to Nancy L. Ranek, Exelon, "Additional Documents Needed for Peach Bottom SLR Environmental Review," dated December 7, 2018

In the Reference 1 letter, Exelon Generation Company, LLC (Exelon) submitted the Subsequent (i.e., Second) License Renewal Application (SLRA) for the Peach Bottom Atomic Power Station, Units 2 and 3 (PBAPS). In the Reference 2 email, the NRC requested that additional documents be docketed to support the Staff's review of the PBAPS SLRA Environmental Report (Appendix E to the SLRA). The table below lists the documents requested by the Reference 2 email and describes Exelon's responses.

Each document being provided for docketing is a separate enclosure to this letter, as indicated in the table.

Two of the documents being provided (Enclosures 13 and 14) were not prepared by Exelon or its contractors (i.e., they are "NonExelon" documents), and Exelon did not control development of the documents. Accordingly, while Exelon believes the information in those documents to be accurate and complete, we cannot make any specific representation as to their accuracy or completeness. The first page of each document is marked with the designation "NONEXELON," and the electronic file names include “NONEXELON.”

Enclosure #	Requested Document	Exelon's Response
01	Exelon Nuclear. 2005. "Letter to PADEP (T. Barron) regarding Peach Bottom Atomic Power Station Proposal for Information Collection for NPDES PA0009733." June 10, 2005.	The requested document is enclosed with file name: 01_ExelonNuclear_2005.pdf
02	Exelon Nuclear. 2008. "Letter to PADEP (L. McDonnell) regarding NPDES Permit PA0009733, Section 316(b) Cooling Water Intake Structure Evaluation." December 22, 2008.	The requested document is enclosed with file name: 02_ExelonNuclear_2008.pdf
03	[NAI] Normandeau Associates, Inc. 2000. "A Report on the Thermal Conditions and Fish Populations in Conowingo Pond Relative to Zero Cooling Tower Operation at the Peach Bottom Atomic Power Station (June-October 1999)." Prepared for PECO Energy Company. February 2000.	The requested document is enclosed with file name: 03_NAI_2000.pdf
04	[NAI] Normandeau Associates, Inc. 2010a. "Data Report on Intake Screen Sampling at Peach Bottom Atomic Power Station in 2010." Prepared for Peach Bottom Atomic Power Station. December 2010.	The requested document is enclosed with file name: 04_NAI_2010a.pdf
05	[NAI] Normandeau Associates, Inc. 2011a. "Data Report or Intake Screen Sampling at Peach Bottom Atomic Power Station in 2011." Prepared for Peach Bottom Atomic Power Station. December 2011.	The requested document is enclosed with file name: 05_NAI_2011a.pdf
06	[NAI] Normandeau Associates, Inc. 2012a. "Data Report or Intake Screen Sampling at Peach Bottom Atomic Power Station in 2012." Prepared for Peach Bottom Atomic Power Station. December 2012.	The requested document is enclosed with file name: 06_NAI_2012a.pdf
07	[NAI] Normandeau Associates, Inc. 2013a. "Data Report or Intake Screen Sampling at Peach Bottom Atomic Power Station in 2013." Prepared for Peach Bottom Atomic Power Station. December 2013.	The requested document is enclosed with file name: 07_NAI_2013a.pdf
08	[NAI] Normandeau Associates, Inc. 2013b. "Peach Bottom Atomic Power Station Entrainment Characterization Study 2012." Prepared for Exelon Generation. February 2013.	The requested document is enclosed with file name: 08_NAI_2013b_REDACTED.pdf A review revealed that Figures 2 and 3 in NAI 2013b are photographs of the PBAPS intake structure marked with the phrase "Non Record Content." Accordingly, pursuant to the Pennsylvania Open Records Law, Figures 2 and 3 have been redacted from the file that is provided.
09	[NAI] Normandeau Associates, Inc. 2014a. "Data Report or Intake Screen Sampling at Peach Bottom Atomic Power Station in 2014." Prepared for Peach Bottom Atomic Power Station. December 2014.	The requested document is enclosed with file name: 09_NAI_2014a.pdf

Enclosure #	Requested Document	Exelon's Response
10	[NAI] Normandeau Associates, Inc. 2015a. "Data Report or Intake Screen Sampling at Peach Bottom Atomic Power Station in 2015." Prepared for Peach Bottom Atomic Power Station. December 2015.	The requested document is enclosed with file name: 10_NAI_2015a.pdf Please note that the title page of the document being provided contains a title that is not consistent with the title given in the citation for the requested document. However, page 1 in the document contains a header that matches the title in the citation. Exelon has verified that "American Shad Sampling" and "Intake Screen Sampling" refer to the same sampling activities at PBAPS during 2015.
11	[NAI and ERM] Normandeau Associates, Inc. and Environmental Resource Management. 2014. "Final Report for the Thermal Study to Support a 316(a) Demonstration: Peach Bottom Atomic Power Station." Prepared for Exelon Generation. February 2014	The requested document is enclosed with file name: 11_NAI-ERM_2014.pdf
12	[NAI and ERM] Normandeau Associates, Inc. and Environmental Resource Management. 2017. "Final Report for Post-EPU Thermal and Biological Monitoring Peach Bottom Atomic Power Station." Prepared for Exelon Generation. February 2017.	The requested document is enclosed with file name: 12_NAI-ERM_2017.pdf
13 NONEXELON	[PADEP] Pennsylvania Department of Environmental Protection. 2011. "Letter to Peach Bottom Atomic Power Station (J. Brozonis) regarding NPDES Permit PA0009733 Entrainment Characterization Study Work Plan." May 5, 2011.	The requested document is enclosed with file name: 13_PADEP_2011_NONEXELON.pdf
14 NONEXELON	[PADEP] Pennsylvania Department of Environmental Protection. 2014b. "Letter to Exelon Generation Company, LLC (P. Navin) regarding "401 Water Quality Certification Peach Bottom Atomic Power Station Extended Power Uprate," DEP File No. EA 67-024, NRC Docket No. NRC-2013-0232, York and Lancaster County. July 23, 2014	The requested document is enclosed with file name: 14_PADEP_2014b_NONEXELON.pdf
15	[PECO] Philadelphia Electric Company. 1975. "Materials prepared for the Environmental Protection Agency, Section 316(a) Demonstration for PBAPS Units No. 2 & 3 on Conowingo Pond." July 1975.	The requested document is enclosed with file name: 15_PECO_1975.pdf
16	[PECO] Philadelphia Electric Company. 1977. "Section 316(b) Demonstration for PBAPS Units No. 2 & 3 on Conowingo Pond." June 1977.	The requested document is enclosed with file name: 16_PECO_1977.pdf
Not applicable	[NAI] Normandeau Associates, Inc. 2006. "Characterization of Mussel Habitat Utilization in the Vicinity of the Holtwood Hydroelectric Project." Prepared for Kleinschmidt Associates. March 2006.	The requested document was mistakenly cited in the PBAPS SLR Environmental Report (ER), Sec. 3.6.4.1.2, as "NAI 2006." The electronic file paired in Exelon's database of references for the PBAPS SLR Environmental Report with "NAI 2006" should have been cited as follows:

Enclosure #	Requested Document	Exelon's Response
		[FERC] Federal Energy Regulatory Commission. 2008. "Final Environmental Impact Statement for License Amendment. Holtwood Hydroelectric Project FERC Project No. 1881-050, Pennsylvania. FERC/EIS-0224F. November 2008. The FERC report, in which "NAI 2006" is named as a reference, is available on the internet at: https://www.ferc.gov/industries/hydropower/enviro/eis/2008/11-14-08.asp. Hence, no file for this document is provided.
Not applicable	URS Corporation. 2008. "316(b) Compliance Report With Source Waterbody Information, Impingement Mortality Characterization Study, and Design and Construction Technology Plan, Peach Bottom Atomic Power Station." Prepared for Exelon Corporation. June 2008.	The requested document is dated June 2008 and is an earlier version of Exelon Nuclear 2008 (see above Enclosure 2), which is dated October 2008. Accordingly, the information in URS Corporation 2008 is redundant. Hence, no file is provided for URS Corporation 2008.

This letter and its enclosures contain no regulatory commitments.

If you have any questions, please contact Ms. Nancy Ranek, Environmental Lead, Exelon Generation License Renewal, at 267-533-1506.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 7th day of January 2019.

Respectfully,

Michael P. Gallagher
Vice President - License Renewal and Decommissioning
Exelon Generation Company, LLC

Enclosures: 1 through 16

cc: Regional Administrator - NRC Region I (w/o Enclosures)
NRC Project Manager (Environmental Review), NRR-DMLR (w/o Enclosures)
NRC Project Manager (Safety Review), NRR-DMLR (w/o Enclosures)
NRC Project Manager, NRR-DORL Peach Bottom Atomic Power Station (w/o Enclosures)
NRC Senior Resident Inspector, Peach Bottom Atomic Power Station (w/o Enclosures)
Rich Janati, PADEP-BNR (w/o Enclosures)
D.A. Tancabel, State of Maryland (w/o Enclosures)

ENCLOSURE 1

01_ExelonNuclear_2005.pdf

Exelon Nuclear. 2005. "Letter to PADEP (T. Barron) regarding Peach Bottom Atomic Power Station Proposal for Information Collection for NPDES PA0009733." June 10, 2005.

Exelon Nuclear
Peach Bottom Atomic Power Station
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Exelon Nuclear

June 10, 2005

Thomas Barron
Pennsylvania Department of Environmental Protection
Office of Water Management
400 Market Street
Rachel Carson State Office Building
Harrisburg, PA 17105

Re: Peach Bottom Atomic Power Station
Proposal for Information Collection for NPDES PA0009733

Dear Mr. Barron,

Enclosed is the Proposal for Information Collection required by the Phase II 316(b) regulations promulgated by the USEPA for Peach Bottom Atomic Power Station. It is our understanding that you will be coordinating the Phase II 316(b) reviews with the other Agencies that you feel should review the required submissions. We look forward to working with the Department on this matter.

If you have questions on this proposal, please contact Daniel Jordan (717) 456-4551, or Tracy Siglin (610) 765-5904.

Sincerely,

Wade Scott

Wade Scott
Chemistry Programs Supervisor
Peach Bottom Atomic Power Station

ccn 05-14067

Cc: H. A. Ryan
Environmental Affairs, KS
Regulatory Affairs

Exelon®

EXELON GENERATION COMPANY, LLC

PROPOSAL FOR INFORMATION COLLECTION
Clean Water Act Section 316(b)

for

Peach Bottom Atomic Power Station
Delta, PA

Technical Consultants:

Normandeau Associates, Inc.
URS Corp.
Triangle Economic Research

May 26, 2005

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EXECUTIVE SUMMARY

Exelon Generation, L.L.C. (Exelon) is submitting this Proposal for Information Collection (PIC) to the Pennsylvania Department of Environmental Protection (PADEP) for the Peach Bottom Atomic Power Station (PBAPS) in accordance with the U.S. Environmental Protection Agency's Clean Water Act §316(b) Phase II Rule, 40 CFR 125. As you know, the PIC is the first submission required for compliance with the Rule, which pertains to existing sources of cooling water intake at electric generating stations. PBAPS is a Phase II Existing Facility as defined in 40 CFR 129.91.

PBAPS is a two-unit boiling water reactor facility with a capacity of 2,304 megawatts. Units 2 and 3 entered commercial service in 1974. Unit 1 is no longer in operation. The power plant is about 5 miles north of the Pennsylvania-Maryland border on the west shore of Conowingo Reservoir, which is the lowermost impoundment on the Susquehanna River in southeast Pennsylvania. Conowingo Reservoir was formed in 1928 with the construction of Conowingo Hydroelectric Station.

Since the facility withdraws cooling water from a reservoir, it is required to meet only the Phase II Rule's impingement performance standard (80 to 95% reduction). This is consistent with the determination that the EPA made in Appendix A of the Phase II Rule when it based its cost estimates on PBAPS only having to meet the impingement performance standard.

PBAPS uses a once-through cooling system to remove waste heat from the station's condensers. The circulating water for both units is withdrawn through an outer intake structure located on the western shoreline of Conowingo Reservoir, through two 3-acre intake basins (one serving each unit), and then through the original (inner) intake structure.

Exelon conducted a preliminary assessment of existing and potential technological, operational, and restoration measures to determine which would be most applicable and feasible at PBAPS and, thus, warrant further evaluation in the Comprehensive Demonstration Study (CDS). In addition to this assessment, Exelon conducted a preliminary evaluation of the potential benefits and costs associated with various compliance measures.

Exelon's preliminary assessment found that the original design to supply cooling water to Units 2 and 3 consisted of just the inner intake structure. When the plant was under construction, it was realized that most fish entering the intake canal would become trapped near the inner intake screens due to the high water velocity approaching the screens and the absence of lateral escape routes. Therefore, the fish would be exposed to the high intake velocities for long periods, resulting in exhaustion, impingement and death. Numerous fish swim speed tests were performed in order to select an appropriate intake velocity for a new intake structure that would minimize impingement. Consequently, the improved outer intake structure was subsequently installed at the mouth of the intake canal to reduce the intake velocity by approximately 70%.

Exelon considers the inner intake structure to be the baseline intake for which the calculation baseline rates of impingement mortality will be computed. Current impingement mortality at the outer intake will be evaluated against the calculation baseline to estimate the magnitude of reductions already achieved by installing the new intake structure. Based on a preliminary evaluation, we conclude that substantial reductions in fish impingement have been achieved due primarily to the much lower water intake velocity at the outer intake screens. PBAPS's seasonal reductions in circulating water volume also reduce impingement from baseline. Exelon will evaluate the previously implemented technological and operational changes in the CDS to determine how much progress has already been achieved toward meeting the performance standard.

Those measures that Exelon has selected for further analysis include technologies to improve the survival of impinged fish, flow reduction and technologies to reduce impingement, and natural resource restoration. Exelon anticipates that the review of compliance alternatives will include a site-specific cost benefit evaluation that compares the relative monetary value of the resource being protected to the cost of the fish protection measures being considered.

Intensive impingement sampling was conducted at PBAPS in November 1973 through March 1979. In most years since 1982, as part of the American shad restoration program, impingement of emigrating juvenile American shad has been monitored at the outer intake. In addition, fish sampling in Conowingo Reservoir was performed during 1996 – 1999 in support of zero cooling tower operation. Exelon believes that the existing impingement and fisheries data are sufficient to characterize fish species composition, size, timing, seasonal patterns, vulnerability to impingement, and factors that contribute to impingement.

In general, species composition of impinged fishes, except for the migratory fishes during the fall outmigration period, is similar to that observed during the intensive study period (1973 – 1979). In short, channel catfish, white crappie, bluegill, and gizzard shad are the most frequently impinged fish currently. However, Exelon is proposing additional impingement sampling to supplement and validate the existing data and to support our calculation of the impingement reductions already achieved.

As mandated by the Phase II Rule, this PIC accomplishes its objective of providing the PADEP with sufficient details on the information that Exelon intends to collect and evaluate in order to assure that the PBAPS CDS will fulfill the applicable requirements of the Phase II Rule.

1.0 INTRODUCTION

Section 316(b) of the Clean Water Act requires the U.S. Environmental Protection Agency (EPA) to ensure that the location, design, construction, and capacity of industrial cooling water intake structures reflect the best technology available (BTA) for reducing adverse environmental impacts. The Federal Rule implementing 316(b) performance standards for Phase II existing steam electric power stations was promulgated July 9, 2004 and became effective September 7, 2004.

This regulation requires that facilities reduce impingement mortality by 80 to 95% and, if applicable, entrainment by 60 to 90% from a calculation baseline. The Rule also provides a number of compliance alternatives to achieve these standards. Finally, the Rule allows site-specific determination of BTA based on cost and benefit analyses.

Exelon's PBAPS meets EPA's definition of a "Phase II Existing Facility" because it is:

- a point source requiring a NPDES permit that commenced construction before January 17, 2002,
- a generator of electric power for transmission or sale, and
- designed to withdraw greater than or equal to 50 million gallons per day (MGD) of water, at least 25% of which is used for cooling.

Determination of the applicable performance standards for PBAPS is based on the source water type. Since PBAPS withdraws cooling water from a reservoir, Conowingo Reservoir, the applicable performance standard is 80 to 95% reduction in impingement mortality. This is consistent with the determination that EPA made in Appendix A of the Phase II Rule when it based its cost estimates on PBAPS only having to meet the impingement performance standard.

Compliance with the final 316(b) regulations requires PBAPS to submit a PIC to the Director of the PADEP for review and comment. The PIC is the first submission required for 316(b) compliance.

This document is the PIC for PBAPS and is organized as follows:

- Section 1 describes the main requirements of the Phase II Rule and how it applies to PBAPS. It also provides information on the location, design, and operation of the facility and its cooling water intake structure system;
- Section 2 provides a preliminary review of technologies and operational and/or restoration compliance measures already implemented and the measures proposed to be evaluated further in the CDS;
- Section 3 summarizes past studies of impingement and discusses their relevance for development of PBAPS's CDS;

- Section 4 summarizes relevant historical consultations with the State and Federal fish and wildlife agencies;
- Section 5 describes the sampling plan for the new field study; and
- Section 6 presents other information available for PBAPS that will assist the Director in commenting on the CDS.

In preparing this PIC, we have relied on:

- existing design, construction and operational specifications for the cooling water intake systems;
- available ecological impact assessment data collected at PBAPS;
- information describing the ecology of Conowingo Reservoir;
- available literature about fish protection alternatives;
- generally accepted cost-benefit methodologies; and
- specific guidance provided by EPA during its rule making.

1.1 Facility Location

PBAPS is a two-unit boiling water reactor with a total output of 2,304 megawatts. Unit 2 began commercial operation in July 1974 and Unit 3 entered commercial service in December 1974. Unit 1 is no longer in service. The power plant is about 5 miles from the Pennsylvania-Maryland border on the west shore of Conowingo Reservoir, a 9,000-acre impoundment on the lower Susquehanna River in southeast Pennsylvania (Figure 1). Conowingo Reservoir was formed in 1928 with the construction of Conowingo Hydroelectric Station Project.

1.2 Cooling Water Intake System

PBAPS uses a once-through cooling system to remove waste heat from the station's condensers. The circulating water for both units is withdrawn from the Reservoir through an outer intake structure located on the shoreline of Conowingo Reservoir. The withdrawn water flows through two 3-acre intake basins (one serving each unit), and then through the original, inner intake structure (Figure 2).

The outer intake is about 500 ft long and 32 ft high. There are 29 trash racks on the face of the intake followed by a set of 24 vertical traveling screens. The trash racks, consisting of 0.25-inch by 3-inch steel bars spaced 3.5-inches on center, are designed to prevent large debris and ice from entering the intake. They are cleaned periodically on an as needed basis.

The traveling screens are located about 44 ft downstream of the trash racks. Each screen is 10 ft wide and has 3/8-inch mesh openings. The design average water velocity approaching the face of the screens (approach velocity) is no more than 0.75 ft/sec at low reservoir elevation and about 0.60 ft/sec at normal elevation. The average water velocity passing through the screen mesh (through-screen velocity), at normal reservoir level, is about 1 ft/sec. The screens are normally rotated when the pressure differential between the front and back of the screen reaches a particular level. During high debris loading and periods of icing, the screens can be rotated continuously. The screens can be rotated at either 5 or 10 ft/min. Debris (including fish) is removed from the screens by a front spray-wash system and washed into a sluiceway. The debris is dewatered as it passes over a vibrating screen at each end of the sluiceway and collected in a trash bin. No fish or debris are returned to the river.

Before reaching the inner intake, the water flows through the intake basins. The initially constructed intake was the single inner structure, which is close to the plant within the embayment or intake canal, as shown in Figure 2. When the improved outer intake was constructed, the intake canal became the basins between the two intake structures. Earthen dikes separate the basins from the Reservoir.

Water enters the inner intake through eight screen bays. Two bays screen the service water flows and six filter the water going to the circulating water pumps. The original standard vertical traveling screens in the circulating water bays were replaced with 3/8-in mesh dual-flow (dual-entry single-exit) traveling screens in the late 1990s to alleviate carry-over of trash to the condensers. These screens differ from standard traveling screens, such as those at the outer intake, in that the screen faces are rotated 90 degrees so that incoming water is filtered by both the ascending and descending sides of the screen. A benefit to this type of screen is that debris always stays on the upstream side of the screens, effectively eliminating any debris carryover to the clean side of the screens. The screens have a spray-wash system on the ascending side of the screens to clean them of debris and fish. Fish live and grow in the basins and can enter them in several ways, e.g., through the screens when they are small, carried over the screens if they are not removed during the screen cleaning process, and through the cross-tie gate from the discharge canal in winter (recirculation system). The materials removed from these screens are deposited in a dumpster or trash bin.

Approximately 47 ft downstream from the dual flow screens, there are the six circulating water pumps, three per unit, each with a capacity of about 361 MGD (250,880 gpm) for a facility total of 2,168 MGD (3,360 cubic feet per second [cfs]). Generally, Exelon operates all six pumps from April through October. From approximately November through March, Exelon operates four pumps to optimize plant performance. This operational change was initiated in 1984.

On an as-needed basis when ice or debris restricts water flow through the outer intake structure, a cross-tie gate between the discharge basin and the intake basin is opened to re-circulate some of the heated discharge water.

During passage through the condensers the temperature of the water is increased by about 21°F at full load. The heated non-contact cooling water is discharged into a common basin and flows down a 4,700-ft long canal to the Reservoir (Figure 2). Until 1997, approximately 58% of the cooling water was pumped through one or two helper cooling towers (as many as five were available) when needed on a seasonal basis to moderate the discharge temperature. The remainder of the discharge water was passed directly into the discharge canal. As a result of a 4-year fishery study of Conowingo Reservoir in 1996 to 1999, and with subsequent concurrence of the regulatory agencies, operation of the helper cooling towers was formally ended in 2001.

The entire circulating water flow is discharged to Conowingo Reservoir via a discharge structure located at the end of the discharge canal. The discharge structure contains one rectangular fixed opening and three regulating gates. The automatic operation of the three regulating gates maintains the velocity of the submerged jet discharge between 5 to 8 ft/s. The high velocity at the jet discharge provides relatively rapid dissipation of heat and discourages entry of large numbers of fish into the discharge canal.

1.3 Source Waterbody Description

Conowingo Reservoir, the lower most impoundment on the Susquehanna River, was formed in 1928 by the backwater of Conowingo Hydroelectric Dam (river mile 10). The Reservoir is bounded upstream by Holtwood Dam (river mile 24) built in 1914. PBAPS, which is at river mile 17, is approximately equidistant from the two dams (Figure 1). Prior to the construction of these dams and two other upstream dams (Safe Harbor at river mile 31 and York Haven at river mile 55), the natural river was wide, relatively shallow, and characterized by areas of swift current with a bottom largely of bedrock, much like which exists today downstream of Conowingo Dam and in the free flowing areas upstream of York Haven Dam.

Conowingo Reservoir has a surface area of about 9,000 acres and has a gross storage capacity of at least 310,000 acre-feet. It is 14 miles long and averages 1 mile in width. The average depth of the Reservoir is 20 ft with a maximum depth of nearly 90 ft in the lower Reservoir behind Conowingo Dam. The elevation at normal full Reservoir is 108.5 ft (Conowingo Datum) and the minimum for operation of Conowingo Hydroelectric Station is 98.5 ft. Reservoir elevation is normally maintained at 106.5 ft or higher for recreational use on weekends between Memorial Day and Labor Day and at levels no less than 104.5 ft at other times for operation of PBAPS.

Thermal stratification, typically characteristic of many temperate lakes and reservoirs, has not been observed in Conowingo Reservoir. However, during the summertime, generally at water temperatures exceeding 75°F and river flows <12,000 cfs, particularly in deeper areas of the lower third of the Reservoir, limited dissolved oxygen stratification can occur. However, this stratification usually is not strong or stable and quickly breaks down during periods of heavy rain or high winds (Mathur et al. 1987). The operation of PBAPS has not had a detectable effect on this phenomenon.

The volume and flow rates of the Reservoir are variable because of the controlled outflows and inflows that can occur on a daily basis from controlled inflows of up to

32,000 cfs from Holtwood Hydroelectric Dam and up to 31,000 cfs (during generation) from Muddy Run Pumped Storage Station (river mile 23). Controlled outflows of up to 85,000 cfs occur at Conowingo Hydroelectric Station and of up to 27,000 cfs (during pumping) at Muddy Run Pumped Storage Reservoir. FERC-mandated seasonally adjusted minimum flow requirements apply at Conowingo Dam while no minimum flow requirements exist at the upstream dams.

2.0 IMPLEMENTED AND PROPOSED COMPLIANCE TECHNOLOGIES

This section provides a brief discussion of the baseline for determining compliance with the impingement performance standard at PBAPS. It continues with a preliminary evaluation of existing implemented technologies. The primary technology already implemented to minimize impingement is the outer intake structure. In addition, seasonal flow reduction further reduces impingement. Finally, this section presents the results of a preliminary assessment of the technologies to be evaluated in the CDS.

As described previously, PBAPS must reduce impingement mortality by 80-95%. This reduction is measured from a "calculation baseline."

The calculation can be generalized as having three basic steps.

- Calculate the impingement mortality for the "baseline" condition,
- Calculate the impingement mortality after whatever technological fixes you propose to use or have already installed, and
- Demonstrate that the reduction attributed to technological or operational changes and/or restoration falls within the range of acceptable percentage reductions. (The site-specific approach is an exception.)

As described in the Phase II Rule, EPA's "baseline" consists of:

- Once-through cooling,
- Opening of the intake located at the shoreline near the surface,
- Standard 3/8-inch traveling screen oriented parallel to the shoreline, and
- Baseline practices, procedures, and structural configuration that the facility would maintain in the absence of any structural or operational controls, including flow or velocity reduction, implemented in whole or part for the purposes of reducing impingement mortality or entrainment.

Based on a preliminary assessment, "baseline" conditions at PBAPS are:

- Once-through cooling.
- The design features of original inner intake structure at the original shoreline of the Reservoir. This baseline intake lacks the design improvements which were built into the present outer intake to reduce intake velocity and to enable fish to escape from the screens, and thereby minimize impingement.
- The baseline intake is equipped with standard 3/8-inch traveling screens (not dual-flow) and has 10 screens to filter the circulating and service water flow.
- All impinged materials are deposited into a trash receptacle resulting in 100% impingement mortality.

- All of the circulating water pumps are always operated at full design flow and none of the heated effluent is re-circulated in the winter. Full design flow is passed through the baseline intake at all times.

2.1 Preliminary Evaluation of Implemented Technologies

In this section we describe the technologies and operational measures that have already been implemented at PBAPS and present a preliminary evaluation of the reduction in impingement mortality that has resulted from their implementation.

PBAPS currently operates as a once-through cooling facility, consistent with the baseline condition. Although the facility had helper cooling towers for part-time use, they are no longer required as a result of studies performed in the late 1990's which showed that the aquatic community was not being harmed by the thermal discharge.

The original design to supply cooling water for Units 2 and 3 consisted of only the inner intake structure. The intake has a total of six vertical traveling screens to filter the circulating water and four to filter service water. The original intake structure was built at the original shoreline of the reservoir. However, fill placed just upstream to create land for station facilities and just downstream for the cooling towers created a canal leading to the inner intake. The total screened area for circulating water was about 60 ft wide (six 10-ft wide screens) and 20 ft deep, for an estimated cross sectional area of 1,200 ft^2. Given the total circulating water intake volume of 3,360 cfs, the construction engineers estimated that the original configuration would have had an average intake approach velocity of about 2.8 feet per second (ft/s). This high velocity was deemed to be adverse for fish, based on high impingement rates observed at other cooling water intakes with similar high velocities. Thus, extensive studies (over 580 laboratory tests) of the swim speeds of resident and anadromous fishes were performed to determine the threshold escape velocity for the common fishes.

The results of these studies, combined with experience from other power stations and knowledge of fish behavior, provided a basis for the design modifications needed to minimize impingement. It was realized that most fish entering the intake canal would become trapped near the inner intake screens due to the high water velocity approaching the screens and the absence of lateral escape routes. Therefore, they would be exposed to the high intake velocities for long periods, resulting in exhaustion, impingement and death.

White crappie was found to be the weakest swimmer, generally unable to escape velocities exceeding 0.75 ft/s. Consequently, based on the swimming ability of white crappie, Exelon installed an improved outer intake structure to filter all of the water withdrawn from the Reservoir. The new structure was lengthened to approximately 500 ft to maintain an average intake approach velocity of less than or equal to 0.75 ft/s at the face of the screens at the lowest operating Reservoir level of 98.5 ft. The new intake was provided with 24 vertical traveling screens (12 per unit) equipped with 3/8-in mesh to filter all of the water going into the plant. Also, the new intake structure was located about 750 ft outward from the original inner screens site and set parallel with the new shoreline to provide fish with lateral escape routes, thus further minimizing impingement. Because the design Reservoir elevation for the velocity determination was conservatively set at 98.5 ft, the actual average velocity is less than 0.75 ft/s at the higher normal reservoir elevations. The 0.75 ft/sec design intake velocity of the outer screens represents about a 73% reduction in average intake velocity compared to the original intake configuration.

The combination of improvements built into the outer intake structure has substantially reduced the number of impinged fish. However, we lack impingement data for the original inner intake, which is the baseline, to calculate the percent reduction.

We note that reducing intake velocity by increasing the screened area has the same effect as reducing intake flow (volume) while keeping the screened area the same. This conclusion is consistent with EPA's finding that "*reducing intake by installing flow reduction technologies will result in similarly high reduction of impinged and entrained organisms,...*" (69 Fed. Reg. 41,612).

In addition, "*EPA believes the record contains ample evidence to support the proposition that entrainment is related to flow (see DCN 2-013L-R15 and 2-013J) while impingement is related to a combination of flow, intake velocity and fish swim speed (see DCN 2-029). ... Swim speeds of affected species as well as intake velocity must be taken into account to predict rates of impingement in relation to flow in order to account for the ability of juvenile and adult life stages of species to avoid impingement*" (emphasis added).

Thus, it is reasonable to conclude that the reduction in numbers of fish impinged has been substantial. Exelon will further evaluate the available data, perform a search for comparable data from other facilities, and may propose a field investigation designed to estimate the magnitude of impingement reduction that has already occurred at PBAPS.

Exelon has made additional progress toward achieving the national impingement performance standard due to intake volume reductions. The volume of cooling water withdrawn through the outer intake screens is reduced by one-third when four circulating water pumps instead of the full complement of six are operating, usually in November through March which correlates with the period when impingement is highest. This one-third reduction in flow and, consequently, intake velocity further reduces impingement rates. Some additional volume reduction also occurs when the cross-tie gate is opened to allow temporary recirculation of a portion of the heated effluent back into the intake basins when ice or debris restricts flow through the outer intake structure. Exelon will evaluate the impingement mortality reduction that occurs due to reducing the circulating water flow.

2.2 Preliminary Evaluation of Proposed Technologies, Operational Measures, and Restoration Options to be Further Evaluated in the CDS

Exelon conducted a preliminary evaluation of the technologies and operational measures that have potential to enable PBAPS to comply with the performance standard for impingement. Technologies were reviewed for compatibility with site-specific conditions, potential effectiveness, and cost. The technologies were screened to determine which are viable for the site and if further assessment is warranted.

Based on the preliminary evaluation, these compliance alternatives, technologies, and operational measures emerge as warranting consideration in the CDS:

- Demonstrate that selected technologies, operational, and/or restoration measures in place of or in combination with existing technologies meet the performance standard, or
- Site-specific BTA determination based on cost-benefit,

  with the following options or combinations of options:

  - Include progress already made toward achieving the performance standard by replacing the "baseline" intake structure with the improved outer intake structure and implementing flow reduction measures
  - Add a fish return system to the outer intake structure
  - Add fish baskets to the outer intake screens
  - Employ behavioral controls such as strobe lights and/or sound.
  - Make other modifications to the outer screens, e.g., incorporate smooth screening material to enhance fish survival
  - Replace the existing outer intake screens, e.g., with Geiger MultiDisc rotary screens incorporating fish handling technology
  - Obtain additional volume/velocity reduction through reduced (optimized) pump operation and recirculation of cooling water
  - Employ restoration, e.g., fish stocking or removal of dams on tributaries to the Susquehanna River that block passage of migratory fish
  - Evaluate other options that become apparent during CDS evaluation and appear justifiable.

2.2.1 Compliance Approaches

Exelon selected the two compliance approaches listed above based on the preliminary evaluation of the measures already implemented to reduce impingement mortality, fish species believed to comprise most of the impingement losses, the anticipated magnitude of current impingement, and preliminary assessment of the value of impingement losses at PBAPS. For the first compliance approach, Exelon will perform a more detailed evaluation of the magnitude of impingement reduction due to design and operational measures already adopted. Additional compliance measures will then be evaluated to determine those that will provide the incremental reductions needed to achieve the performance standard. The site-specific alternative is being advanced because many of the technologies evaluated thus far are likely to result in "costs that are significantly greater than the benefits." To further evaluate this supposition, Exelon intends to conduct a site-specific cost and benefits evaluation in the CDS.

2.2.2 Modify Screens, Install Fish Return System

Modification or replacement of the existing screens is being considered because the present traveling screen system does not have any provision for returning fish back to Conowingo Reservoir. An initial step will be to evaluate means of returning impinged fish back to the Reservoir as an incremental enhancement to the present intake screens. A further enhancement could include changes such as addition of simple fish baskets (not necessarily enhanced Ristroph baskets) to the screen panels and a low-pressure spray-wash and fish return system incorporated with more frequent or continuous rotation of the screens. This may be a viable approach to reduce impingement mortality sufficiently to achieve the performance standard in combination with other measures. In addition, this approach is consistent with EPA's determination in Appendix A of the Phase II Rule which identified the addition of a fish handling and return system to the existing traveling screen system at the outer intake as the most appropriate compliance technology for addressing impingement at PBAPS.

If necessary and justifiable within the limits of the benefit valuation, Exelon may evaluate more extensive changes to the outer intake structure. For example, vertical traveling screens equipped with Ristroph/Fletcher modified baskets and a fish return system have proven to yield high impingement survival rates at other large, once-through power plants. As an additional modification, if needed, the performance (impingement survival) of Ristroph/Fletcher-modified screens may be improved by including "smooth screen" technology, i.e., replacing the original coarse woven mesh with a smoother screening material. If screen replacement is justifiable, a relatively new technology, the Geiger Multidisc screen, may also be considered. This screening technology is installed and operating successfully at the D. C. Cook Plant on Lake Michigan and is currently being evaluated for impingement and entrainment reduction in a retrofit situation at a power plant on the Potomac River.

2.2.3 Behavioral Devices

Another option is to employ behavioral devices, such as sound or light systems, as an enhancement to one or more screen modifications to divert fish away from the intake structure before they contact the screens. Behavioral devices have limited potential to reduce impingement but may prove, upon further evaluation, to have the potential to be effective with the species at this facility to achieve incremental impingement reductions.

2.2.4 Operational Controls

Reduction in volume of water pumped is a proven way to reduce impingement and will be evaluated. Reducing the number of circulating water pumps in operation or use of variable speed pumps when the full design circulating flow is not needed for efficient plant operation will be further evaluated. Another measure that will be evaluated is recirculation of a portion of the heated effluent through the cross tie-gate between the discharge basin and the intake basins. Flow reduction can be implemented with other options, such as those previously mentioned, to achieve compliance with the performance standard.

2.2.5 Restoration

If restoration is not eliminated as a compliance option in the Phase II Rule, various restoration alternatives may be applicable to PBAPS and will be considered for the CDS. Most likely, potential restoration measures will be evaluated within the limits indicated by the benefits valuation.

3.0 LIST AND DESCRIPTION OF PREVIOUS STUDIES

The second regulatory requirement of the PIC involves providing a list and description of historical studies that characterize impingement mortality, entrainment, and the physical and biological conditions near the cooling water intake structures. In addition, the PIC must also describe the relevance of these data to developing the CDS.

A list of the historical studies that have been conducted for PBAPS is provided in Appendix A of this PIC. This section includes a summary of the relevant studies.

3.1 Historical Studies Listed in Appendix A

The impingement, fishery and entrainment studies conducted at PBAPS in the 1970s provided the basis for development of the station's 316(a) and 316(b) demonstrations which were issued in 1977. Numerous other studies in support of the demonstrations were performed over many subsequent years to further evaluate the effects of the station's thermal discharge and to evaluate the hydrothermal and biological characteristics in Conowingo Reservoir. Impingement and entrainment studies as well as other ecological, engineering and technical studies continued to be conducted through the late 1970s and early 1980s.

More recently, impingement sampling has been performed to monitor river herring and American shad takings on the intake screens during the fall out-migration period. In addition, a fisheries study to evaluate the effects of the thermal discharge was performed in the late 1990s to support elimination of the helper cooling towers at PBAPS.

3.2 Review and Evaluation of the Relevant Studies

The selection of technologies for fish protection at the PBAPS to meet the 316(b) performance standard is based, in part, on the species and life stages of the important fish subject to the effects of the intake structure, their spatial and temporal abundance, and their relative hardiness. Since the performance standard is based on reduction from a calculated baseline, some understanding of the fish communities in the source waterbody and their interaction with the intake structure is necessary to make predictions about the efficacy of potential compliance options. The studies previously performed at the PBAPS provide the information needed to achieve this understanding.

We performed a review of the study designs employed in the sampling programs for impingement to assess data adequacy and relevance to current conditions. Our review included:

- Sampling gear and deployment methods,
- Sampling frequency and periodicity,
- Sample processing, and

- Data analysis methods

Results of this examination show that:

- Sample collection gear and methods used for the impingement studies were state-of-the-art at the time they were employed. In addition, essentially these same methodologies have been used in more recent impingement studies conducted at similar facilities and would be applicable to impingement studies today.
- Sample design was adequate to describe diel, seasonal, and inter-annual variability. The field studies were performed over several years and sampling frequency was sufficient to describe diel and seasonal variability.
- Acceptable measures were employed to assure collection of quality data. In fact, several of the studies formed the basis of peer-reviewed technical publications.

We believe that the existing impingement and fish community data are sufficiently representative to characterize species composition, relative abundance, seasonal patterns, and vulnerability to intake impacts.

3.3 Summary of the Relevant Studies

Extensive fishery sampling of Conowingo Reservoir between 1966 and 1999 showed that the Reservoir supports a productive and diverse warm water fish community. Recent sampling, in 1996 – 1999, indicated patterns in temporal variation and spatial distribution similar to those observed in 1966 to 1980. Except for the species introduced in Conowingo Reservoir since 1966, the relative abundance of the previously designated representative important species (RIS) has not shown significant changes. However, the abundance of white crappie, though within the historical range, has declined since the introduction of gizzard shad, which is now the most abundant species. While the gizzard shad is numerically dominant, its population size in the Reservoir tends to fluctuate widely from year to year. The game fishes such as the smallmouth bass, largemouth bass, yellow perch and walleye are well represented. No designated threatened or endangered species are present, nor are any commercially harvested fishes present in the Reservoir.

The following fishes were designated as the RIS for the original 316(a) and 316(b) demonstrations for PBAPS: white crappie, channel catfish, bluegill, gizzard shad, smallmouth bass, largemouth bass, walleye, bluntnose minnow and spotfin shiner. The alewife, American shad, blueback herring and striped bass have been re-introduced during the last 30 years. Except for the American shad, large populations of the other species have not developed.

No large concentrations of fish have been observed near the PBAPS intake location, even prior to operation of PBAPS. Additionally, the thermal effluent from PBAPS has neither acted as a thermal barrier to the upstream movement of American shad nor does it impede the downstream winter movement of white crappie. The location of PBAPS was selected to minimize potential interference with fish spawning areas; studies had shown that major spawning areas of common fishes in Conowingo Reservoir do not occur near the PBAPS intake.

Records of fishes passed upstream at the Conowingo East Fish Lift and Holtwood Fish Lift provide additional data on the fish fauna of Conowingo Reservoir and species that may be impinged. Except for the migratory fishes, the species composition is similar to that observed in Conowingo Reservoir prior to the construction and operation of the fish lifts. Gizzard shad is the most abundant species passed at the lifts. American shad, blueback herring, and alewife have collectively comprised up to 35% of total fish passed dependent on prevailing hydrological conditions.

3.3.1 Impingement Studies

Intensive impingement sampling was conducted at PBAPS in November 1973 through March 1979. Sampling frequency varied from two to four 12-hour periods per week in 1973 through 1976 with four 12-hour periods the norm in July-September. After 1976, sampling generally was conducted weekly (one 24-hour sample per week). Fish were identified, measured, and weighed.

More recently in most years since 1982, as part of the American shad restoration program, impingement of emigrating juvenile American shad on outer intake screens has been quantified during fall. Sampling has occurred three times weekly, generally from October through mid-December. The out-migration data provide information on size, timing, and origin (hatchery versus wild) of juvenile American shad outmigrants. Although the primary focus of this program has been for enumeration of American shad impinged, information on other fishes was also obtained.

In general, species composition of impinged fishes, except for the migratory fishes during the outmigration period, is similar to that observed in these same months during the intensive, quantitative study period (1973 – 1979). The number of taxa impinged during the outmigration period (generally September through mid-December) has ranged from 14 to 27 with gizzard shad dominating the collections (channel catfish and bluegill were the other numerous species). Although impingement rates appear to be affected by a host of hydrological-physical factors and the year-class strength of the particular fishes, the number of alosids (American shad, blueback herring, and alewife) observed in impingement collections appears to be dependent on numbers of adult alosids passed by fish lifts and the numbers of young American shad stocked annually by the Pennsylvania Fish and Boat Commission.

In the historic studies, channel catfish, white crappie, bluegill, and gizzard shad were most frequently impinged. Most of these fishes averaged less than 120 mm (ages 0 and 1). In general, impingement rates for the most common fishes were highest from November to March. However, average rates were affected by a few episodes of high impingement coincident to exceptionally high river flows. We believe that the existing

4.0 AGENCY CONSULTATIONS

Exelon submitted the initial 316(b) demonstration to the PADEP (then DER) in 1977. Subsequently, PADEP sent Exelon notice that they accepted the conclusions of the document which demonstrated that Best Technology Available was employed at the facility.

Exelon did not hold any further discussions specific to 316(b) at PBAPS until November 19, 2004 when Exelon met with PADEP representatives to discuss the Phase II 316(b) implementation process in general. PADEP did not raise any specific issues or concerns with respect to impingement and entrainment at PBAPS. Subsequently, on May 25, 2005, Exelon met with representatives of the PADEP, Pennsylvania Fish and Boat Commission, and Maryland Department of Natural Resources to review the draft PIC. No other consultations that are relevant to compliance with the §316(b) Rule have occurred with any environmental or fish and wildlife agency.

5.0 PLANS FOR ADDITIONAL INFORMATION COLLECTION

This section describes the field study we propose to conduct at PBAPS. The objective of the sampling program is to determine the species and numbers of fish impinged on the traveling screens at the PBAPS outer intake structure. Data collected in this sampling program will also be used to identify temporal trends in impingement abundance, to evaluate the utility of the existing impingement study data, and to support preparation of the CDS.

Exelon also intends to collect additional data to support evaluation of impingement at PBAPS and evaluation of technologies, operational measures, and/or restoration measures. However, specific plans for these efforts will depend on additional evaluation of the measures already implemented to reduce impingement. These additional data collection efforts will not affect how the proposed study to develop a scientifically valid estimate of current impingement is performed, but it is expected that the new data will validate and support the calculations of impingement reductions that have occurred due to Exelon's design improvements and operational measures.

5.1 Impingement Sampling Design

Impingement sampling will be performed over one 24-hour sampling event per week at each outer screenhouse over a 1-year period. Each weekly sampling event will be scheduled for the same day each week to assure systematic spacing of the events. In some weeks, holidays, equipment or plant operations may interfere with this schedule and an adjustment of a day or two may be necessary.

Note that the screens are normally run in response to a pressure (head) differential, but that they may run continuously when debris loads are high, usually as a result of high river flows associated with storms or when icing is expected. Therefore, provision will be made with the station personnel to assure the screens are operated when needed for sampling and to identify periods when the screens may be running continuously. Coordination with PBAPS personnel would occur to identify periods when screen or other equipment is undergoing maintenance which could interfere with impingement sampling.

The weekly sampling events will not be subdivided into predominantly day and night collection periods on a routine basis to obtain information about diel variability in impingement since PBAPS consistently operates at a constant high generation level. Variable operation of PBAPS to take advantage of diel differences in impingement is not a viable compliance option.

5.2 Sample Collection at the Trash Bins

Each weekly sampling event will start by running the screens for at least one revolution to clean them of previously impinged fish. The organisms from this initial cleaning run will to be disposed of as per the normal practice at the facility. After the cleaning run, a clean net or basket, trash receptacle, or other device will be installed to capture the impinged fish from the periodic screen cleanings during the impingement sampling event. Fish collected from the subsequent periodic screen cleanings (the sample collection periods) constitute the periodic samples. Starting with a clean bin or placing a net over the bin will adequately collect the sample for each sample collection period. If a net or basket is used, it will have a mesh size smaller than the mesh size of the intake screens (3/8-inch) to help assure adequate capture of the impinged fish.

5.3 Sample Processing

For each sample collection period (within each weekly sampling event), the fish will be separated from the debris, identified to species, categorized as to condition, and enumerated. If there are two size groups (e.g. young of the year and older) then each size group will be enumerated, measured and categorized as to condition separately. If possible, the impingement sample technician will be on-hand to observe the sampling run of the screens in order to determine the condition of impinged fish as soon as they are collected.

Fish will be identified to species and at least 20 individuals of each species or size group (age class) in each sample will be measured for total length to the nearest millimeter. If excessive numbers of a particular species are collected in a sample, the total number in each length group for that species will be estimated from a sub-sample count or weight extrapolation. Care will be taken that the sub-sampling technique is random to minimize size bias.

For each sample the following information will be recorded on the appropriate data sheets:

- Date and time of the day at the start and end of each sample.
- Fish enumerations, measurements and observations of condition.
- Intake water temperature and dissolved oxygen at the start and end of each sampling period.
- Identification of the circulating and service water pumps in operation for each unit during the sampling period.
- Identification of the screens in operation during the sampling period.
- Note if the cross-tie gate is in open and heated water is being re-circulated, obtain any available information about the use of the tie-gate during the sampling period.
- Reservoir water level.
- Names of the sample collectors.
- Any deviations from the sampling protocol, unusual conditions, or other pertinent observations (e.g., observations of dead/moribund gizzard shad drifting into the intake).

5.4 Fish for Collection Efficiency Tests

After analysis, specimens needed for the next collection efficiency study will be retained. At least 100 fish per species/length class are needed for each calendar quarter's release, of those species making up at least 10% of the quarter's total collection. The fish will be frozen until needed. If representatives of those species making up more than 10% of a quarter's total collection are not available, substitutes may be selected from species of comparable size and body shape, purchased or obtained elsewhere.

5.5 Collection Efficiency Studies

The purpose of the collection efficiency testing is to determine the percentage of fish placed directly on the screens that are subsequently recovered in the impingement collections. Studies at many power plant cooling water intakes have shown that the impingement sampling may underestimate the number of fish that are actually being impinged because some proportion of impinged fish may be consumed by predators, pass through openings in the screening structure, carry over to the clean side of the screens, etc.

Collection efficiency studies will be conducted when the species of interest (dominant or numerically high ranking fish) are available and numerous in the collections. Studies will be conducted periodically, at least quarterly or on a modified schedule if needed to accommodate the presence of the species of interest. A target number of 100 marked/tagged dead fish per species and length class (if available) are to be released as close as possible to face of the traveling screens at the start of a 24-hr sampling event. Several screens encompassing both units will be evaluated. The actual number released and the number subsequently recovered in each size class over the following 24 hr will be recorded. No subsampling will be allowed on sampling dates on which collection efficiency studies are conducted.

5.6 Sample Handling

When processing of a sample is complete, we will determine the disposition of the sample (whether to discard it or subject it to QC procedures for counts and identifications). After fish for collection efficiency testing and any fish needed for the reference collection or needing verification have been removed from the sample, the specimens will be discarded into the trash bin. All young American shad will be provided to the Pennsylvania Fish and Boat Commission so that they can determine if the specimens are of wild or hatchery origin.

5.7 Quality Assurance and Control

A detailed Standard Operating Procedure and Quality Assurance Project Plan will be prepared to govern the performance of this study prior to initiating the field collections. Fish identifications, counts, and measurements will be subject to QC checks. Field instruments will be calibrated prior to each sample event. Data entry and processing will also be subject to quality checks. QA audits and tests will be performed periodically to verify the achievement of quality during the study and to indicate when corrective action is needed.

5.8 Data Analysis and Reporting

Numbers of fish impinged for each weekly 24-hr sampling event will be used to calculate the number of fish impinged per week and these will be summed to develop the annual totals. Impingement data from the sampling periods within 24-hr sampling events will be evaluated to determine diel variation. The periodic collection efficiency tests will indicate the correction factors that need to be applied to the data to develop the total impingement numbers.

Seasonal and annual descriptions of species composition and abundance will be provided. The results from this new study will be compared to impingement data obtained in previous studies at PBAPS to assess annual variability and will be compared with other data sets that may be available or applicable.

6.0 OTHER INFORMATION

The final component of the PIC involves providing other information that will aid the Director in reviewing and commenting on the plans for developing PBAPS's CDS. This section presents an overview of some studies and plans required for the site-specific determination of BTA.

6.1 Benefits Valuation Study

The Phase II 316(b) Rule allows for site-specific impingement and entrainment reduction requirements based on cost-benefit assessment. Specifically, a demonstration that the costs of technological compliance with the performance standards is significantly greater than the benefit allows for lesser reduction in impingement and entrainment or the use of restoration to achieve compliance. A Benefits Valuation Study (BVS) is required for this assessment and is based on a comprehensive methodology to value the impacts of impingement mortality and entrainment at the site and the benefits of complying with the applicable performance standards. The BVS study plan will include:

- A description of the methodology(ies) used to value commercial, recreational, and ecological benefits (including any non-use benefits, if applicable).
- Documentation of the basis for any assumptions and quantitative estimates.
- An analysis of the effects of significant sources of uncertainty on the results of the study.
- If requested by the Director, a peer review of the items submitted in the BVS. The facility operator would choose the peer reviewers in consultation with the Director who may consult with EPA and Federal, State, and Tribal fish and wildlife management agencies with responsibility for fish and wildlife potentially affected by your cooling water intake structure. Peer reviewers must have appropriate qualifications depending upon the materials to be reviewed.
- A narrative description of any non-monetized benefits that would be realized at your site if the facility were to meet the applicable performance standards and a qualitative assessment of their magnitude and significance.

There are a number of inputs to developing a BVS for an individual facility. The following list describes the inputs and the methods that will be used for each.

<u>Convert impingement and entrainment sample data to annual estimates:</u>

The BVS will use a sample-period weighted extrapolation to convert the sample data to annual loss estimates.

Determine the number of Age-1 equivalents impinged and/or entrained:

The BVS will use EPA's life history parameters to determine the number of Age-1 equivalents impinged or entrained.

Determine the ratio of caught to uncaught fish:

The value of impingement and entrainment reductions depends on whether or not spared organisms are harvested. This determination will be based on EPA assumptions of catch by species.

Determine commercial versus recreational breakdown:

Harvested fish are valued differently in the commercial and recreational markets. This determination will be based on EPA assumptions regarding recreational and commercial catch.

Determine commercial impacts:

This determination will employ EPA's percent change in dockside value approach.

Determine recreational impacts:

Recreational impacts are the largest benefit category in EPA's national analysis. In this analysis, EPA employs regional random utility models (RUMs) to estimate the dollar value impacts from increases in catch rates. The BVS will use these models to develop a rigorous benefits transfer.

Address nonuse values of uncaught fish:

EPA requires a narrative description of non-monetized benefits and a qualitative assessment of their magnitude and significance. The BVS will provide this narrative description.

Include uncertainty analysis:

Analysis of uncertainty in recreational benefits estimates may include bootstrapping to address sample variance, Monte Carlo Analysis for model variance, and an interactive evaluation of variance arising from model specification.

6.2 Comprehensive Cost Evaluation Study

The Comprehensive Cost Evaluation Study component of the CDS must include engineering cost estimates for implementing design and construction technologies, operational measures, and/or restoration measures that would comply with 316(b) performance standards. The three components of the Comprehensive Cost Evaluation Study are:

- Engineering cost estimates of technologies/measures to meet the applicable performance standards, expressed as Net Present Value including energy penalties, carrying charges, as examples discussed below

- Demonstration of cost-benefit test.
- Engineering cost estimates to document the cost of technologies/measures in the Site-Specific Technology/Restoration Plan.

6.3 Site-Specific Technology Plan

If Exelon requests a site-specific determination of BTA, this plan will be included in the CDS. This plan is required to contain:

- A narrative description of the design and operation of all existing and proposed design and construction technologies or operational measures and/or restoration measures that we have selected.
- An engineering estimate of the efficacy of the proposed and/or implemented technologies and/or measures based on representative studies at existing facilities and, if applicable, site-specific prototype or pilot studies.
- A demonstration that the proposed and/or implemented technologies and/or measures achieve an efficacy that is as close as practicable to the performance standards without resulting in costs significantly greater than the benefits of complying with the applicable performance standards.

6.4 Site-Specific Restoration Plan

The final Phase II Rule states that EPA views restoration measures as part of the "design" of a cooling water intake structure and considers restoration measures one of several technologies that may be employed to minimize adverse environmental impact. If restoration remains an option in the Phase II Rule, Exelon will consider small restoration projects to achieve compliance.

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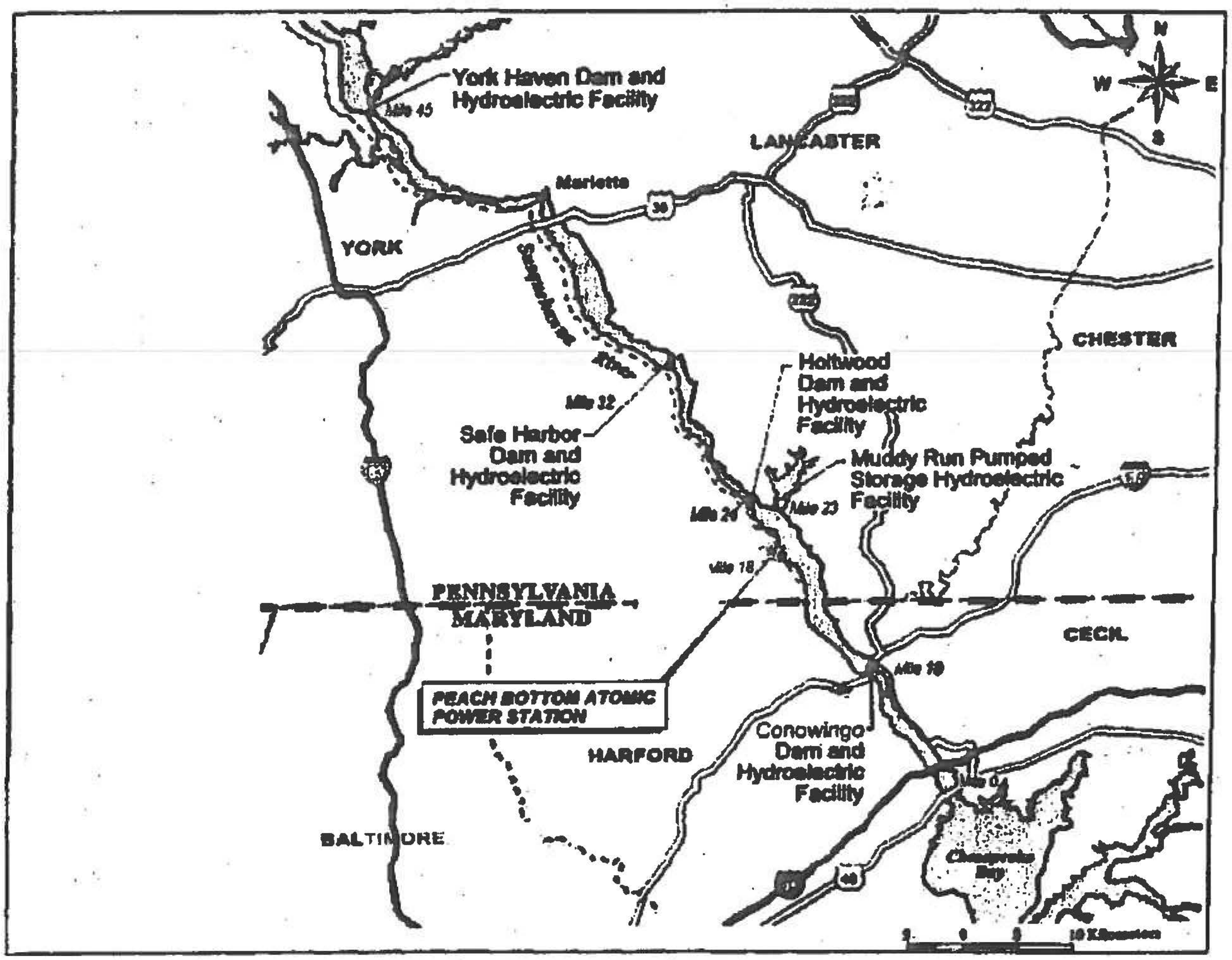

Figure 1. Map of Conowingo Reservoir showing locations of Peach Bottom Atomic Power Station and other power plants.

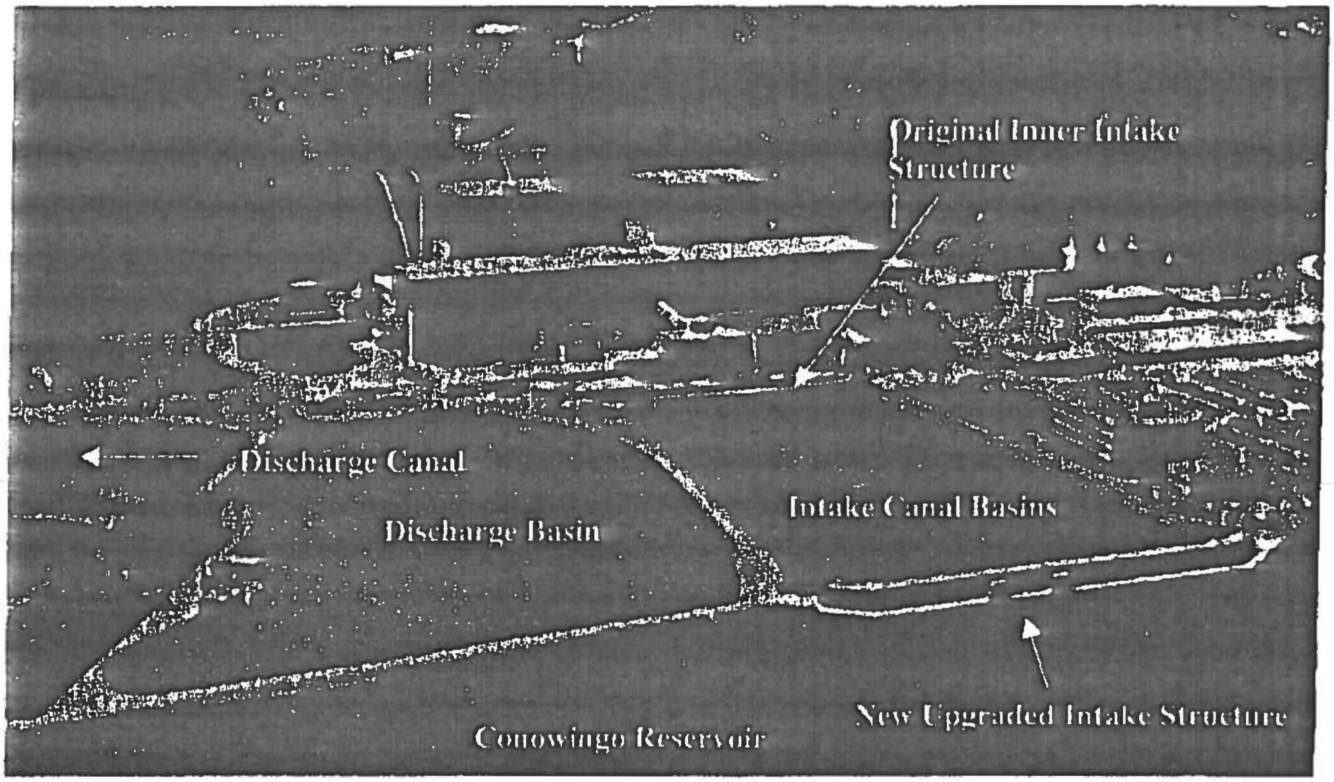

Figure 2. Peach Bottom Atomic Power Station's cooling water intakes and discharge.

APPENDIX A

List of Historical Studies

316(b) and Related

316(b) Demonstration

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Peach Bottom Atomic Power Station
1848 Lay Road
Delta, PA 17314

www.exeloncorp.com

Exelon.
Nuclear

December 22, 2008

Mr. Lee McDonnell, Manager
Water Management Program
Pennsylvania Department of Environmental Protection
South Central Regional Office
909 Elmerton Avenue
Harrisburg, PA 17110

Re: Exelon Generation Company LLC - Peach Bottom Atomic Power Station
NPDES Permit PA0009733
Section 316(b) Cooling Water Intake Structure Evaluation

Dear Mr. McDonnell,

Enclosed please find two copies of the 316(b) Cooling Water Intake Evaluation for Peach Bottom Atomic Power Station. The report includes the Source Waterbody Flow Information, the Impingement Mortality Characterization Study (IMCS), and the Design and Construction Technology Plan (DCTP).

If you have questions or require additional information, please contact Tracy Siglin, (610) 765-5904 or tracy.siglin@exeloncorp.com.

Sincerely,

Garey L. Stathes

Garey L. Stathes, Plant Manager
Peach Bottom Atomic Power Station.

CCN 08-108

316(b) COMPLIANCE REPORT WITH SOURCE WATERBODY INFORMATION, IMPINGEMENT MORTALITY CHARACTERIZATION STUDY, AND DESIGN AND CONSTRUCTION TECHNOLOGY PLAN

PEACH BOTTOM ATOMIC POWER STATION

Prepared for:

Exelon

by URS Corporation

October 2008

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Executive Summary

Section 316(b) of the Clean Water Act requires the location, design, construction, and capacity of Cooling Water Intake Structures (CWIS) reflect the Best Technology Available (BTA) to minimize Adverse Environmental Impact (AEI).

In 2004, the United States Environmental Protection Agency (USEPA) promulgated a rule for existing facilities to establish National Performance Standards for the reduction of impingement mortality and/or entrainment from a calculated baseline configuration. In 2007, the 2nd Circuit Court remanded several key components of the rule. As a result of this ruling the USEPA suspended the rule and its requirements. The USEPA also instructed the State Agencies to use their Best Professional Judgment (BPJ) to determine BTA for the CWIS.

Peach Bottom's assertion is that the baseline configuration is the original intake design consisting of the Intake Canals and the Inner Screen Intake only. The installation of the Outer Screen Structure was designed and installed to reduce the through screen velocity and, therefore, minimize the amount of impingement occurring at the facility.

The Pennsylvania Department of Environmental Protection (PADEP) has issued letters to facility owners specifying submittal requirements or has included those requirements in newly issued permits. These submittal requirements include information on the source water body, intake structure design and operation, impingement mortality (IM) characterization study, and a Design and Construction Technology Plan (DCTP).

The DCTP is to include an evaluation of the efficacy of the current intake structure and other technologies and operational practices employed at the facility for minimizing the environmental impacts. The DCTP should also contain information on the capacity utilization of the intake structure and the facility.

Peach Bottom's position is that the Outer Screen Structure was designed and installed to reduce impingement compared to the original design of the smaller inner screen intake and the intake canals. This technology has minimized adverse environmental impacts of the operation of Peach Bottom. Data shows that the operation of Peach Bottom has minimal effect on the biology of Conowingo Pond. The diversity and relative abundance of the aquatic populations are unchanged from the levels before operation at Peach Bottom began.

Calculated annual impingement at PBAPS, using the results of the current IM study at the outer intake structure, is 221,421 fish whereas the Calculation Baseline, estimated for the original inner intake structure, is 1.47×10^6 fish. Thus, a reduction in IM of approximately 85 percent from the Calculation Baseline is already achieved by the installation of the outer intake alone. Since the design, location, and operation of Peach Bottom's intake structure minimizes impingement mortality and therefore adverse environmental impact, it is the best technology available.

Introduction

Regulatory Background

This report provides information requested by the Pennsylvania Department of Environmental Protection (PADEP or the Department) to demonstrate that Exelon's Peach Bottom Atomic Power Station (PBAPS) cooling water intake structures (CWIS) reflect the Best Technology Available (BTA) for minimizing adverse environmental impacts.

Section 316(b) of the Clean Water Act requires the U.S. Environmental Protection Agency (EPA) to ensure that the location, design, construction, and capacity of industrial CWIS reflect the BTA for reducing adverse environmental impacts. The Federal Rule implementing 316(b) performance standards for Phase II existing steam electric power stations was promulgated July 9, 2004 and became effective September 7, 2004.

This regulation required that facilities reduce impingement mortality (IM) by 80 to 95 percent and, if applicable, entrainment by 60 to 90 percent from a Calculation Baseline. The Rule also provided a number of compliance alternatives to achieve these standards. Finally, the Rule allowed site-specific determination of BTA based on cost and benefit analyses.

Exelon's PBAPS meets EPA's definition of a "Phase II Existing Facility" since it meets the following four criteria stated in §125.91:

- It is a point source;
- It uses CWIS with a total design intake flow of 50 million gallons per day (MGD) or more to withdraw cooling water from waters of the United States;
- As its primary activity, it both generates and transmits electric power, or generates electric power but sells it to another entity for transmission; and
- It uses at least 25 percent of water withdrawn exclusively for cooling purposes, measured on an annual basis.

In accordance with the Proposal for Information Collection (PIC) submitted to and revised by the Department, PBAPS is subject only to the performance standards for IM.

On January 25, 2007, the U.S. Court of Appeals, Second Circuit vacated or remanded portions of the Rule in its decision in Riverkeeper, Inc. v. EPA 475 F.3d 83 (2nd Cir.2007) (Riverkeeper II Decision). EPA subsequently suspended the Rule on July 9, 2007 and instructed permitting authorities to develop Best Professional Judgment (BPJ) controls for existing facility CWIS that reflect the BTA for minimizing adverse environmental impacts.

Subsequently, PADEP has indicated that they will request that owners/operators of facilities with existing CWIS provide information to demonstrate BTA for minimizing adverse environmental impacts. Since the design, location, and operation of Peach Bottom's intake structure minimizes impingement mortality and, therefore, adverse environmental impact, it is the best technology available.

The applicable information required for PBAPS includes the following:

- Impingement Mortality Characterization Study

- Design and Construction Technology Plan

This document is intended to:

- Provide information requested by PADEP.
- Provide information on the environmental impacts of IM on Conowingo Pond to support a BPJ determination of BTA at PBAPS.

This report, containing five documents, three appendices and two attachments, is organized into the following sections:

SECTION 1	Facility Description & Classification		
SECTION 2	Impingement Mortality Characterization Study		
SECTION 3	Narrative Description of Design and Operating Measures and Demonstration of the Efficacy		
SECTION 4	Assessment of Environmental Impact of Impingement Mortality on the Conowingo Pond Populations		
SECTION 5	Conclusion		
SECTION 6	Appendices and Attachments		
		Appendix A	Detailed Characterization of the Aquatic Resources and Impingement Mortality at the Peach Bottom Atomic Power Station
		Appendix B	List of the Historical Studies Conducted at the Peach Bottom Atomic Power Station
		Appendix C	Summary of Fish Impingement Sampling at Peach Bottom Atomic Power Station Conowingo Pond, Pennsylvania 2005-2006
		Attachment I	40 CFR §122.21(r) NPDES Application Requirements for Facilities with Cooling Water Intake Structures
		Attachment II	Statistical Analysis of Impingement at Peach Bottom Atomic Power Station, 2005-2006

SECTION 1

FACILITY DESCRIPTION & CLASSIFICATION

FOR

PEACH BOTTOM ATOMIC POWER STATION

Prepared for:

Exelon

by URS Corporation

October 2008

1.0 Facility Description & Classification

1.1 Facility Description

PBAPS is a two-unit (Units 2 & 3) nuclear-fueled boiling water reactor electric power generating facility with a generating capacity of nominally 2,304 megawatts (MW). Unit 2 began commercial operation in June 1974 and Unit 3 entered commercial service in December 1974. The facility is located in York County, Pennsylvania on the west shore of the Conowingo Reservoir (also known as Conowingo Pool or Conowingo Pond; henceforth called "the Pond" or "Conowingo Pond" in this report) at River Mile (RM) 18, about 5 miles upstream from the Pennsylvania-Maryland border (see location map and aerial photograph in Attachment I, 40 CFR §122.21(r) NPDES Application Requirements for Facilities with Cooling Water Intake Structures). Three hydroelectric dams in the lower Susquehanna River form a reservoir system stretching 32 river miles (Hainly et al. 1995). These are: Conowingo Dam at about RM 10, Holtwood Dam at about RM 25, and Safe Harbor Dam at about RM 32. Conowingo Dam, located in Maryland, creates the Conowingo Pond that extends about 14 miles upstream into Pennsylvania. PBAPS is located on the west side of the Susquehanna River within the Conowingo Pond.

PBAPS withdraws water for its cooling and service/process water needs from the Conowingo Pond through an outer intake structure located on the shoreline. Water flows through the screens of the outer intake structure, through two 3-acre intake ponds (one serving each unit), and then through an inner intake structure/pumphouse. These components supply water for once-through cooling of the main condensers and for plant services (process/equipment needs). (Attachment I, Figure 1)

1.2 Circulating Water System

The existing configuration at PBAPS includes an outer intake structure located on the shoreline of Conowingo Pond and an original inner intake structure. Neither the inner nor the outer structures have a fish handling system. Thus, there is 100 percent IM at the facility. The PBAPS CWIS provides a continuous supply of water from the Conowingo Pond to Units 2 and 3.

The outer screenhouse structure is approximately 480 feet long and 32 feet high. The structure occupies the water column from the surface down to the level of the bottom of the trash racks, at an elevation of 84'-0" (Conowingo Datum[1]). The operating floor level of the screenhouse is at elevation 116'-0" (Conowingo Datum) and is enclosed with walls and a roof. To prevent large debris and ice chunks from entering the intake, there are 29 active trash racks with ¼-inch wide by 3-inch deep steel bars spaced 3 ½ inches on center on the face of the outer intake structure. Divers manually clean the trash racks periodically when needed and collected debris is disposed of offsite. Structures for a previous automatic raking system with a manual collection system are still in place. Twenty-four traveling water screens (12 per unit) are located approximately 44 feet inboard of the trash racks. Each screen, most recently rebuilt by Hawco Screens, Inc., is 10 feet wide with a ⅜-inch square opening mesh. Debris, including fish, is removed from

[1] The Conowingo Datum, used exclusively at PBAPS, is 0.7 feet below the NGVD 1929 datum.

the screens by a high-pressure spray-wash system on the ascending side of the screens to sluiceways (one per unit). The debris from the screens is collected in dumpsters and disposed of offsite.

Water flows from the outer screenhouse structure into two intake basins (one per unit) before reaching the inner screenhouse structure. Water from the basins enters the inner screenhouse structure through eight bays (4 per unit). Six of the bays, each with their own traveling screen, direct the water to six circulating water pumps (3 per unit). These screens are dual-entry, single-exit (dual-flow) traveling screens, originally manufactured by FMC, with ¼-inch by ½-inch opening mesh. The remaining two bays (one bay per unit) have four traveling screens installed (2 per bay), which are a single-entry, single-exit (through-flow) design. The water pumped from these two bays provides service water to the units. Debris, including fish, is removed from the screens by a high-pressure spray-wash system on the ascending side of the screens to sluiceways (1 per unit). The debris is collected in dumpsters and disposed of offsite.

Approximately 47 feet downstream of the inner dual-flow and through-flow screens are the six circulating water pumps (3 per unit) and six service water pumps (3 per unit), respectively.

The pumps that withdraw water from the intake structure and their design flow rates are shown in Table 1-1.

The CWIS operates to provide a continuous supply of water from the Pond to PBAPS for once-through cooling of the main condensers, when condenser cooling is required, and for other plant service water needs.

Table 1-1 PBAPS Intake Pump Design Capacities

Operation	Number of Installed Pumps	Design Flow (gpm)[1]
Condenser Cooling	6 (3 per unit)	250,000 each
Service Water	6 (2 and 1 spare per unit)	14,000 each
High Pressure Service Water	8 (4 per unit)	4,700 each
Emergency Service Water	2 (common to both units)	8, 000 each
Outer Screen Wash	3 (1 per unit and 1 common to both units)	4,400 each[2]
Inner Service Water Screen Wash	2 (1 per unit)	475 each
Fire Protection	2 (1 electric and 1 diesel driven)	2,500 each

[1]These flow capacities are based on the pump manufacturer's ratings and do not account for dual operation head loss, pipe capacity, and other "as-built" conditions.
[2]These pumps withdraw water from the condenser discharge (not the intake).

The six circulating water pumps are started up, as required, for condenser cooling during plant startup to generate electricity and shut off when no longer required. Certain operational measures at PBAPS result in flow variations. Through most of the year (April through October), all six circulating water pumps are in operation. However, in the winter months (late November/early December through March) lower water temperatures in the Pond generally allow for two pumps (one per Unit) to be shut down. Once a year, for approximately one month, one unit is shut down for refueling and maintenance, leaving only three pumps in operation for the other operating unit.

The various service water pumps are started when necessary to meet the normal and emergency plant demands during plant operation or shutdown, and shut off when no longer required. Normally, two service water pumps per unit run to supply water for equipment and building cooling, to water treatment facilities for production of domestic and demineralized water, and for washing of the traveling screens in the inner screen structure associated with the circulating water pumps. One service water pump per unit is an installed spare. Normally, the other service water pumps (i.e., the high pressure and emergency service water pumps) and Fire Protection Pumps are maintained in standby for operation as necessary only during plant shutdown, in the event of an emergency, or required testing. Each pump bay is provided with a sluice gate, which may be closed in the event of high or low water levels in the Pond.

The outer and inner traveling water screens are normally operated automatically, but can be operated manually from local control panels. In normal (automatic) operation, rotation of the screens is activated by preset timers for a predetermined time as set by duration timers, and, additionally, by a set pressure differential across the screens. During automatic operation, required pumps and valves are started/opened to provide wash water to the screens. For the outer screen structure, the wash water is supplied from screen wash pumps that take suction from the cooling water discharge pond. After the trash is separated from the wash water, the wash water flows to a sump located in the trash pit and is pumped to the Pond. For the inner screen structure, wash water for the circulating water screens is supplied from the service water pump discharge headers, and wash water for the service water screens are supplied from screen wash pumps that take suction from the screen structure. For the inner screen structures, the trash is separated from the wash water and the wash water is returned to the intake water flow using sump pumps located in the trash pits.

Intake flows are calculated based on pump run time and design pump capacity.

Heated water is provided from the circulating water system discharge canal through a recirculation gate for freeze protection of the CWIS in the winter. Also, an air bubbler system is provided for the outer screen structure for breaking up surface ice formation at the inlet side of the structure.

Design intake flow for Units 2 and 3 collectively, conservatively based on design pump capacities (excluding installed spare pumps, pumps that operate under shutdown, emergency, or testing conditions only, and pumps that do not increase intake flow requirements) and maximum operating demands, is shown in Table 1-2.

Table 1-2 PBAPS Design Intake Flow	
Operation	Design Intake Flow (MGD)
Condenser Cooling Water	2,160.0
Service Water	80.6
High Pressure Service Water	0[1]
Emergency Service Water	0[1]
Screen Wash	0[1]
Fire Protection	0[1]
Total Design Intake Flow	2,240.6[1]

[1] Excludes shutdown, emergency, and testing periods

The PBAPS Units 2/3 CWIS operate to supply water to support facility demand in line with its power generation and process needs.

The once-through cooling water system at PBAPS consists of the CWIS, a supply conveyance network to the main condensers and other equipment requiring raw water for non-contact cooling or other processes, and a discharge conveyance network to dissipate waste heat and discharge wastewater into the Pond through a discharge structure or other outfalls. During normal operation, approximately 96 percent of the design intake flow is used for condenser cooling with the remainder used for plant services.

Non-contact cooling water is pumped from the CWIS through the main condensers, where it becomes heated, and then discharges into a discharge pond and canal that flows back to the Conowingo Pond downstream of the intake. The discharge pond and discharge canal also provide a place of discharge for heated water from the Service Water System, the High-Pressure Service Water System, and the Emergency Service Water System, and other process wastewaters. Helper cooling towers are installed in the discharge flow path, but are bypassed (the current PBAPS NPDES permit does not require them to be operated). The discharge canal is oriented parallel to the shoreline. The discharge structure consists of one rectangular fixed opening with three regulating gates that are controlled by differential water level measurements to maintain a discharge velocity of 5 to 8 fps. This is intended to enhance mixing of the discharge with the ambient water and also to prevent immature fish from entering the canal and being exposed to potential thermal shock during plant operation. Screen wash water for the outer screen structure, derived from the discharge canal, is discharged to the Pond via Outfalls 002 and 005.

1.3 Through-Screen Velocity

The through-screen velocity was calculated using formulas adapted from Pankratz (1995):

V = Q / WD * OA * TW * K

where:

V = through-screen velocity in feet per second (fps)

Q = flow rate in gallons per minute (gpm)
WD = water depth in feet (ft)
OA = proportion of mesh open area to total mesh surface area
TW = nominal screen tray width (ft)
K = constant = 396 for through-flow screen; this provides unit conversion and accounts for a reduction in the screen open area due to typical screen features (e.g., boot seal at the bottom of the screen, mesh support frame, etc.)

and:

OA = (W x L) / ((W + D) x (L + d))

where:

d = screen horizontal wire diameter in inches (in)
D = screen vertical wire diameter (in)
W = width of mesh opening (in)
L = vertical length of mesh opening (in)

Although the normal water level of the Pond at PBAPS is between 104.5 feet and 108.5 feet (Conowingo Datum), the lowest the Pond can be without causing the shut down of the Muddy Run facility is 104.0 feet (Conowingo Pond Management Plan, SRBC 2006). Therefore, this water elevation was used as the design minimum low water level in the through screen-velocity calculation. The design inputs and calculations of the through-screen velocity are provided in Section 6 in Attachment I. The results of these calculations show the maximum through-screen velocity at the outer screens at the design intake flow is conservatively estimated as 1.21 fps at a Pond elevation of 104.0. The through-screen velocity is lower under normal pond elevations.

1.4 Additional Source Water and Facility Information

Additional information on the source water physical data, cooling water intake structure, and cooling water system data is provided as Attachment I – 40 CFR §122.21(r) NPDES Application Requirements for Facilities with Cooling Water Intake Structures.

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SECTION 2

IMPINGEMENT MORTALITY CHARACTERIZATION STUDY

FOR

PEACH BOTTOM ATOMIC POWER STATION

Prepared for:

Exelon

Technical Consultants

URS Corporation
Normandeau Associates, Inc.

October 2008

2.0 Impingement Mortality Characterization Study

This section provides information required by the 316(b) Phase II Rule at suspended §125.95 (b)(3). Specifically, it describes the following:

- the fish, shellfish, and protected species in the Susquehanna River, specifically in the vicinity of the Peach Bottom Atomic Power Station (PBAPS),
- the historic and current Impingement Mortality (IM) at the PBAPS cooling water intake structures (CWIS), and
- the computed IM to be used as the Calculation Baseline.

The 316(b) Phase II Rule was suspended on July 9, 2007 in response to the United States Second Circuit Court of Appeals decision in Riverkeeper, Inc. v. EPA, 475 F.3d 83 (2nd Cir.2007) (referred to as the Riverkeeper II decision). The Riverkeeper II decision remanded sections of the Rule that addressed the performance standard relative to the Calculation Baseline. Therefore, references to the performance standards in relation to the Calculation Baseline are not included in this report. A summary of the Rule requirements at suspended §125.95 (b)(3) with references to text sections is provided below:

Rule Requirements (suspended §125.95(b)(3))	Report Section
1. Taxonomic identification of all life stages of fish, shellfish, and any species protected under federal, state, or tribal law (including threatened or endangered species) that are in the vicinity of the CWIS and are susceptible to IM;	**Section A.7** **Appendix A**
2. A characterization of all life stages of fish, shellfish, and any species protected under federal, state or tribal law (including threatened or endangered species) identified above, including a description of their abundance and temporal and spatial characteristics in the vicinity of the CWIS, based on sufficient data to characterize annual, seasonal, and diel variations in IM. Historical data that are representative of the current operation of the facility and of biological conditions at the site may be used if appropriate;	**Section A.7** **Appendix A**
3. Documentation of the current IM of all life stages of fish, shellfish, and any species protected under federal, state, or tribal law (including threatened or endangered species) identified above and an estimate of IM to be used as the "Calculation Baseline".	**Section A.7** **Appendix A**

2.1 Fish, Shellfish, and Protected Species Characterization.

All fish, shellfish, and protected species in the vicinity of the CWIS have been identified through existing studies of the Susquehanna River and impingement studies conducted at the PBAPS. A list of the historical studies that have been conducted for the PBAPS is provided in Appendix B. The relevant studies reviewed for the IM characterization report include:

- Extensive fishery sampling of the Conowingo Pond (1966-1999),
- A thermal condition and fish population study in the Conowingo Pond (NAI 2000),
- A fish impingement study at the PBAPS in 1974-76 (PECO 1977), and
- The current impingement study at the PBAPS from August 2005 through November 2006 (NAI 2006: provided as Appendix C).

Each of these studies documented all species collected, and noted any species that were protected (i.e., threatened, endangered, etc.) at the time of collection. Based on these studies, a total of 57 fish species may be in the vicinity of the PBAPS CWIS (Table 2-1). The results of these studies are detailed in Appendix A.

2.2 Historic IM at the PBAPS

The impingement sampling programs conducted from November 1973 through March 1976 and August 2005 through November 2006 included identification and enumeration of impinged organisms collected over a 12 or 24 hour period. Therefore, these sampling programs characterize annual, seasonal, and diel variation in impingement at the PBAPS.

From 1973 through 1976, a total of 240 12-hour samples were collected at Unit 2, resulting in the collection of 16,859 fish representing 37 species. Unit 3 was sampled a total of 137 times from December 1974 through 1976, with a total of 42,088 individuals representing 35 species being collected. Channel catfish, white crappie, and bluegill were the most abundant species collected. Most of the impinged individuals averaged less than 120 millimeters (mm) (age-0 and age-1 in length). Overall, impingement rates for the most abundant species were greatest from November through March. However, it is important to note that average rates were skewed by several episodes of high impingement primarily due to exceptionally high river flow events.

In addition, during most years since 1982, impingement rates of emigrating juvenile American shad on the outer intake screens have been quantified during the fall as part of the Susquehanna River American shad restoration program. In general, species composition of impinged fishes during the migration sampling, except for several migratory species, is similar to that observed during the historic quantitative study period (1973 – 1976). The number of taxa impinged during the out-migration period (September through mid-December) ranged from 14 to 27, with gizzard shad dominating the collections. Other abundant species collected during the migration sampling included channel catfish and bluegill.

2.3 Current IM at the PBAPS

Current field studies were conducted from August 29, 2005 through November 17, 2006. A total of 208 sampling events (104 each at Unit 2 and Unit 3) were completed during this period to record the daily and seasonal rates of IM at the outer CWIS. A summary report of the impingement sampling is provided in Appendix C. The 2005-2006 IM raw catch data were adjusted for periodic sub-sampling (necessary during the fall of 2005 and 2006 due to high debris load) and gear efficiency as described in Appendix A. The annualized number of individuals impinged were calculated from the beginning of sampling at PBAPS (August 30, 2005) to one year later (August 29, 2006).

The August 30, 2005 to August 29, 2006 adjusted IM data showed 158,062 individuals with gizzard shad comprising 94 percent (148,633) of impinged organisms at PBAPS. A seasonal peak in total IM was evident during the fall 2005 sampling interval (September 23 – December 21) (Figure 2-1). Gizzard shad collected during this time period (n=147,660) accounted for approximately 90 percent of the total catch throughout the entire study period. In order to annualize IM numbers, impingement for days not sampled was calculated using a 30 day rolling average or by significant relationships found though regression analysis (Appendix A). Annualization resulted in yearly numbers of 221,421 fish impinged at the PBAPS. This represents the annual "as built" IM for the existing PBAPS outer CWIS. Table 2-2 provides a summary of the analysis for the current IM study at the PBAPS.

2.4 Calculation Baseline at the PBAPS

The outer CWIS is a structural configuration that results in velocity reductions and reductions of fish entrapment, and was installed for the purpose of reducing IM. In addition to the construction of the outer CWIS, the PBAPS has adapted procedures (e.g. the shutdown of circulation pumps in the winter) to reduce IM. The inner intake structure was the original design and represents baseline practices, procedures, and structural configuration of the facility. Thus IM at the inner intake structure would be defined as the Calculation Baseline. However, IM measurements are not available at the inner intake structure. Therefore, the Calculation Baseline must be computed using available IM data (2005-2006 IM study at the outer CWIS), plant operations, laboratory and field data on IM, and intake velocity. The relationship between intake velocity and IM is well established. USEPA acknowledges this relationship at 69 FR 41612 by stating:

> *"...impingement is related to a combination of flow, intake velocity, and fish swim speed"* and *"...EPA agrees that reducing intake by installing flow reduction technologies will result in a similarly high reduction of impinged...organisms..."*

The correlation between velocity and impingement has also been demonstrated in laboratory studies (Peake 2004, EPRI 2006 cited in ARL 2007). Peake (2004) found a statistically significant linear relationship between impingement of northern pike and approach velocity ($P<0.05$, $R^2=0.70$) and that IM was reduced by 74 percent when approach velocity was reduced from 1.8 to 1.1 feet per second (fps). Similarly, in a more extensive study evaluating 10 species commonly impinged at CWIS, a statistically significant positive relationship was demonstrated between approach velocity and impingement ($P<0.05$, $R^2=0.72$) (EPRI 2006 cited in ARL 2007). ARL (2007) concluded that impingement rates can be reduced with reductions in approach velocities and reductions in impingement may average 45 to 75 percent, depending on species, when intake velocities are decreased from 2 to 1 fps. The methodology and analytical and statistical analysis used to compute the Calculation Baseline are provided in Appendix A. The Calculation Baseline for the inner intake structure is 1,465,857 fish, of which

1,419,750 are gizzard shad (Table 2-2). Thus the "as built" IM for the existing PBAPS outer CWIS is 85 percent less compared to the Calculation Baseline.

2.5 References

ARL (Alden Research Laboratory Incorporated). 2007. Review of Laboratory and Field Data To Determine Influence of Approach Velocities on Fish Impingement at Cooling Water Intakes.

EPRI (Electric Power Research Institute) 2000. Technical Evaluation of the Utility of Intake Approach Velocity as an Indicator of Potential Adverse Environmental Impact under Clean Water Act Section 316(b). 1000731.

EPRI (Electric Power Research Institute) 2006. Laboratory Evaluation of Modified Ristroph Traveling Screens for Protecting Fish at Cooling Water Intakes. 1013238

"National Pollutant Discharge Elimination System–Final Regulations to Establish Requirements for Cooling Water Intake Structures at Phase II Existing Facilities; Final Rule." Federal Register 69 (9 July 2004): 41575-41693

NAI (Normandeau Associates, Inc.) 2000. A Report on the Thermal Conditions and Fish Populations in Conowingo Pond Relative to Zero Cooling Tower Operation at the Peach Bottom Atomic Power Station (June-October 1999). Prepared for PECO Energy Company.

Peake, S. 2004. Effect of Approach Velocity on Impingement of Juvenile Northern Pike at Water Intake Screens. North American Journal of Fisheries Management 24: 390-396.

PECO (Philadelphia Electric Company). 1977. 316(b) Demonstration for PBAPS Units No. 2 & 3 on Conowingo Pond. Materials prepared for the Environmental Protection Agency, June 1977.

Table 2-1 List of all Fish Species Collected During Studies of the Aquatic Resources in the Vicinity of the PBAPS

Common Name	Scientific Name	Community Sampling		IM&E Studies	
		1999[a]	1997-2006[b]	1974-76[c]	2005-06[d]
River Herrings	Clupeidae				
Blueback herring	*Alosa aestivalis*		X		
Gizzard shad	*Dorosoma cepedianum*	X	X	X	X
American shad	*Alosa sapidissima*	X	X	X	X
Alewife	*Alosa psuedoharengus*		X	X	X
Pikes & Pickerels	Esocidae				
Muskellunge	*Esox masquinongy*			X	
Minnows and Carps	Cyprinidae				
Central stoneroller	*Campostoma anomalum*	X	X		X
Common shiner	*Luxilus cornutus*	X			X
Spotfin shiner	*Cyprinella spiloptera*	X	X	X	X
Common carp	*Cyprinus carpio*	X	X	X	X
Rosyside dace	*Clinostomus funduloides*	X			
Cutlips minnow	*Exoglossum maxillingua*	X			
Golden shiner	*Notemigonus crysoleucas*	X	X	X	X
Silverjaw Minnow	*Notropis buccatus*	X			
Rosyface shiner	*Notropis rubellus*	X		X	
Mimic shiner	*Notropis volucellus*	X	X		X
Bluntnose minnow	*Pimephales notatus*	X	X	X	X
Fathead minnow	*Pimephales promelas*			X	
Blacknose dace	*Rhinichthys atratulus*	X		X	
Creek chub	*Semotilus atromaculatus*	X	X		X
Comley shiner	*Notropis amoenus*	X	X	X	X
Spottail shiner	*Notropis hudsonius*	X	X	X	X
Swallowtail shiner	*Notropis procne*	X	X	X	X
Longnose dace	*Rhinichthys cataractae*	X			
Fallfish	*Semotilus corporalis*	X			
Suckers	Catostomidae				
Quillback	*Carpiodes cyprinus*	X	X	X	X
White sucker	*Catostomus commersoni*	X	X	X	X
Northern hog sucker	*Hypentelium nigricans*	X	X	X	X
Shorthead redhorse	*Moxostoma macrolepidotum*	X	X	X	X
Bullhead Catfishes	Ictaluridae				
White catfish	*Ameiurus catus*	X	X	X	X
Yellow bullhead	*Ameiurus natalis*	X	X	X	X
Brown bullhead	*Ameiurus nebulosus*	X	X	X	

Table 2-1 (continued) List of all Fish Species Collected During Studies of the Aquatic Resources in the Vicinity of the PBAPS					
Common Name	Scientific Name	Community Sampling		IM&E Studies	
		1999[a]	1997-2006[b]	1974-76[c]	2005-06[d]
Channel catfish	*Ictalurus punctatus*	X	X	X	X
Flathead catfish	*Pylodictis olivaris*		X		X
Margined madtom	*Noturus insignis*			X	X
Killifishes	Fundulidae				
Mummichog	*Fundulus heteroclitus*		X	X	X
Banded killifish	*Fundulus diaphanus*	X			
Sunfishes	Centrarchidae				
Rock bass	*Ambloplites rupestris*	X		X	X
Green sunfish	*Lepomis cyanellus*	X		X	X
Pumpkinseed	*Lepomis gibbosus*	X		X	X
Bluegill	*Lepomis macrochirus*	X		X	X
Smallmouth bass	*Micropterus dolomieu*	X		X	X
Largemouth bass	*Micropterus salmoides*	X		X	X
White crappie	*Pomoxis annularis*	X		X	X
Black crappie	*Pomoxis nigromaculatus*	X		X	X
Redbreast sunfish	*Lepomis auritus*	X		X	X
Eels	Anguillidae				
American eel	*Anguilla rostrata*			X	
Temperate Basses	Moronidae				
White perch	*Morone americana*	X	X		X
Striped Bass	*Morone saxatilis*		X		X
Hybrid striped bass	*M. chrysops x M. saxatilis*	X			
Perches	Percidae				
Tessellated darter	*Etheostoma olmstedi*	X		X	X
Banded darter	*Etheostoma zonale*				X
Yellow perch	*Perca flavescens*	X		X	X
Logperch	*Percina caprodes*	X			X
Walleye	*Sander vitreus*	X		X	X
Greenside darter	*Etheostoma blennioides*	X			X
Shield darter	*Percina peltata*	X			
Smelts	Osmeridae				
Rainbow smelt	*Osmerus mordax*		X		

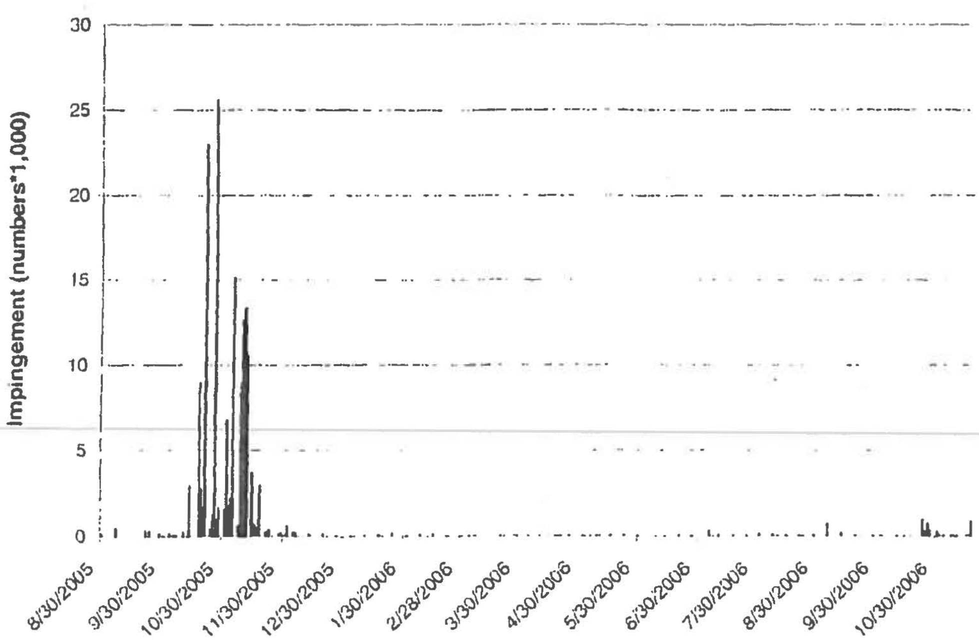
[a] NAI 2000
[b] NAI 2007
[c] PECO 1977
[d] NAI 2006

Table 2-2 Summary of Current IM Based on Total Number at the PBAPS

Common Name	Adjusted Number Collected[a]	Annual IM[b]	Baseline Inner CWIS[c]
Gizzard shad	148,633	191,180	1,419,750
Bluegill	5,589	11,861	23,524
Channel catfish	2,262	14,096	15,159
Walleye	400	791	972
American shad	138	281	281
White crappie	122	264	500
Comely shiner	86	335	584
Smallmouth bass	50	211	365
Largemouth bass	41	95	212
Non-RS Recreational [d]	503	1,430	2,986
Non-RS Forage [d]	238	877	1,524
Total	**158,062**	**221,421**	**1,465,857**

[a] adjusted for sub-sampling and gear efficiency August 30, 2005 through August 29, 2006
[b] based on operating conditions over one year (as built) August 30, 2005 through August 29, 2006
[c] based on linear relationship between ($\log_{10}$) Population I IM and TSV, and IM reductions associated with reduced in intake velocities (EPRI (2006) as reported in ARL (2007)) for population II.
[d] RIS = representative important species. See Appendix A

Figure 2-1 Impingement at the PBAPS during August 30, 2005 - November 17, 2006 Sampling



SECTION 3

NARRATIVE DESCRIPTION OF DESIGN AND OPERATING MEASURES AND DEMONSTRATION OF THE EFFICACY

FOR

PEACH BOTTOM ATOMIC POWER STATION

Prepared for:

Exelon[SM]

by URS Corporation

October 2008

3.0 Narrative Description of Design and Operating Measures and Demonstration of the Efficacy

3.1 Background and Introduction to Design and Construction Technology Plan

Pennsylvania Department of Environmental Protection (PADEP or the Department) requested that facilities provide a Design and Construction Technology Plan (DCTP) which includes the following:

a. The capacity utilization rate for the facility and/or for individual cooling water intake structures;

b. The average annual net generation of the facility (in megawatt hours [MWh]) measured over a 5-year period of representative operating conditions;

c. The total net capacity of the facility (in megawatts [MW]) and underlying calculations;

d. A narrative description of the design and operations of all design and construction technologies and/or operational measures (existing and proposed), including fish handling and return systems, that are in place or may be used to reduce impingement mortality of those species expected to be susceptible to impingement, and information that demonstrates the efficacy of these technologies and/or operational measures for those species;

e. A narrative description of the design and operation of all design and construction technologies and/or operational measures (existing and proposed), that are in place or may be used to reduce entrainment of those species expected to be susceptible to entrainment, if applicable, and information that demonstrates the efficacy of the technologies and/or operational measures for those species; and

f. Calculations of the reduction in impingement mortality and entrainment of all life stages of fish and shellfish that would be achieved by the technologies and/or operational measures that may be selected. In determining reductions of impingement mortality and/or entrainment, a facility should assess the total reduction against the Calculation Baseline. Reductions in impingement mortality and entrainment from this Calculation Baseline as a result of any design and construction technologies and/or operational measures already implemented at the facility should be added to the reductions expected to be achieved by any additional design and/or construction technologies and operational measures that will be implemented.

In addition, the PADEP has request that all Phase II facilities investigate the availability of closed cycle cooling (CCC) as a technology.

The required data for the DCTP is provided in this section as follows:

- Plant Data
- Implemented Technologies and Operational Measures for IM Reduction
- Efficacy of Implemented Technologies
- Cooling Tower Evaluation
- Evaluation of IM Reduction Technologies

In accordance with the Proposal for Information Collection (PIC) submitted and revised by the Department, PBAPS is subject only to performance standards for impingement mortality. Requirements for design and construction technologies and/or operational measures for reduction in entrainment (item (e) above) are not applicable for PBAPS. Although PBAPS has assessed the effectiveness, site compatibility, and cost of implementing additional technologies and operational measures to achieve 316(b) compliance, Exelon is not proposing any new technologies or operational changes at PBAPS because implemented technologies and operational measures, especially installation of the outer intake, already achieve a significant reduction in IM from the Calculation Baseline.

3.2 Plant Data

3.2.1 Capacity Utilization

PBAPS is a base-load plant that is available to operate year round. Either unit could be in shutdown mode or operating at less than 100 percent capacity as a result of maintenance outages, reduced electric demand, or other factors. Based on annual operations from 2001 through 2006, the PBAPS' average net facility capacity utilization rate was 93.5 percent. Typically, cooling water demand is less during the winter months (late November/early December through March) due to colder intake water temperatures. Cooling water system operation generally coincides with electric power generation with additional operating time needed before plant startup and after plant shutdown.

3.2.2 Annual Net Generation

The annual net generation for Unit 2 for the period of January 2003 through June 2007 is provided in Table 3-1 below (U.S. DOE).

Table 3-1 Total Annual Generation in MWh for Unit 2

Year	Total Generation MWh
2003	9,291,121
2004	8,845,679
2005	9,569,015
2006	9,042,327
2007*	4,925,989

*Through June, 2007

The annual net generation for Unit 3 for the period of January 2003 through June 2007 is provided in Table 3-2 below (U.S. DOE).

Table 3-2 Total Annual Generation in MWh for Unit 3

Year	Total Generation MWh
2003	8,893,599
2004	9,973,702
2005	8,824,435
2006	9,890,350
2007*	4,873,423

*Through June, 2007

The calculated average annual net generation for Units 2 and 3 combined at PBAPS is approximately 18,695,500 MWh per year for the period of January 2003 through June 2007.

3.2.3 Capacity of Facility

PBAPS is a two-unit (Units 2 and 3) nuclear-fueled boiling water reactor electric power generating facility with a generating capacity of nominally 2,304 (MW). Unit 2 has a net capacity of 1,112 megawatt electric (MW(e)) and Unit 3 has a net capacity of 1,112 MW(e) (U.S. DOE).

3.3 Implemented Technologies and Operational Measures for IM Reduction

As identified in the PIC, existing technologies and operational measures implemented at PBAPS include:

- Outer intake structure specifically designed and installed to reduce impingement by lowering the approach and through-screen velocities, having flush alignment of the screens with the shoreline with lateral fish escape passages, and eliminating the need for intake canals;
- Flow reductions by not operating all of the designed circulating water pumps during the late fall and winter months (late November/early December through March) and by recirculating warm discharge water to the intake basins in the winter;
- Air bubbler system in front of trash racks that may encourage fish avoidance behavior; and

Operational measures account for an annual flow reduction due to seasonal and maintenance shutdowns. Three circulating pumps (one unit) are shut down for approximately one month for maintenance each year. From late November/early December through March, four circulating water pumps (2 per unit) instead of six are generally operated due to lower intake water temperatures.

The outer CWIS is a structural configuration that results in velocity reductions and avoids fish entrapment, and was implemented for the purpose of reducing IM. The outer CWIS was designed to minimize fish impingement during construction of the station. The original intake (in 1967), consisting of only an inner set of vertical traveling screens, three circulating water screens per unit (a total of six) and two service water screens per unit (a total of four), is located at the end of the intake canal. The relatively high velocity resulting from this configuration and the absence of lateral escape routes would entrap most fish in the intake canal where they would eventually become impinged. Consequently, extensive swim speed studies of resident and anadromous fishes (over 580 tests) were initiated in June 1967 to determine the most sensitive species and the critical maximum velocity that would minimize entrapment and impingement. Based on data from these studies and experience from other facilities at that time, the outer CWIS was designed and installed with an approach velocity of ≤0.75 fps; the maximum velocity tolerated by most sensitive species (i.e., young white crappie).

In addition, the PBAPS has adapted procedures that were implemented to reduce IM (e.g. the shutdown of circulation pumps in the winter). The inner intake structure was the original design and represents baseline practices, procedures, and structural configuration of the facility. Thus IM at the inner intake structure would be defined as the Calculation Baseline. However, field data are not available for IM at the inner intake structure. Therefore, the Calculation Baseline must be estimated using available IM data (2005-2006 IM study at the outer CWIS), plant operations, laboratory and field data on IM, and intake velocity.

3.4 Efficacy of Implemented Technologies

The outer CWIS was designed and constructed to reduce intake velocity for fish protection purposes, and results in a reduction in IM. The efficacy of the existing outer CWIS was evaluated by comparing the estimated annual IM at the outer CWIS to that of the inner CWIS at original design conditions (i.e., the Calculation Baseline). Details of the methods and statistics used in this evaluation are presented in Appendix A and a summary of the results is provided below.

To determine the percent reduction of IM, or credit, attributable to the presence of the outer CWIS as operated between August 30, 2005 and August 29, 2006, the estimated annual IM at each structure (measured as total number) was compared. Results show that overall IM was reduced by approximately 85 percent (Table 3-3).

Table 3-3 Summary of IM calculations from August 30, 2005 through August 29, 2006

	Population I[1]	Population II[2]	Total Impingement
Outer CWIS (as built)	183,435 ± 82,892	37,986 ± 3,821	221,421 ± 86,713
Inner CWIS (Calculation Baseline)	1,411,438 ± 103,517	54,419 ± 6,379	1,465,857 ± 109,896
		Percent Reduction From Baseline	**85%**

[1] Population I represents a statistically distinct population of migrating gizzard shad impinged during the fall season.

[2] Population II represents gizzard shad impinged during winter, spring and summer months and all other fish impinged throughout the year.

A number of assumptions were made in this evaluation to ensure that the calculated IM and credit for IM reduction are at the lower end of the range. The following paragraphs describe these assumptions and the potential effects on the final conclusions.

EPRI (2006) evaluated the reduction of IM resulting from decreases in approach velocities of 3, 2, and 1 fps. In the calculation of the annual IM at the inner intake structure for Population II (IM excluding gizzard shad in Fall 2005, see Appendix A), the percent decrease in IM corresponding to the change in approach velocity from 2 to 1 fps (a difference of 1 fps) was used because these data were available and best approximated the change in approach velocities at PBAPS. The average approach velocities for the inner CWIS and outer CWIS during the study period were approximately 1.2 and 0.3 fps respectively (a difference of 0.9 fps).

IM reductions were only applied to fish of similar size classes to those tested in the EPRI (2006) study (cited in ARL 2007), though IM is likely reduced for all size classes. This conservative employment of the IM reductions results in a lower calculated IM at the inner screens and is a source of uncertainty. If IM reductions were expanded to include all impingement, the estimated IM at the inner intake structure would increase (i.e., Calculation Baseline), resulting in a greater credit for the outer intake structure.

Another source of uncertainty is the evaluation of only differences in approach velocity in calculating the outer CWIS credit. The outer CWIS was constructed to eliminate the intake canals that resulted in fish entrapment, as well as reduce approach velocity. The elimination of fish entrapment reduces IM. However, data were not available to estimate a potential efficacy for the design of the outer CWIS to reduce entrapment. Therefore, the calculated credit, using only approach velocity, is likely underestimated.

The Calculation Baseline for Population I (gizzard shad impinged in fall 2005, see Appendix A) utilized linear regression analysis to find a relationship between through screen velocity (TSV) and IM for the data collected at the outer CWIS. This relationship was applied to inner CWIS TSV values for the Population I Calculation Baseline. TSV at the outer screens ranged from approximately 0.5 – 1.0 fps while TSV at the inner CWIS ranged from 1.2 – 2.5 fps. Extrapolating IM data beyond the limits of measured independent variables (outer CWIS TSV) added uncertainty to the estimated IM at the inner intake. To be conservative, a linear correlation was used to estimate IM at higher TSV rather than the best-fit logarithmic relationship. There is evidence, however, that impingement rates increase exponentially with increasing intake velocity. EPRI (2000) demonstrated this relationship from impingement studies conducted at the Indian Point Plant on the Hudson River in the 1970s, where there was an exponential rise in impingement when the intake velocity exceeded approximately 1 fps. Therefore, using the linear regression models to estimate IM at the inner intake is a conservative approach and underestimates the efficacy for the outer screen.

3.5 Cooling Tower Evaluation

The PADEP has requested that all Phase II facilities investigate the availability of closed cycle cooling (CCC) as a technology. Therefore, a preliminary analysis was completed for PBAPS to address the feasibility, costs for construction and operation, and the net environmental impact of CCC at the facility.

3.5.1 Cooling Tower Conceptual Design

A preliminary evaluation of CCC was completed for PBAPS assuming the installation of mechanical-draft evaporative cooling towers (MECT) at the current location of the existing helper cooling towers. Non-contact cooling water at PBAPS is currently pumped from the CWIS through the main condensers, where it becomes heated, and then discharges into a discharge pond and canal that flows back to the reservoir downstream of the intake. Five helper cooling towers were constructed on site to help lower the discharge temperature of the cooling water. However, as a result of a four-year study of the Pond, the operation of the helper cooling towers ceased in 1997. For the purposes of this evaluation, the MECTs were assumed to be installed on the same sites as the existing helper towers, but with larger basin footprints. Two 22-cell back-to-back towers (each 602' x 104' x 6') and one-half of a 20-cell back-to-back tower (one tower sized at 548' x 104' x 6' to be shared between the two units) would be needed for each generating unit. Water from the cooling towers may be routed back to the intake basins; and the inner intake structure may continue to be used. Or the heated cooling water could continue to be routed to the discharge canal, which may be used to feed the cooling towers.

The basic characteristics of the towers include a design wet bulb temperature of 74°F (for the Conowingo Pond area), a range of 20.8°F, reservoir TDS of 126 ppm (from PBAPS NPDES permit renewal application), and eight cycles of concentration. Estimated per unit water flow requirements include 750,000 gpm condenser cooling water flow rate, 3.8 gpm drift rate, 15,600 gpm cooling tower evaporation rate, 2,229 gpm blowdown rate, and 17,829 gpm make up rate.

The current location of the helper cooling towers was assumed to be the optimal location for this facility and no other locations were evaluated. However, the site of the existing helper cooling towers appears to be suitable only for MECT. An alternate location would be required for natural draft or dry cooling towers, which were assumed to be not practicable.

3.5.2 Estimated Costs for CCC Conceptual Design

Preliminary costs were evaluated for the installation and annual Operation and Maintenance (O&M) of the CCC described in 3.5.1. Initial retrofit capital costs were based on an average cost of $265 per gpm of cooling water. This average cost was derived for a fossil fuel plant from the results of a survey of 50 plants conducted by Maulbetsch Consulting in 2002. The retrofit capital cost was then scaled up 35% to account for higher costs related to the retrofit of nuclear facilities. This 35% increase was found to be typical by Maulbetsch Consulting in their 2002 study and it correlates with the 1.35 cost factor for O&M costs at PBAPS interpolated from Table 2-27 of cost modules for the EPA final Phase II 316(b) Rule. The estimated capital cost associated with the installation of MECT at PBAPS is $536.6M[2]. The estimated O&M costs, including operating power costs, maintenance, and a heat rate penalty, are estimated at

[2] All costs for cooling tower retrofit are in 2002 dollars.

$47.5M[3] per year. Assuming a 5% discount rate and an expected plant life of 20 years, these costs equate to an annualized cost of $90.6M[4].

3.5.3 Net Environmental Effects

The following environmental and social effects will potentially occur with the installation of MECT:

- Aquatic biota

The conversion from once-through cooling to CCC results in a significant decrease (97.6 percent) in the amount of cooling water withdrawn from the water body and a subsequent decrease in impingement mortality at PBAPS. The current calculated annual impingement, of 221,421 would decrease to an estimated 5,313 if PBAPS were to convert to CCC. It should be noted that more than 85 percent of all impingement was comprised of gizzard shad, a forage species of limited value.

- Human health related to air quality

Potential human health issues are driven by possible health impacts resulting from additional air emissions from MECTs in the form of PM_{10} or $PM_{2.5}$. Impacts associated with exposure to PM include:

  - Mortality due to long-term exposure to an increased concentration of PM that measures 2.5 microns or less in diameter ($PM_{2.5}$), and
  - Hospital admissions for treatment of morbidity effects such as heart disease, bronchitis, emphysema, and pneumonia due to exposure to increased concentrations of $PM_{2.5}$ and/or PM that measures between 10 and 2.5 microns in diameter ($PM_{10-2.5}$).

Based on estimated emissions from MECTs at PBAPS, approximately 7,500 people over age 30 and 1,300 people over 65 could be exposed to increased PM and resulting adverse health impacts.

- Terrestrial resources

Salt and mineral drift from MECTs may adversely affect native vegetation, soils and crops. Based on estimated emissions from MECTs at PBAPS:

  - Approximately 13 acres of woody vegetation would be exposed to moderate levels of salt mineral drift possible resulting in visible leaf damage (NRC 2003);
  - 26 hectares of agricultural land would receive adverse levels of salt mineral drift

- Water resources

Retrofitting to MECT may result in adverse impacts on water resources including the net increase in evaporation of water resulting in a decrease in the availability of water in the

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[3] All costs for cooling tower retrofit are in 2002 dollars.

[4] All costs for cooling tower retrofit are in 2002 dollars.

source waterbody. In turn, this could potentially lower water surface elevations in the waterbodies, decrease the availability of potable water, and decrease littoral habitats. Additional evaporative loss from MECTs may also increase the frequency of drought declarations in the watershed.

The estimated net increase in evaporation (over evaporation from once through cooling) from MECTs at PBAPS is approximately 25,500,000 gallons per day (39.5 cfs). This is the equivalent daily water use of between 200,000 and 300,000 people (based on residential water use of 75 to 130 gallons per capita per day (gpcd) (Lindeburg, 2003)). The 39.5 cfs loss to evaporation is approximately 2.6 percent of the minimum monthly average flows of the Conowingo Reservoir of the Susquehanna River. However, flow levels are controlled by reservoir releases and, as such, consumptive water loss associated with cooling tower operation would be mitigated by existing institutional mechanisms.

- Safety and Security

Retrofitting to MECT may result in fogging interference with nuclear facility security systems and the plant perimeter.

- Quality of life (noise and visual);

The installation of a MECT at PBAPS will result in an adverse impact to quality of life through increased noise levels and visual impacts. Increased noise level will be perceived on the Conowingo Pond, adjacent recreation area and nearby homes. Likewise vapor plumes of various lengths and plume shadows will impact the surrounding area. These noise and visual impacts will decrease property values and enjoyment of recreational areas.

- Greenhouse gases.

The installation of a MECT at PBAPS will result in an increase in CO_2 gas emissions associated with:

  - Lost generation capacity from increased parasitic load associated with cooling towers (electricity required to operate the pumps and fans) and the need for nuclear facilities to optimize their condensers.
  - Replacement of power by a mix of fossils plants during the period PBAPS is offline to optimize the condensers for closed-cycle cooling. This outage may vary from 6 to 12 months.

This lost power would be made up by increased generation at fossil plants which have available capacity. Based on an 8 month outage and a value of 1.341 pounds of carbon dioxide per kilowatt-hour (DOE and EPA 2000) emitted from the current 'mix' of fuels and facilities, an additional 8.24 million tons of CO_2 would be emitted to compensate for the loss of electricity generation.

3.5.4 Cost Effectiveness of Cooling Towers

Although the Second Circuit remanded the use of cost-benefit for 316(b) compliance, the U.S. Supreme Court is hearing arguments in the Fall of 2008 that may allow cost-benefit analysis. Benefits transfer and the methods outlined by EPA in its 316(b) Phase II and III regional benefits assessment (USEPA 2002 and 2004b) are used to estimate willingness to pay (WTP) to avoid the assumed foregone recreational harvest, foregone commercial harvest, and foregone production. Using the EPA approach, the annual benefit (WTP) of installing MECTs at PBAPS is $6,484 annually. This value is low due, in part, to the fact that juvenile gizzard shad, a forage species of limited value, would comprise more than 85 percent of the fish saved by the installation of MECTs. In comparison to the $6,484 of annual benefit, the annualized cost to install and operate the MECTs is $90.6M. Thus, the costs are wholly disproportionate to the benefits.

3.6 Evaluation of IM Reduction Technologies

The PIC indicates that PBAPS will assess the effectiveness, site compatibility, and cost of implementing additional technologies and operational measures that may be used to achieve 316(b) compliance. The PIC further identified two primary categories of technologies that would be evaluated, including upgrades to the outer intake with screen improvements/replacement and diversion systems. This section provides a summary of the preliminary technology evaluation for alternative compliance technologies. These are:

Screening Improvement/Replacement Technologies

- Addition of fish buckets, fish handling system, and potential upgrade with smooth screening material
- Replacement of through-flow traveling water screens with Geiger Multi-Disc rotary screens with a fish handling system

Diversion Technologies

- Replacement of existing trash bars with modified louvers to encourage fish avoidance behavior
- Behavioral controls such as strobe lights and/or sound
- Installation of water jet screen to encourage fish avoidance behavior

3.6.1 Coarse-mesh Modified-Ristroph Vertical Traveling Screens at Existing Outer Screen Structure with New Fish Return System

Options evaluated for screen upgrades at the outer intake included both:

- A complete replacement of the existing screens with new modified-Ristroph screens (including smooth finer mesh (¼ x ½-inch) wire baskets) with a fish handling and return system; and
- A retrofit of the existing screens with smooth finer mesh (¼ x ½-inch) baskets, fish buckets upgrade and a fish return system.

These types of screen modifications are generally accepted as 'off-the-shelf' technology and have been widely implemented at power plant CWISs across the country. However, at PBAPS, significant modifications will be required within the screen house to accommodate the two separate fish and debris handling systems. Additionally, the fish return trough would have to be buried outside the screen house to minimize interference with roadways and other plant structures. The magnitude of construction (24 screens to be replaced or retrofitted) and the complexity involved in tying all screens to the new fish return system contribute to high installation costs, and are expected to result in significant downtime for the plant.

Although this alternative potentially has moderate to high biological benefits, gizzard shad dominate the catch at PBAPS and site specific factors may affect their survival. Since the screen mesh open area would be kept the same (0.14 square inches) or slightly finer (0.13 square inches), a minimal change in the number of organisms impinged is expected. However, adding a fish return system would reduce IM. Additionally, the smooth mesh wire would, in general, reduce fish injuries and increase the likelihood for survival. Expected survival using modified Ristroph screens ranges from nearly 100 percent for hardy species (bluegill and channel catfish) to 64 percent for more fragile species (gizzard shad) (EPRI and ARL 2003). Overall efficacy of this technology at PBAPS is uncertain due to gizzard shad abundance and the variability of their survival.

The estimated initial cost associated with replacing the screens with new modified-Ristroph screens and a fish return system is approximately $10.0M[5] with an estimated incremental O&M cost of approximately $1.3M[6]. The estimated initial cost associated with retrofitting the screens with smooth top mesh and a new fish return system is approximately $7.7M[7] with an estimated incremental O&M cost of approximately $1.1M[8].

Based on this preliminary evaluation, this alternative is not recommended for PBAPS due to the uncertainty in overall biological efficacy for the most abundant fish species and the moderate to significant construction and installation issues, and significant initial costs relative to the anticipated reduction in IM.

3.6.2 Geiger Screens with Fish Return

This alternative includes replacing the existing 24 screens with Geiger traveling water screens (also called Multi-Disc Screens) and installing a new fish handling and return system. The Geiger screen design would require a separate fish and debris wash system on the front of the screens, and space constraints within the screen house may complicate installation of the new troughs. As with the replacement or retrofit with modified-Ristroph screens, significant modifications will be required within the screen house to accommodate the two separate fish and debris handling systems. Additionally, the fish return trough would have to be buried outside the screen house to minimize interference with roadways and other plant structures. The magnitude of construction (24 screens to be replaced or retrofitted) and the complexity involved in tying all screens to the new fish

[5] Cost derived from 2006 vendor quotes and construction cost data, and then scaled up to 2008 dollars using Engineering News Record Construction Cost Indices.
[6] Cost derived using EPA Phase II Final Rule cost modules and scaled up from 2002 dollars to 2008 dollars using Engineering News Record Construction Cost Indices.
[7] Cost derived from 2006 vendor quotes and construction cost data, and then scaled up to 2008 dollars using Engineering News Record Construction Cost Indices.
[8] Cost derived using EPA Phase II Final Rule cost modules and scaled up from 2002 dollars to 2008 dollars using Engineering News Record Construction Cost Indices.

return system contribute to high installation costs, and are expected to result in significant downtime for the plant.

The most abundant species of fish impinged at PBAPS are gizzard shad, bluegill, and channel catfish, in that order. Geiger screens have displayed similar impingement survival rates to modified Ristroph screens, up to 100 percent, for bluegill and channel catfish (EPRI 2007). However, survival was poor for gizzard shad, 50 percent in the Fall of 2005 and 0 percent in the Spring of 2006. Note that the number of gizzard shad impinged was very low (7 individuals), so these results may not be representative. Likewise, survival of American shad (97 individuals) was also poor (0 percent). Therefore, the biological efficacy, as it applies to PBAPS, has a high uncertainty compared to modified-Ristroph screens.

The estimated initial cost associated with replacing the screens with new Geiger screens and a fish return system is approximately $10.1M[9] with an estimated incremental O&M cost of approximately $1.3M[10].

Based on this preliminary evaluation, Gieger screens are not recommended for PBAPS due to the lack of data and the uncertainty in overall biological efficacy for the most abundant fish species, the moderate to significant construction and installation issues and significant initial costs relative to the anticipated reduction in IM.

3.6.3 Modified Louver System

Traditional louver systems consist of vertical panels (the frame) arranged side-by-side at an angle to the source water flow direction (typically 15 to 30 degrees) with the individual blades perpendicular to the source water flow. Certain features of a traditional louver system, such as a frame angled to the source water flow direction, cannot be utilized at PBAPS. PBAPS is located on a reservoir, and flow through the reservoir is generally too slow to provide a parallel current along a traditional louver system installed in front of the outer screen structure. It would also be difficult to structure a fish bypass as the louver would be directing fish downstream of the intake and into the Pond. The length of the outer intake structure requires any traditional louver system to be very large (a minimum of 500-feet in length at an angle of 15 degrees from the screen structure and protruding into the Pond over 100-feet) and expensive.

However, a "modified" louver system that would replace the existing trash racks and utilize the existing rack slots could be installed at a significantly lower cost and could potentially provide fish diversion at the outer intake at PBAPS. This "modified" louver system would consist of vertical panels arranged parallel with the screen structure; the blades would be at an acute angle to the frame. This configuration also creates an abrupt change in flow direction and velocity that fish may avoid. A total of 29 individual "modified" louver frames would be installed parallel with the shoreline (outer screen structure) and with louver blades installed at a 45- to 60-degree angle to the frame (instead of the 90-degrees angle of the existing bar racks).

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[9] Cost derived from 2006 vendor quotes and construction cost data, and then scaled up to 2008 dollars using Engineering News Record Construction Cost Indices.

[10] Cost derived using EPA Phase II Final Rule cost modules and scaled up from 2002 dollars to 2008 dollars using Engineering News Record Construction Cost Indices.

Installation of the modified louver system is expected to be straightforward, although louver manufacturing experience appears to be limited. O&M efforts would be expected to increase with the added responsibility of the operators to maintain the modified louver, the increased debris loading, and additional power requirements for the mechanical cleaning system and conveyor.

Based on the efficiency studies conducted using louvers and angled screens across a number of target fish species, EPA (EPA 2004a) concluded that, with proper design, louvers and angled screens can be effective (70 – 90+ percent) in diverting fish and reducing impingement. However, this assumes a significant bypass current to carry fish past the louver system, a condition that often is not present at PBAPS. Note that study results discussed in this section are based on a traditional louver design. As indicated above, the "modified" louver system at PBAPS would replace the existing trash racks and utilize the existing rack slots. Since biological data are not readily available for this specific louver configuration, a pilot study or field study will be required to confirm the biological efficacy at PBAPS.

The estimated initial cost associated with replacing the existing bar racks with a modified louver system is approximately $4.4M[11] with an estimated O&M cost of approximately $0.35M[12].

Based on this preliminary evaluation, a modified louver system is not recommended at PBAPS due to limited manufacturing experience, the lack of biological efficacy data, and high initial costs relative to the anticipated reduction in IM.

3.6.4 Hybrid Acoustic and Lighting Deterrent System

This alternative includes the installation of a hybrid light and sound system upstream of the outer intake structure. Effective diversion of fish by acoustical means requires the sound field to extend smoothly across the width of the intake location. Both sound and light must extend a sufficient distance from the intake to allow fish to escape by swimming away from the intake. Additional field information and/or studies would be required to optimize the hybrid system for site-specific conditions. Installation in front of the bar racks would require a configuration that would not compromise the bar rack cleaning and O&M.

The effectiveness of these systems is dependent on the health of the fish, as was demonstrated at a test of a light and dual-frequency (400 to 4000 Hz and 120 to 130 kHz) acoustic system at Barry Electric Generating Plant on the tidal freshwater Mobile River, Alabama. The test system was ineffective at deterring fish completely; however, inspection of the impinged fish indicated a high incidence of disease, which may have contributed to their inability to respond to the stimuli. There have been several laboratory and field studies involving the dominant species impinged at PBAPS. Tests at the Pickering Station in Ontario demonstrated that "poppers" had no effect on gizzard shad (EPA 2004). However, vendor information for a combined strobe and acoustic

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[11] Cost derived from 2006 vendor quotes and construction cost data, and then scaled up to 2008 dollars using Engineering News Record Construction Cost Indices.

[12] Cost derived using 2006 vendor estimates and EPA Phase II Final Rule cost modules and scaled up to 2008 dollars using Engineering News Record Construction Cost Indices.

system from unpublished reports (Kinectrics Inc. 2005) shows 60 and 85 percent effectiveness for catfish and gizzard shad (two of the top impinged fish species at PBAPS), respectively.

Laboratory studies reported by Richards (2006), ORNL (1979), EPRI (2006) and Patrick and Filopovic (undated) indicated that strobe light and acoustic deterrent systems can be effective for gizzard shad and channel catfish. Effectiveness ranged from 74.4 to 96.3 percent for gizzard shad and 14.2 to 60.6 percent for channel catfish. A field study of the effectiveness of a sound deterrent system (125 kHz) at Danskammer Station located on the Hudson River found a 76.5 percent reduction in river herring (i.e. alewife, American shad and blueback herring) impingement (EPRI 2006). Furthermore, another strobe and acoustic deterrent system study at Lambton Generating Station on the St. Clair River in Ontario, Canada found a 73 to 80 percent reduction in gizzard shad impingement (Kinectrics Inc. 2005). Despite these findings, a strobe light/ultrasonic tandem system was tested at York Haven Dam to guide migrant juvenile American shad (Susquehanna River, PA), but was deemed inadequate and was subsequently dropped from consideration for a full installation (OTA 1995).

Therefore, light and acoustic deterrent systems have been found to have variable results in diverting important species occurring at PBAPS. These results suggest that site-specific factors (hydraulic, environmental, etc.) must be considered and that a pilot study will be necessary to determine the overall effectiveness at PBAPS.

The estimated initial cost associated with installing a hybrid acoustic and lighting fish deterrent system is approximately \$3.8M[13] with an estimated O&M cost of approximately \$0.56M[14].

Based on this preliminary evaluation, a hybrid lighting and deterrent system is not recommended at PBAPS due to the uncertainty in overall biological efficacy for the most abundant fish species and high initial costs relative to the anticipated reduction in IM.

3.6.5 Water Jet Curtain

The water jet system would include a pipe distribution network and discharge nozzle array to provide pressurized water from the cooling water discharge to the front of the trash racks. Water for the jet system would be conveyed to a horizontal header located along the top of the trash rack structure. Vertical discharge headers could be placed along the existing center walls between the trash racks, and nozzles would be installed to direct a curtain of water outward from the bar racks toward the Pond. Specific design parameters (flow, pressure, nozzle angle, nozzle spacing, etc.) and the biological efficacy of each parameter would have to be evaluated during a pilot study. New pumps and additional power may be required and special consideration will need to be made to avoid interferences with existing equipment, piping and appurtenances, and cleaning of the trash racks.

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[13] Cost derived from 2006 construction cost data, and then scaled up to 2008 dollars using Engineering News Record Construction Cost Indices.

[14] Cost derived using 2006 vendor estimates and EPA Phase II Final Rule cost modules and scaled up to 2008 dollars using Engineering News Record Construction Cost Indices.

Water jets induce an abrupt change in flow direction and velocity that most fish species avoid (EPA 1976). Water jets have been evaluated on a limited basis including one full-scale, one prototype and two laboratory studies. EPRI (1984) reported biological effectiveness of 75 to 80 percent based on this limited data. However other installations indicate little to no biological efficacy. Species/life-stage-dependency or the variables that affect performance were not assessed.

The estimated initial cost associated with installing a water jet curtain is approximately $1.2M[15] with an estimated O&M cost of approximately $0.08M[16].

Based on this preliminary evaluation, a water jet system is not recommended at PBAPS due to the uncertainty in overall biological efficacy and high initial costs relative to the anticipated reduction in IM.

3.6.6 Summary

The existing intake design at PBAPS greatly reduces IM and therefore adverse environmental impact. The cost of any additional technology far exceeds the small potential benefit of $6,484 annually. Additionally, there is a high level of uncertainty of the biological efficacy for these technologies for PBAPS target fish species. Additional studies and/or pilot tests may be required to evaluate the actual biological efficacy at PBAPS and assess the overall cost effectiveness of these alternatives. Based on the results of this preliminary evaluation, the current design, location, and operation of PBAPS's intake structure is the best technology available (BTA).

3.7 References

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[15] Cost derived from 2006 vendor quotes and construction cost data, and then scaled up to 2008 dollars using Engineering News Record Construction Cost Indices.
[16] Cost derived using 2006 construction cost data and EPA Phase II Final Rule cost modules and scaled up to 2008 dollars using Engineering News Record Construction Cost Indices.

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SECTION 4

ASSESSMENT OF ENVIRONMENTAL IMPACT OF IMPINGEMENT MORTALITY ON THE CONOWINGO POND POPULATION

FOR

PEACH BOTTOM ATOMIC POWER STATION

Prepared for:

Exelon

by URS Corporation

October 2008

4.0 Assessment of Environmental Impact of Impingement Mortality on the Conowingo Pond Population

4.1 Narrative Description

Conowingo Pond presents a complex and dynamic ecosystem in which fish recruitment and losses occur on a daily basis. Fish recruitment into Conowingo Pond, particularly of juvenile fishes, occurs primarily from upstream sources and from the Muddy Run Pumped Storage Station (Muddy Run) when it is in a generating mode. Since 1972, obligate migratory fishes and several resident species are recruited into the Pond via the operation of the West Fish Lift and later (1991) the East Fish Lift at Conowingo Hydroelectric Station (Conowingo) during their operation from April through early June. Fish losses occur during Muddy Run pumping mode, impingement mortality (IM) at PBAPS, entrainment through Conowingo, and via the spring operations of the Holtwood Hydroelectric Station Fish Lift.

Because of the above stated dynamic processes, the impact of fish losses at PBAPS Units 2 and 3 have been quantified on a relative basis using two approaches: (1) considering PBAPS as an angling "predator" and comparing to losses inflicted by angler harvest and (2) examining changes in relative abundance of common, representative, important species (RIS) of Conowingo Pond (current RIS: American shad [*Alosa sapidissima*], bluegill [*Lepomis macrochirus*], channel catfish [*Ictalurus punctatus*], comely shiner [*Notropis amoenus*], gizzard shad [*Dorosoma cepedianum*], largemouth bass [*Micropterus salmoides*], smallmouth bass [*Micropterus dolomieu*], walleye [*Stizostedion vitreum*], and white crappie [*Pomoxis annularis*]) via long-term fish sampling (1966-1986) by multiple gear types and locations (e.g., trawls, trap net, haul seine, electroshocking, meter net) during the pre-operational (1966-1973) and post-operational (1976-1986) periods. The most recent fish sampling occurred from 1996 to 1999 for the assessment of impacts on Conowingo Pond fish community from cooling tower operations (NAI 2000). Sampling stations and gear used throughout the various periods were similar, enabling direct comparisons of fish relative abundance (RMCESI 1994).

Results of the two different approaches indicate that PBAPS operational-related fish losses were low. Relative abundance of most common species was either within the historic range of that observed during the pre-operational period or exceeded it; much variability between sampling locations and years was observed. Overall, no change in relative abundance of most species was detected. Additionally, other indices (e.g., diversity, percent similarity) of the fish community indicated no detectable changes. However, a significant decline in the relative abundance of white crappie, a common resident species in Conowingo Pond, was observed beginning in the late 1970s. This decline was coincident with the sizeable population growth of gizzard shad, which were inadvertently introduced into Conowingo Pond in 1972 during the American shad restoration efforts. It was determined that a large population of gizzard shad, particularly young fish, out-competed white crappie for the same food resources and may have caused or been an important factor in its decline (RMCESI 1994). This conclusion was further strengthened when the white crappie population did not recover during the shutdown of PBAPS in 1987-1989, a period in which the fish community did not incur losses at the intake. The population's inability to rebound suggested that other factors besides PBAPS may have been responsible for the decline in abundance (RMCESI 1994).

The other metric, a comparison of fish losses at PBAPS with recreational fishing mortality of white crappie, indicated that daily fish losses at PBAPS were equivalent to less than that caused by five recreational fishermen (Mathur et al. 1977). This estimate is deemed conservative because most fish impinged at PBAPS are juveniles and those taken by anglers are adults; no adjustment for natural mortality between juvenile and adult life stage was made in this comparison. Furthermore, it was concluded that an additional five anglers (equivalent to PBAPS losses) fishing Conowingo Pond would not result in detectable changes in the population sizes of common resident fishes (NAI 2000).

4.2 References

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NAI (Normandeau Associates, Inc.) 2000. A report on the thermal conditions and fish populations in Conowingo Pond relative to zero cooling tower operation at Peach Bottom Atomic Power Station (June-October 1999). Prepared for PECO Energy Company, Philadelphia, PA.

RMCESI (RMC Environmental Services, Inc.) 1994. Analysis of potential factors affecting the white crappie population in Conowingo Pond. Prepared for PECO Energy Company, Philadelphia, PA.

SECTION 5

CONCLUSION

FOR

PEACH BOTTOM ATOMIC POWER STATION

Prepared for:

Exelon

by URS Corporation

October 2008

5.0 Conclusion

This submittal provides information to support a Best Professional Judgment Determination of Best Technology Available (BTA) for Peach Bottom Atomic Power Station (PBAPS). It also provides data and information requested by Pennsylvania Department of Environmental Protection (the Department), including the Impingement Mortality (IM) Characterization Study (Section 2 above and Appendix A) and applicable sections of the Design and Construction Technology Plan (Section 3 above).

In accordance with the Proposal for Information Collection submitted and reviewed by the Department, PBAPS is subject only to performance standards for impingement mortality. Additionally, PBAPS has already achieved a significant reduction in IM from the Calculation Baseline because of implemented technologies and operational measures, especially installation of the outer intake. Therefore, Exelon is not proposing any new technologies or operational changes at PBAPS since the implemented technologies already represent BTA.

This conclusion is supported by data collected from the current IM study (Aug 2005 – Nov 2006). Calculated annual impingement at PBAPS, using the results of the current IM study at the outer intake structure, is 221,421 fish, 191,180 of which are gizzard shad. The Calculation Baseline, estimated for the inner intake structure, is 1,465,857 fish, of which 1,419,750 are gizzard shad. A reduction in IM of approximately 85 percent from the Calculation Baseline is already achieved by the installation of the outer intake alone. Additionally, by comparing IM losses at PBAPS to losses inflicted by anglers' harvest, it has been found that PBAPS operational-related fish losses were low and could not be detected in relative abundance of common resident species (NAI 2000). Considering reductions in IM from the Calculation Baseline from the use of the outer intake and results of the NAI evaluation, the environmental impacts from current PBAPS operations are very limited and PBAPS already has BTA.

5.1 References

Mathur, D., P. G. Heisey, and N. C. Magnuson. 1977. Impingement of Fishes at Peach Bottom Atomic Power Station, Pennsylvania. Trans. Amer. Fish. Soc. 106: 258-267.

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SECTION 6

APPENDICES AND ATTACHMENTS

FOR

PEACH BOTTOM ATOMIC POWER STATION

Prepared for:

Exelon

by URS Corporation

October 2008

6.0 Appendices and Attachments

Appendix A – Detailed Characterization of the Aquatic Resources and Impingement Mortality at the Peach Bottom Atomic Power Station

Appendix B – List of the Historical Studies Conducted at the Peach Bottom Atomic Power Station

Appendix C – Summary of Fish Impingement Sampling at Peach Bottom Atomic Power Station Conowingo Pond, Pennsylvania 2005-2006

Attachment I – 40 CFR §122.21(r) NPDES Application Requirements for Facilities with Cooling Water Intake Structures

Attachment II – Statistical Analysis of Impingement at Peach Bottom Atomic Power Station, 2005-2006

APPENDIX A

DETAILED CHARACTERIZATION OF THE AQUATIC RESOURCES AND IMPINGEMENT MORTALITY AT THE PEACH BOTTOM ATOMIC POWER STATION

FOR

PEACH BOTTOM ATOMIC POWER STATION

Prepared for:

Exelon

Technical Consultants

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October 2008

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A.1 Purpose

This appendix provides a detailed summary of both historic and recent studies of the aquatic resources of the Susquehanna River and impingement at the Peach Bottom Atomic Power Station (PBAPS) Cooling Water Intake Structures (CWIS). In addition, it provides calculations of the current annual Impingement Mortality (IM), the Calculation Baseline at the PBAPS CWIS, and a detailed description of the statistical analyses used in determining these calculations. The following information provided the basis of the IM Characterization Study for the PBAPS.

A.2 Historical Studies

The fish community and impingement studies conducted at the PBAPS in the 1970s were used to develop the station's 316(a) and 316(b) demonstrations, which were issued in 1977. Numerous other studies in support of the demonstrations were performed over subsequent years to further evaluate the effects of the station's thermal discharge and to evaluate the hydrothermal and biological characteristics of the Conowingo Pond. Impingement studies, as well as other ecological, engineering and technical studies, continued to be conducted through the late 1970s and early 1980s. More recently, sampling has been performed to monitor river herring and American shad impingement on the intake screens during the fall out-migration period. In addition, a fisheries study to evaluate the effects of the thermal discharge was performed in the late 1990s to support elimination of the helper cooling towers at the PBAPS. A list of the historical studies that have been conducted for the PBAPS is provided in Appendix B of this report. The following section includes a summary of the studies relevant to the characterization of the IM at the PBAPS.

A.2.1 Fish Community Description

Extensive fishery sampling of the Conowingo Pond (1966 - 1999) shows that the Pond supports a productive and diverse warm water fish community. Sixty (60) species were collected in the Pond, the fish lifts at Conowingo and Holtwood dams, and other surrounding areas. The spotfin shiner, bluegill, pumpkinseed, bluntnose minnow, white crappie, and channel catfish historically were the most common fish. Recent sampling (1996 - 1999) indicates patterns in temporal variation and spatial distribution similar to those observed from 1966 through 1980. Except for several species introduced in Conowingo Pond post-1966, the relative abundance of the previously designated representative species (RS) has also not changed significantly. One exception is that the abundance of white crappie has declined, primarily due to the introduction of gizzard shad, which is currently the most abundant species within the Pond. While gizzard shad is generally the most abundant fish species present, its population size in the Pond may fluctuate greatly from year to year. Game fishes such as smallmouth bass, largemouth bass, yellow perch, and walleye are all well represented within the Pond. No Pennsylvania protected (threatened or endangered) or commercially harvested species are present in the Pond.

The following fishes were designated as RIS for the original 316(a) and 316(b) demonstrations for PBAPS: white crappie, channel catfish, bluegill, gizzard shad, smallmouth bass, largemouth bass, walleye, bluntnose minnow, and spotfin shiner. The alewife, American shad, blueback herring, and striped bass have all been re-introduced to the area within the last 30 years. Only populations of American shad have responded favorably to these efforts, establishing a comparatively large population which utilizes the Susquehanna River.

Records of fish passed upstream at the Conowingo East Fish Lift and Holtwood Fish Lift provide additional data on the fish populations of Conowingo Pond. Except for several migratory fishes, the species composition observed at the fish lifts is similar to that observed within Conowingo Pond prior to the construction and operation of the fish lifts. Gizzard shad is the most abundant species passed at the lifts. American shad, blueback herring, and alewife have comprised up to 35 percent of the total fish passage in recent years depending on prevailing hydrological conditions.

The most common species (channel catfish, pumpkinseed, bluegill, gizzard shad, and spotfin shiner) are widely distributed throughout the Pond. Game fish, including walleye, smallmouth bass, and largemouth bass, have a more limited distribution. Largemouth bass are more common in the southern downstream Pond, while smallmouth bass, walleye, and bluntnose minnow are more abundant in the northern upstream Pond.

A.2.2 Historical Impingement Studies

Impingement sampling was conducted at the PBAPS from November 1973 through March 1979. From 1973 through 1976, intensive impingement monitoring was performed with sampling frequency varying from two to four 12-hour periods per week; typically four periods per week generally conducted between July and September. After 1976, sampling was usually performed once weekly (24-hour sample). All fish were identified, measured (total length [TL]) to the nearest millimeter (mm), and enumerated.

During most years since 1982, impingement rates of emigrating juvenile American shad on the outer intake screens have been quantified during the fall as part of the Susquehanna River American shad restoration program. Sampling generally occurs three times weekly from October through mid-December. The migration data provide information on size, temporal scale, and origin (hatchery versus wild) of juvenile American shad individuals. Although the primary focus of this program is the enumeration of impinged American shad, information on all other fish species is also collected.

From 1973 through 1976, a total of 240 12-hour sampling events were conducted at Unit 2, resulting in the collection of 16,859 fish representing 37 species. Unit 3 was sampled a total of 137 times from December 1974 through 1976, with a total of 42,088 individuals representing 35 species being collected. During this quantitative impingement sampling, channel catfish, white crappie, bluegill, and gizzard shad were the most abundant species collected. Most of the individuals measured less than 120 mm (age-0 and age-1). Overall, impingement rates for the most abundant species were greatest from November through March. No significant differences in impingement rates between day and night samples were found. The authors noted that average rates were skewed by several episodes of high rates of impingement that coincided with exceptionally high river flow events (>200,000 cubic feet per second).

In general, species composition of impinged fishes during the migration sampling, except for several migratory species, is similar to that observed during the quantitative study period (1973 – 1979). The number of taxa impinged during the out-migration period (September through mid-December) ranged from 14 to 27, with gizzard shad dominating the collections. Other abundant species collected during the migration sampling included channel catfish and bluegill. Although impingement rates appear to be influenced by various hydrological-physical factors and year-class strength of a particular species, the number of alosids (American shad, blueback herring, and alewife) observed in impingement collections appears to be correlated with the abundance of alosids passed by fish lifts and the abundance of early life stage American shad stocked annually by the Pennsylvania Fish and Boat Commission.

A.3 Current Impingement Study

A.3.1 Methods

Field studies were conducted in accordance with the Proposal for Information Collection (PIC) by Normandeau Associates, Inc. (NAI) at PBAPS from August 30, 2005 through November 17, 2006 to document the rate of IM at the outer CWIS. A total of 208 sampling events (104 each at Unit 2 and 3) were completed during this period. The study was designed to account for both seasonal and diel variation. Sampling generally occurred once per week. However, sampling was increased to multiple times per week during the American shad out-migration (primarily October and November). The peak out-migration period, and corresponding increased sampling, occurred from October 18 through December 6 in 2005 and from October 23 through November 17 in 2006. Each sampling event comprised a 24-hour monitoring period.

Impingement samples were collected in a trash bin located at the end of the sluiceway. At the end of the monitoring period, the bin was removed from the sluiceway and the contents of the bin were sorted by hand. Fish and shellfish were identified, enumerated, measured (TL) to the nearest mm, and assessed for condition (uninjured, injured, or dead). Environmental variables (water temperature, dissolved oxygen, turbidity) were noted on the datasheets at the time of collection.

A.3.2 Representative Species

The suspended Phase II Rule allows the use of RIS for evaluation. Current RIS included species used as RIS for earlier 316 demonstrations at the PBAPS and other species added to improve estimates using U.S. Environmental Protection Agency (USEPA) 316(b) guidance (1977). The following RIS are used for the current IM study at the PBAPS:

- Walleye (*Sander vitreus*) – an important recreational piscivore;
- Gizzard shad (*Dorosoma cepedianum*) – an abundant invasive omnivorous forage fish;
- American shad (*Alosa sapidissima*) – an important migratory species;
- Channel catfish (*Ictalurus punctatus*) – an abundant recreational fish;
- Comely shiner (*Notropis amoenus*) – an important forage species;
- White crappie (*Pomoxis annularis*) – an abundant recreational species;

- Bluegill (*Lepomis macrochirus*) – an important recreational insectivore;
- Smallmouth bass (*Micropterus dolomieu*) – an important recreational piscivore; and
- Largemouth bass (*Micropterus salmoides*) – an important recreational piscivore.

USEPA methodology used in the suspended Rule development included accounting for all species by combining the remaining fish into two categories: non-RS fisheries species and non-RS forage species. All remaining non-RS species were thus grouped as forage species or fisheries (recreational) species (Table A-1) and analyzed collectively.

Table A-1
Categorization of Non-RIS species impinged at PBAPS August 30, 2005 - November 18, 2006

Non-RIS Recreational species		**Non-RIS Forage species**	
Black crappie	*Pomoxis nigromaculatus*	Alewife	*Alosa pseudoharengus*
Flathead catfish	*Pylodictis olivaris*	Bluntnose minnow	*Pimephales notatus*
Green sunfish	*Lepomis cyanellus*	Carp	*Cyprinus carpio*
Pumpkinseed	*Lepomis gibbosus*	Central stoneroller	*Campostoma anomalum*
Redbreast sunfish	*Lepomis auritus*	Common shiner	*Luxilus cornutus*
Rock bass	*Ambloplites rupestris*	Creek chub	*Semotilus atromaculatus*
Shorthead redhorse	*Moxostoma macrolepidotum*	Golden shiner	*Notemigonus crysoleucas*
Striped bass	*Morone saxatilis*	Greenside darter	*Etheostoma blennioides*
White catfish	*Ameiurus catus*	Logperch	*Percina caprodes*
White perch	*Morone americana*	Mimic shiner	*Notropis volucellus*
Yellow bullhead	*Ameiurus natalis*	Mummichog	*Fundulus heteroclitus*
Yellow perch	*Perca flavescens*	Northern hogsucker	*Hypentelium nigricans*
		Quillback	*Carpiodes cyprinus*
		Spotfin shiner	*Cyprinella spiloptera*
		Spottail shiner	*Notropis hudsonius*
		Swallowtail shiner	*Notropis procne*
		Tessellated darter	*Etheostoma olmstedi*
		White Sucker	*Catostomus commersoni*

A.3.3 Raw Data

Over the entire study a total of 61,504 fish, representing 40 fish species, were collected at the PBAPS CWIS. Gizzard shad (n=53,432) was the most abundant species collected, comprising 87 percent of the catch. Other important species collected included bluegill and channel catfish, which comprised an additional seven percent and four percent of the catch, respectively. No other species constituted greater than three percent of the total catch.

Overall impingement was greatest during the fall months of each year of the study. Peak impingement rates were observed during October and November of 2005 and September through mid-November of 2006. The majority of impinged fish collected over the entire study were collected during these periods, comprising 85 percent of the overall impingement observed throughout the study.

A.3.4 Adjustment of Raw Data

The 2005-2006 impingement raw catch data were adjusted for periodic sub-sampling that was necessary during the fall of 2005 and 2006 due to high debris load. Twenty-seven (27) sub-samples were processed in 2005 and six were processed in 2006. On these sampling dates, a representative portion of at least 20 percent of the debris and fish was removed from the collection bin and sorted to collect impinged specimens. A correction factor based on the amount of sample processed was then applied to the catch for that given day using the following equation:

$$I_{(s)} = I_{(d)}/S_{cf} \qquad \text{Equation (1)}$$

where S_{cf} is the sub-sampling correction factor, $I_{(d)}$ is the daily (24-hour) impingement collection, and $I_{(s)}$ is the impingement adjusted for sub-sampling.

The raw catch data were also adjusted for gear efficiency. Traveling screen collection efficiency was determined during several collection efficiency tests. For each test, either dyed or radio-tagged dead fish of several species and representative sizes to those predominantly collected in impingement samples were released directly in front of the screens through doors on the traveling screen covers. The ratio of fish recovered to fish released during the trials was reported as the gear efficiency for each particular test. An efficiency value of 84 and 86.5 percent for Units 2 and 3, respectively, were determined based on pooled results for each unit. All impingement catch data were adjusted to account for this efficiency value using the following equation:

$$I_{(adj)} = I_{(s)}/e \qquad \text{Equation (2)}$$

where $I_{(adj)}$ is the total daily impingement adjusted for gear efficiency and sub-sampling, and e is the unit-specific collection efficiency.

The August 30, 2005 to August 29, 2006 adjusted impingement data showed 158,062 individuals, with gizzard shad comprising 94 percent (148,633) of impinged organisms at the PBAPS. A seasonal peak in total impingement was evident during the fall (September 23 – December 21) 2005 sampling interval. Gizzard shad collected during this time period accounted for approximately 90 percent (n=147,660) of the total catch throughout the entire study period.

A.3.5 Statistical Analysis

Statistical output from the tests discussed here is provided in Attachment II.

Based on the dominance of individuals impinged during fall 2005, seasonal differences in the impingement data were analyzed using SYSTAT 11 statistical software. Statistical tests applied in this assessment that describe or compare populations of data result in a probability value, or p-value, which is a measure of the significance of a particular test. In general, the more significant the relationship is the lower the p-value will be. For example, if the p-value is less than a designated value, the null hypothesis that two or more populations are the same is rejected. For our comparisons, a p-value below 0.05 was considered statistically significant (i.e., that the populations are different).

The total number of impinged gizzard shad was analyzed separately from other species because its overall abundance was the primary driver of impingement totals throughout the study, specifically during fall 2005. Gizzard shad impingement data were first evaluated to determine whether the population followed a normal distribution. Tests for normality (Shapiro-Wilk, D'Agostino-Pearson K^2) showed that the data were not normally distributed and that common transformations for positively skewed distributions did not result in normality. Therefore, gizzard shad impingement data were analyzed with the non-parametric two-sample Kolmogorov-Smirnov test to explore differences between seasons. The results showed fall 2005 gizzard shad impingement differed from all other seasons, and therefore must be analyzed separately to determine relationships with independent variables.

The remaining data (all impingement excluding fall 2005 gizzard shad) were analyzed to assess whether there was a statistical difference in mean impingement of this dataset between seasons (fall 2005, winter 2005/06, spring 2006, and summer 2006). Normality was attained using a $\log_{10}$ transformation. ANOVA analysis showed that no one season differed from all other seasons, allowing the remaining IM data to be evaluated as a single population.

Therefore, two separate populations of impingement data exist and were used in subsequent analyses: 1) Population I, consisting of gizzard shad impinged during fall 2005, and 2) Population II, comprised of all other impinged fish and gizzard shad collected in seasons other than fall 2005. Population II represented approximately 10 percent of the total number of fish impinged during the study.

A.3.5.1 Regression Analysis

Environmental conditions may have an effect on impingement at the PBAPS. Stepwise multiple regression analysis was used to determine if independent variables potentially associated with fish abundance and distribution were correlated with impingement and could potentially explain variability in observed impingement rates. Environmental variables used in this analysis include the following:

- Water temperature
- Dissolved oxygen
- Turbidity (secchi depth)
- Through-screen velocity (TSV)
- Pool elevation
- Daily change in pool elevation
- River flow

Before performing the multiple regression analysis, the data for each population were $\log_{10}$ transformed to satisfy assumptions for normality.

When testing the relationship between variables, an R-squared (R^2) value was calculated, in addition to the p-value. This value measures the amount of variation that can be explained by a particular variable. In general, a higher calculated R^2 value indicates a stronger correlation between the independent variables (e.g., river flow) and the response variable (e.g., impingement), and vice-versa.

Because statistical analyses showed that two separate populations exist within the impingement dataset, regression analyses were performed on each population separately. A reverse stepwise regression was performed, where each of the variables was removed one by one (in increasing order of importance) and the statistical results for the remaining variables was observed.

The following sections provide the results of regression analysis performed on data from gizzard shad impinged in fall 2005 (Population I) and data from all other species combined with gizzard shad collected from the remainder of the sampling study (Population II). When significant relationships were detected, regression plots are provided.

A.3.5.1.1 Population I

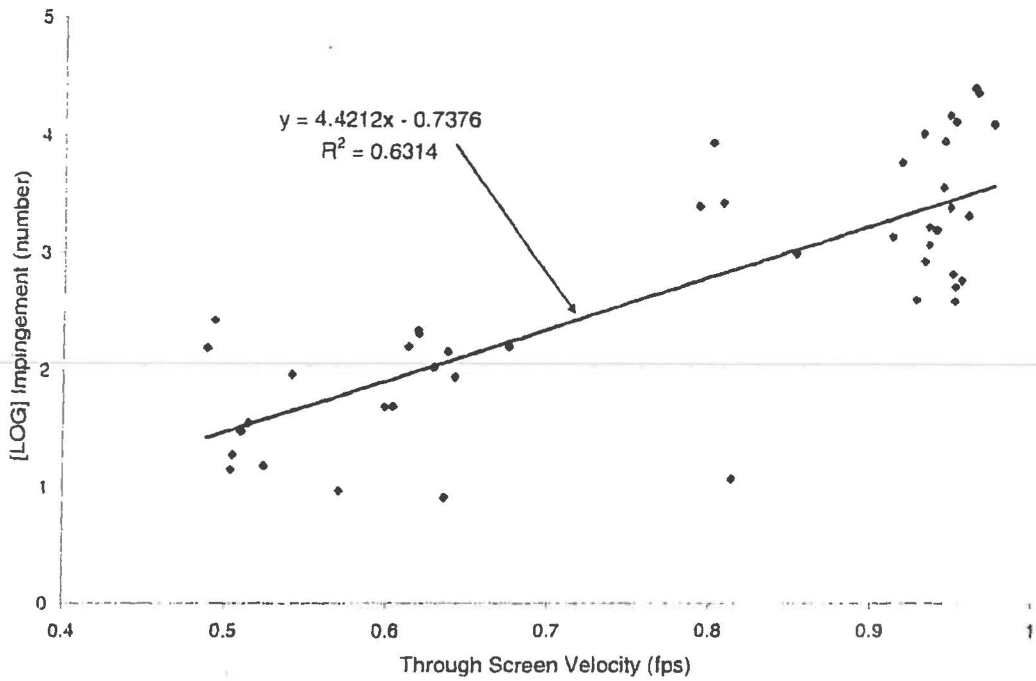
Multiple regression analysis resulted in a highly significant correlation between TSV and $\log_{10}$(#gizzard shad impinged) during fall 2005 (Table A-2).

Table A-2
Reverse Stepwise Multiple Regression Results for the Number of Gizzard Shad Impinged During the Fall 2005 (Population I).

Variable	Step Removed	p-value	R^2 Value
Change in River Flow	1	0.984	N/A
Pool Elevation	2	0.884	N/A
Temperature	3	0.622	N/A
Turbidity	4	0.242	N/A
Dissolved Oxygen	5	0.266	N/A
Change in Pool Elevation	6	0.214	N/A
Through-screen Velocity	---	<0.0001	0.63

The plot of $\log_{10}$(#gizzard shad impinged) values included in the regression analysis for Population I versus TSV is shown in Figure A-1. The coefficient of determination (R^2) generated by the linear regression model (0.63) indicates that approximately 63 percent of the variation in $\log_{10}$(#gizzard shad impinged) can be accounted for by TSV.

Figure A-1
Regression Plot of [$\log_{10}$ #Gizzard Shad Impinged] Values as a Function of TSV for Population I.



A.3.5.1.2 Population II

A step-wise multiple regression analysis was performed to determine if environmental variables were correlated with impingement using the Population II impingement dataset. Although three variables were statistically significant (Table A-3), there were no strongly correlated relationships between observed impingement rates and these variables. The R^2 value of the most significant variable was 0.09, and the two most significant variables combined (pool elevation and TSV) had a coefficient value of approximately 0.15, indicating that only 15 percent of the variation in impingement could be explained by these two variables collectively.

Table A-3
Reverse Stepwise Multiple Regression Results for Population II

Variable	Step Removed	p-value	R^2 Value
Change in Pool Elevation	1	0.804	N/A
River flow	2	0.441	N/A
Temperature	3	0.165	N/A
Turbidity	4	0.114	N/A
Dissolved Oxygen	---	0.075	0.04
Through-screen Velocity	---	0.023	0.06
Pool Elevation	---	0.008	0.09

A.3.5.2 Additional Analysis

All RIS species/groups were also examined separately in an attempt to discern any correlation between a particular species' impingement rate and any of the environmental variables tested. The fall 2005 season encompassed 45 sampling events, due in part to an effort to sample intensively through the American shad migration period. Therefore, during this particular season there is generally a wide distribution in the values of tested environmental variables, making it useful for regression analysis. Each species was tested through multiple regression analysis against several environmental variables (Section A.3.5.1). No significant correlations ($R^2 > 0.50$) were found between any of the RIS species (other than gizzard shad) and the variables tested. Other seasons could not be tested due to small sample sizes.

A.4 Calculation of Impingement on Days Not Sampled

Impingement sampling at the PBAPS was generally conducted once per week, and more frequently during the American shad migration period (September 21 – December 6, 2005). Impingement collections were not conducted on a daily basis; therefore, calculations must be made for days not sampled in order to determine the annual IM. The following sections describe the methodology used for calculating days not sampled during the IM characterization study to account for uncertainty and provide a defensible approach for annualizing the IM data.

Annualization methods differed between Population I and II because regression analyses showed that impingement was correlated with TSV for Population I. However, no strong correlations ($R^2 > 0.50$) were observed with any of the independent variables used in Population II. Therefore, the regression equations derived from the regression analyses were used to calculate impingement for Population I and a 30-day rolling mean was used for calculating days not sampled for Population II.

The regression equations used for Population I require the TSV for the days not sampled. The TSV for all days not sampled during fall 2005 was calculated using formulas adapted from Pankratz (1995):

$$TSV = Q / (WD * OA * TW * K) \qquad \text{Equation (3)}$$

where:

TSV = through-screen velocity in feet per second (fps)
Q = flow rate in gallons per minute (gpm)
WD = water depth in feet (ft)
OA = proportion of screen open area to total screen area
TW = nominal screen tray width (ft)
K = constant = 396 for through-flow screen

and:

$$OA = (W * L) / ((W + D) * (L + d)) \qquad \text{Equation (4)}$$

where:

> d = screen horizontal wire diameter in inches (in)
> D = screen vertical wire diameter (in)
> W = width of screen opening (in)
> L = vertical length of screen opening (in)

A.4.1 Population I

The following model, based on the regression analysis, was selected to calculate fall gizzard shad impingement numbers, measured as fish impinged per day, for days not sampled during the fall 2005 period:

$$LOG_{10}(I_{(\#)}) = 4.4212(TSV) - 0.7376 \qquad \text{Equation (5)}$$

where $I_{(\#)}$ is the number of fish impinged. Equation (5) was used to calculate daily impingement values for days not sampled using TSV values computed from daily flow rates and water depths for that day.

To account for *uncertainty*, 95 percent confidence intervals (95% CI) for the year were calculated by multiplying the number of days in the season (90) by the 95% CI about the mean. The calculated seasonal impingement for gizzard shad (± 95% CI) for fall 2005 (September 23 – December 21) was 183,435 ± 82,892 individuals, or 2,038 ± 921 individuals per day.

A.4.2 Population II

Regression results for Population II data do not allow for the utilization of a statistical approach for predicting impingement on non-sampled days. To calculate impingement for the days not sampled, a 30-day rolling mean was developed using sample data from the 2005-2006 dataset. All available impingement values for the 15 days preceding and following the date of interest were averaged to create a mean daily value for all dates not sampled. Calculated daily values were rounded to the nearest individual and summed to obtain the calculated annual impingement. To account for uncertainty, 95% CI for the year were calculated by multiplying the number of days in the year (365) by the 95% CI about the mean.

The calculated annual (August 30, 2005 – August 29, 2006) impingement (± 95% CI) of Population II was 37,986 ± 3,821 individuals, or 104 ± 10 individuals per day.

A.5 Annual Impingement at the PBAPS

The calculated daily numbers impinged for each population (gizzard shad collected in the fall 2005 [Population I] and the remaining impinged individuals [Population II]) were summed to quantify the total annual IM for the PBAPS (Table A-4). Ninety-five percent CI from each population were summed to account for uncertainty.

Table A-4 Total Annual IM for the PBAPS August 30, 2005 through August 29, 2006.		
Population I	Population II	Total Impingement
183,435 ± 82,892	37,986 ± 3,821	221,421 ± 86,713

A.5.1 Annual Variability

The annualized impingement numbers in Table A-4 were calculated from the beginning of sampling at the PBAPS (August 30, 2005) to one year later (August 29, 2006). An annual estimate of fish impinged calculated using the final 365 days of the study, November 18, 2005 - November 17, 2006, shows the effect of annual variability. During this time period, an annualized total of 53,771 ± 11,870 individuals were impinged at the PBAPS. This annual impingement is approximately 75 percent lower than the first 365 days of the study and is largely due to the relatively low numbers of gizzard shad observed from mid-October through mid-November 2006. The out-migration in the fall of 2006 was unusually low due to the very high flow event that occurred in June of 2006. General trends in species year class strengths, including broadcast spawners such as gizzard shad, in the Susquehanna and other river systems can fluctuate widely depending upon an environmental variable such as river flow. If high flows occur during or shortly after the spawning season of many species of fish, recruitment of young will be reduced. In contrast, low river flows in the spring generally result in production of a greater number of young-of-the-year fish. Therefore, the first 365 days of sampling were used to compute the Calculation Baseline (inner intake) IM. This period will result in the most conservative numbers, since numbers of young were atypically low in the fall of 2006.

A.6 Calculation Baseline at the PBAPS

The Calculation Baseline is designed to evaluate impingement mortality (IM) encountered at baseline practices, procedures, and structural configuration. The outer CWIS at PBAPS is a structural configuration that results in velocity reductions and reductions of fish entrapment, and was implemented for the purpose of reducing impingement. In addition PBAPS has adapted procedures that were implemented in part for reducing impingement. These include restricted plant operations during times of low water elevations in Conowingo Pond and the seasonal shut down of circulating water pumps. The inner intake structure was the original design and represents the baseline practices, procedures, and structural configuration of the facility. Thus IM at the inner intake structure would be defined as the Calculation Baseline. However, impingement data are not available for the inner intake structure. Therefore, the Calculation Baseline must be computed using available data (2005-2006 IM field study at the outer CWIS), plant operations, laboratory and field data on impingement, and intake velocity. This was done by using the same methodology and similar analytical and statistical analysis as was used to calculate impingement on days not sampled for the annual impingement calculations at the outer intake as described above. Because the PBAPS does not have a fish return system, 100 percent mortality is assumed. Therefore, for the purposes of this evaluation, the number of impinged fish is the same as IM.

For Population I, the relationship between gizzard shad impingement and TSV derived from the regression analysis of data from the outer CWIS were used to calculate potential gizzard shad IM at the inner CWIS during the fall 2005. For Population II, percent reductions of impingement observed over a range of approach velocities in laboratory trials of various species were used for calculating IM at the inner CWIS.

A.6.1 Annual IM at the Inner Intake Structure – Population I

In order to compute the Calculation Baseline at the inner intake, the TSV was calculated using water depth and plant flow. Based on these calculations, the inner intake TSV conservatively ranged from 1.2 to 2.5 fps. To compute the Baseline Calculation of Population I, the daily inner CWIS TSV was used in the regression equation for the outer intake (Equation 5 above).

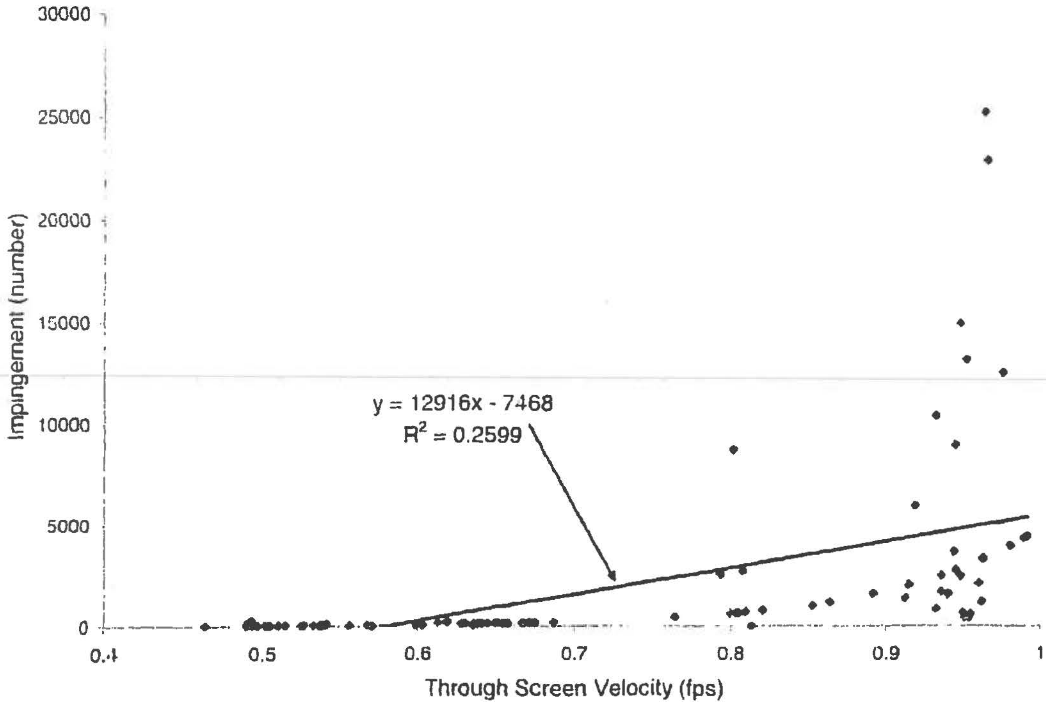
Extrapolation of Population I data to inner screen values using the regression equation based upon the LOG_{10} transformed impingement data resulted in the impingement of over 103 billion individuals, or slightly over 1.1 billion per day over the fall out-migration. Extrapolating data beyond the limits of measured independent variables is not realistic in that the calculated regression equation may not apply at TSV values above the measured maximum of 1.0 fps at the outer CWIS. However, there is a demonstrated positive relationship between TSV and IM rates of gizzard shad during the fall 2005. Therefore, to utilize a more conservative approach, the linear regression equation (see Figure A-2), developed from the untransformed fall 2005 gizzard shad collection, was used to extrapolate IM rates at the calculated daily inner intake TSV.

Equation (6) $I_{(Inner)} = 12,916*TSV - 7,468$

where $I_{(Inner)}$ is the calculated total number of fish impinged at the inner intake structure.

The Calculation Baseline of the inner intake for Population I is 15,683 ± 1,150 per day, or 1,411,438 ± 103,517 over the fall out-migration. This calculated rate is reasonable since daily impingement greater than 20,000 were sampled in the fall 2005 at the outer CWIS.

Figure A-2
Regression Plot of Impingement Values as a Function of TSV for Population I



A.6.2 Annual IM at the Inner Intake Structure – Population II

No significant correlation between impingement and TSV was observed for Population II, most likely due to numerous confounding variables in the system. However, the relationship between intake velocity and IM is well established. USEPA acknowledges this relationship at 69 FR 41612 by stating:

> "*...impingement is related to a combination of flow, intake velocity, and fish swim speed*" and "*...EPA agrees that reducing intake by installing flow reduction technologies will result in similarly high reduction of impinged... organisms...*"

The correlation between velocity and impingement has also been demonstrated in laboratory studies as well (Peake 2004, EPRI 2006 as cited in ARL 2007). Peake (2004) found a statistically significant linear relationship between impingement of northern pike and approach velocity ($P<0.05$, $R^2=0.70$) and that IM was reduced by 74 percent when approach velocity was reduced from 1.8 to 1.1 fps. Similarly, in a more extensive study evaluating 10 species commonly impinged at CWIS, a statistically significant positive relationship was demonstrated between approach velocity and impingement ($P<0.05$, $R^2=0.72$) (EPRI 2006 cited in ARL 2007). ARL (2007) concluded that impingement rates can be reduced with reductions in approach velocities and reductions in impingement may average 45 to 75 percent, depending on species, when intake velocities are decreased from 2 to 1 fps.

Therefore, inner screen daily IM for Population II were calculated using percent reductions observed over a range of approach velocities in laboratory trials (EPRI 2006 as cited in ARL 2007). The percent reduction of impingement observed from changing approach velocity from 2 to 1 fps in the laboratory trials was used, because this difference best approximated actual approach velocities at the PBAPS between the inner and outer intakes. Four species impinged at the PBAPS (bluegill, channel catfish, largemouth bass, and yellow perch [Non-RIS recreational]) were studied during the trial, and the inverse of the observed *percent* reductions for these species were applied to the outer intake structure daily impingement to compute the Calculation Baseline for Population II.

For species not specifically examined in the laboratory trials, surrogates were chosen that best represented the RIS from the PBAPS, based on factors such as swimming speed, body shape and size (morphometrics), taxonomy, and overall life history characteristics. Published swimming speed data were reviewed to assess the similarities between the RIS and surrogate species. Since swimming capability is highly variable depending on fish length and water temperature, sufficient data were not available to relate one species to another in all cases. However, all of the examined species do exhibit carangiform type locomotion; that is, the main power for swimming is accomplished by side to side sweeps of the tail region (Lagler et al. 1962). Therefore, body morphometrics were considered in the impingement evaluation because morphometry plays an integral role in determining swimming ability. Species with similar morphometry (specifically in the posterior region) are likely to exhibit similar swimming capacity. Morphometric measurements were used to compare the RIS not included in the laboratory study to species that were studied to determine a suitable surrogate for an IM reduction (Table A-5). Morphometric values provided are presented as the percent of the fish's total length, with the exception of caudal fin aspect ratio. Aspect ratio of the caudal fin is calculated as:

Equation (7) $AR_{cf} = H^2_{cf} / SA_f$

where AR_{cf} is equal to the aspect ratio of the caudal fin, H^2_{cf} is equal to the height of the caudal fin (squared), and SA_f is equal to the surface area of the fin. This ratio is directly related to fish swimming ability. In general, faster swimming fish possess higher ratios in comparison to slower swimming species. Using these measurements, surrogate species for three RIS , bluegill (surrogate: white crappie), walleye (surrogate: yellow perch), and smallmouth bass (surrogate: largemouth bass) were determined. Smallmouth bass was also found to have similar critical swimming speeds as largemouth bass: 31.7 and 35.7 centimeters per second at 20°C, respectively (EPRI 2000).

Table A-5 Morphometric Comparison of RIS and Surrogate Species from EPRI 2006 Laboratory Experimentation[1]						
Morphometric Character	RIS	Surrogate	RIS	Surrogate	RIS	Surrogate
	White Crappie	Bluegill	Walleye	Yellow Perch	Smallmouth Bass	Largemouth Bass
Standard length	82.3%	81.6%	86.7%	84.6%	82.8%	85.8%
Fork length	96.8%	95.4%	95.2%	97.6%	96.5%	96.8%
Pre-anal length	46.7%	49.6%	57.6%	61.1%	55.6%	51.5%
Body depth	36.4%	40.5%	15.5%	23.4%	26.7%	28.0%
Aspect ratio of caudal fin	1.62	1.62	1.29	1.23	1.43	1.28

[1]Species specific morphometric data acquired from http://www.fishbase.org.

The hybrid striped bass is a cross of the striped bass and white bass species. Percent reduction values for the hybrid striped bass were used for both American shad and gizzard shad based on swim speed data and their life history similarities. Castro-Santos (2005) observed relatively similar prolonged swim speeds of American shad and striped bass (7.2 and 10.4 body lengths per second, respectively). American shad, striped bass, and white bass are all anadromous and are subject to similar migratory patterns, and consequently experience similar flow and temperature regimes. Therefore, these species are assumed to exhibit similar swimming capacity.

Morphometric data were unavailable for the comely and spottail shiners and much of these species' life histories are poorly understood. Therefore, the percent reductions of the fathead minnow were used for comely shiner and spottail shiner, based on their taxonomic relationship (Family Cyprinidae) and similar body shape and size. Table A-6 summarizes the results of this evaluation.

The laboratory trials were conducted on specific size ranges of fish. Age class was determined to be a more appropriate comparative measure than fish length due to the use of surrogates for many of the RIS . Therefore, age class was estimated for each tested species, and the percent reduction value was applied only to the percentage of impinged RIS that fell within the age classes tested. To be conservative, no adjustments were made to individuals that were outside of the tested age classes, although some reduction is likely. For example, there is no credit for a reduction in American shad IM because the age classes impinged were outside of age class used in the tests.

Table A-6 List of RIS, Surrogate Species Used to Calculate Population II IM, and Mode of Selection			
RIS	**Surrogate Species (EPRI 2006)**	**Mode of Selection**	**Percent Reduction (EPRI 2006)[1]**
Walleye	Yellow Perch	Morphometric measurements	59%
Bluegill	Bluegill	Same Species	50%
Largemouth Bass	Largemouth Bass	Same Species	60%
Smallmouth Bass	Largemouth Bass	Morphometric measurements, critical swimming speed	60%
White Crappie	Bluegill	Morphometric measurements	50%
American Shad	Hybrid Striped Bass	Life History, prolonged swimming speed, limited morphometry	7%
Channel Catfish	Channel Catfish	Same Species	15%
Comely Shiner	Fathead Minnow	Taxonomy, limited morphometry	44%
Yellow Perch (Non-RIS Recreational)	Yellow Perch	Same Species	59%
Spottail Shiner (Non-RIS Forage)	Fathead Minnow	Taxonomy, limited morphometry	44%

[1]Percent reduction in impingement between 1-2 fps approach velocities

Following the adjustments for observed percent reductions on surrogate species, the Calculation Baseline of the inner intake for Population II is calculated to be 54,419 ± 6,379 individuals, or 149 ± 18 per day.

A.6.3 Total Calculated IM at the Inner Intake Structure

By summing the calculated annual IM at the inner intake structure for both populations the overall Calculation Baseline was determined (Table A-7).

Table A-7 Calculated Total IM at the Inner Intake Structure From August 30, 2005 to August 29, 2006.		
Inner Intake Population I	**Inner Intake Population II**	**Total**
1,411,438 ± 103,517	54,419 ± 6,379	1,465,857 ± 109,896

A.7 Rare, Threatened, and Endangered Species

There were no collections of any Pennsylvania Endangered, Threatened, and Candidate species (Pennsylvania Code Title 58 §75) in the reviewed community or impingement studies in the vicinity of the PBAPS. There is one species of concern that occurs in the vicinity of the PBAPS: the American shad, a species targeted for restoration along the Susquehanna River. A description of the life history of this species is presented below.

A.7.1 Life History Description of American Shad (Alosa sapidissima)

The range of the American shad extends from the Bay of Fundy in Nova Scotia to the St. Johns River in Florida. Large populations of adult American shad spend the summer months in the Gulf of Maine, Bay of Fundy, and the St. Lawrence estuary. In mid-fall, large schools migrate south, where they overwinter in deeper pelagic habitats off the Mid-Atlantic coast (ASMFC 1999). Water temperatures generally trigger spawning migrations to natal rivers; however, photoperiod, flow velocity, and water turbidity also influence the onset of spawning (USFWS 1985a, 1986).

Spawning in the Susquehanna River generally occurs from late-April to early June (Chesapeake Executive Council 1989). The United States Fish and Wildlife Service (USFWS) reports that American shad is non-selective for spawning substrate, indicating that it will spawn over sand, silt, muck, gravel, and boulder substrates in higher gradient stretches of river with flow velocities of 0.5 to 3 fps (USFWS 1985a; Chesapeake Executive Council 1989). The Atlantic States Marine Fisheries Commission (ASMFC) (1999) indicates that spawning type is likely not critical to the spawning success rate, given that thousands of eggs are broadcast over a range of substrates and are transported downstream. Spawning may occur in water depths ranging from 3 to 30 feet, but typically occurs in less than 10 feet of water (USFWS 1985a). Emigration occurs in the fall and is initiated when water temperatures drop below 60°F (USFWS 1985b). Once in the open ocean, young American shad join schools from other rivers and begin their seasonal migrations northward and southward along the Atlantic Coast.

The American shad has not maintained its value in the modern market. However, in 1989, econometric models estimated that a restored American shad fishery in the Chesapeake Bay could be valued from 42 million to 178 million dollars (Chesapeake Executive Council 1989). To enhance restoration efforts of American shad, the Pennsylvania Fish and Boat Commission has imposed a year-round closed season in the Susquehanna River in Pennsylvania. In some regions, non-consumptive uses of the alosine resources still remain as an important part of public education, local heritage and outdoor recreation. American shad also play a major role as a food source for many other wildlife species (ASMFC 1999).

A.8 Uncertainty

Statistical uncertainty is an unavoidable aspect of any environmental monitoring study. Uncertainty arising from imperfect precision and accuracy of biological data (sampling and measurement errors) is often of primary concern, particularly with respect to monitoring studies of fish impingement. However, beyond simple mechanical error, there is uncertainty stemming from the normal sampling regime used at PBAPS that called for impingement sampling once per week. It was assumed that weekly sampling was sufficient to capture seasonal variation in the aquatic community. However, daily variations in numbers of fish impinged could have skewed annualization calculations. For example, daily IM of gizzard shad varied greatly in fall 2005 (during a time when impingement was sampled five times per week in an attempt to capture the seasonal American shad out-migration). More than 25,000 gizzard shad were impinged on October 26, 2005, whereas less than 1,200 individuals were impinged on the previous and following days. Sampling only once per week may not have captured other large impingement events which would lead to smaller estimated annual IM. On the other hand, if the weekly sampling did capture large one-day IM events, estimated annual IM would be inflated, inaccurately suggesting a higher impingement rate than the actual. Furthermore, collection efficiency at the CWIS screens was assumed to be constant throughout the study and across all species collected. Uncertainty about numeric values used in the extrapolation to annualized IM will generally lead to imprecision rather than inaccuracy since inaccuracies across parameters (above and below actual values) will tend to counteract each other.

A.8.1 Yearly Impingement Calculations

Extrapolation to annualized IM required several assumptions even with the most appropriate methods. The extrapolation of Population I IM numbers to days not sampled used a regression equation (based on the $\log_{10}$ IM) that indicated that 63 percent of the variation in the gizzard shad IM in Fall 2005 was explained by TSV. The remaining 37 percent represents other potential sources of error. The procedure for developing daily impingement numbers for Population II (i.e., using the 30-day rolling mean approach for days not sampled) represented an alternative approach for calculating impingement since no significant correlations were found between impingement and any environmental or operational variable. Because statistical tests showed no difference in impingement between seasons for Population II (Attachment II), seasonal data were pooled as one data set. A rolling average (mean impingement of 15 days before and 15 days after) was used to calculate impingement for days not sampled. For days that were sampled, the observed impingement number was used. Total annual impingement was calculated as the sum of the daily impingement numbers. This method takes into account the temporal variability in impingement on a daily basis, rather than evaluating variability from means of a unit of time such as weeks or months. Uncertainty is reduced by estimating daily impingement for days not sampled from actual impingement values around the data point to be calculated (15 days prior and post), compared to the assumption that impingement is constant over a given week, month, or other arbitrary time period.

Collection efficiency studies conducted September and November 2006 produced viable estimates of collection efficiency that could be applied to the impingement data set. Given that the number of collection efficiency trials from these studies were limited, calculation of confidence intervals based on seasonal collection efficiency values as requested by the Maryland Department of Natural Resources was not feasible. Instead, collection efficiency values of 84 and 86.5 percent for Unit 2 and Unit 3, respectively, from the September and November 2006 studies were applied to actual impingement numbers prior to implementing annualization procedures. The requested methodology also called for determination of seasonal impingement by multiplying the average number impinged by the number of days in the season. Since impingement rates vary throughout a season, this methodology would bias the estimate towards portions of the season in which more sampling occurred. This uneven spacing of sampling events occurs throughout the current study. The methods employed in this report, rolling averages and the regression equation, do not require even temporal spacing of sampling events. The 95% CI about the calculated annual number impinged was computed as the product of the

95% CI of the calculated daily impingement values and the number of days in the year (365).

A.8.2 Calculation Baseline Computation

Impingement data were not available for the inner CWIS, so the Calculation Baseline needed to be computed from data collected at the outer CWIS. The Calculation Baseline for Population I used a linear regression equation based on IM and TSV. Uncertainty arises from the fact that Calculation Baseline IM numbers are extrapolated from beyond the limits of measured independent variables (TSV). (i.e. the highest TSV value recorded at the outer CWIS was <1 fps, whereas the inner CWIS had TSV values between 1.3 and 2.8 fps). It is likely that this method results in conservative numbers since the best fit regression equation, based on the $\log_{10}$ IM and TSV, extrapolated to inner CWIS TSV values resulted in over 103 billion impinged fish over the fall 2005 season. The Calculation Baseline for Population II assumed a percent reduction in IM from the inner to outer CWIS based upon published IM reductions resulting from an approach velocity decrease from 2 to 1 fps. Other aspects of this method added to the uncertainty. First, some RIS species were not included in the published study and required surrogates for inclusion in the analysis. Second, reductions were only applied to fish in the same size class as those in the published study even though reduced approach velocities are likely to have an effect on IM across all sizes of fish.

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APPENDIX B

LIST OF THE HISTORICAL STUDIES CONDUCTED AT THE PEACH BOTTOM ATOMIC POWER STATION

FOR

PEACH BOTTOM ATOMIC POWER STATION

Prepared for:

Exelon

by URS Corporation

October 2008

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LIST OF THE HISTORICAL STUDIES CONDUCTED AT THE PEACH BOTTOM ATOMIC POWER STATION

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APPENDIX C

SUMMARY OF FISH IMPINGEMENT SAMPLING AT PEACH BOTTOM ATOMIC POWER STATION, CONOWINGO POND, PENNSYLVANIA, 2005-2006

FOR

PEACH BOTTOM ATOMIC POWER STATION

Prepared by Normandeau Associates, Inc. for:

Exelon[SM]

October 2008

Normandeau Project Number 20501.000

FINAL

SUMMARY OF FISH IMPINGEMENT SAMPLING AT PEACH BOTTOM ATOMIC POWER STATION, CONOWINGO POND, PENNSYLVANIA, 2005-2006

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EXECUTIVE SUMMARY

This report characterizes fish impingement at the outer vertical traveling screens of Peach Bottom Atomic Power Station Units 2 and 3 (PBAPS), located on Conowingo Pond, as required by the U.S. Environmental Protection Agency's 316(b) Phase II Rule for large, existing power producing facilities (July 2004). This report also provides information on; fish of Conowingo Pond; and a comparison with the historical trends of variation in fish impingement.

The designed approach velocity of the new outer vertical traveling screens represented about a 73% reduction in velocity over what would have presumably been the baseline velocity at the inner intakes. Assuming a linear relationship between velocity and impingement rate, implicit in the EPA criterion, this reduction in velocity would translate in about 73 % reduction in impingement rate.

Extensive fishery studies of Conowingo Pond between 1966 and 1999 indicate that the Pond supports warm water fishes. The common fishes are gizzard shad, channel catfish, bluegill, and spotfin shiner. Gizzard shad was inadvertently introduced in 1972 and its population has exploded since then and is beset with natural winter die-offs. Except for large annual fluctuations in abundance and introduction of some species, the present day fish community of Conowingo Pond is similar to that observed in the preoperational period and early years of plant operation. The game fishes include largemouth bass, smallmouth bass, and walleye. Since 1997, migratory fishes (e.g., American shad and river herrings) and other species have been given direct access to Conowingo Pond via the Conowingo East Fish Lift.

Prior to initiating the present impingement sampling, a detailed study plan was prepared and distributed to various regulatory agencies (primarily Pennsylvania Department of Environmental Protection, Pennsylvania Fish and Boat Commission, Maryland Department of Natural Resources, and Susquehanna River Basin Commission) in May 2005 for their review and comments. Upon concurrence of these agencies and incorporation of their comments, the study plan was implemented on 30 August 2005 and sampling continued until 17 November 2006, including collection efficiency tests. The characterization of fish impingement is based on this sampling period.

In the current investigation, 61,504 fish representing 40 species and 532 crayfish were impinged at Units 2 and 3. Some 60.2% of the fish representing 38 species were collected at Unit 3, and 39.7% of the fish comprising 29 species were collected at Unit 2. Gizzard shad represented 86.9% of the impingement samples. Bluegill and channel catfish comprised an additional 6.9% and 4.1% of the catch, respectively. Collectively, the remaining 38 species made up less than 3.0% of the samples.

Impingement of fishes (all species combined) was greatest (85%) from September through November. This was most evident for gizzard shad; American shad impingement was low (0.3%) and coincident with their emigration period out of the river. It is difficult to quantify the proportion of gizzard shad which may have been in moribund state or dead prior to impingement, particularly at water temperatures ≤ 45° F, and were swept onto the screens. Natural die-offs of gizzard shad are common at water temperatures < 45° F in Conowingo Pond (RMC 1194b; field observations).

The trends in impingement rates and species composition, except for those introduced via restoration efforts or inadvertently since 1972, observed in the 2005-2006 sampling period were similar to those observed in 1973 to 1978. Most fishes impinged in both periods measured ≤140 mm.

1. CONOWINGO POND FISH COMMUNITY

Fishery studies in Conowingo Pond consisted of over 25,000 collections by meter net, trap net, trawl, seine, and electrofishing between 1966 and 1999 to assess changes, if any, in relative abundance, distribution, spawning areas, etc., due to the operation of PBAPS (PECO 1975; Normandeau Associates 2000). Sampling locations were selected upstream and downstream from PBAPS and in areas expected to be within the heated plume. Collected fishes were measured and important life history aspect data were recorded to characterize reproduction, food habits, and age class-growth of representative, important species (RIS) established for PBAPS (gizzard shad, inadvertently introduced in 1972; white crappie, channel catfish, bluegill, largemouth bass, smallmouth bass, walleye, spotfin shiner, and bluntnose minnow).

In general, the above sampling indicated wide annual variations in species abundance between sampling locations and seasons. No large concentrations of fish near the PBAPS intake were observed. Additionally, the thermal effluent from PBAPS did not impede the downstream winter movement of white crappie. Recent radio tagging studies of adult American shad did not indicate impedance of upstream migration through Conowingo Pond by PBAPS effluent (Normandeau Associates 2000).

The fishes in the Pond are, for the most part, classified as warm water species. Some 60 species were taken in the Pond or in the fish lifts at Conowingo and Holtwood dams and the tributary streams. The spotfin shiner, bluegill, pumpkinseed, bluntnose minnow, and channel catfish are the most common fish; the white crappie, once most common until the early 1970's, are not as abundant at present. Its decline in abundance was attributed to concomitant explosive population increase of gizzard shad, which was inadvertently introduced in 1972; both species compete for zooplankton for food (RMC 1994). Gizzard shad is the most abundant species at present, though wide annual fluctuations in its population occur; natural winter die-offs occur when water temperatures are < 45° F (RMC 1194b; field observations). The game fishes include the smallmouth bass, largemouth bass, and walleye. No rare, endangered, or commercially harvested fishes are present in the Pond.

The alewife, American shad, blueback herring, and striped bass have been introduced during the last 35 years. The Pennsylvania Fish Commission has stocked muskellunge upstream in the vicinity of Falmouth, Pennsylvania and a few adult muskellunge were taken in the Pond and at PBAPS (Mathur *et. al.* 1977).

Recent sampling (1996-1999) of Conowingo Pond indicated trends in variation and distribution of fishes were similar to those observed in 1966 to 1980 (Normandeau Associates 2000). Except for the fishes introduced in Conowingo Pond since 1966, the abundance of the representative important species (RS) has not changed significantly due to the operation of PBAPS.

The common species (channel catfish, pumpkinseed, bluegill, gizzard shad, and spotfin shiner) are widely distributed in the Pond (PECO 1975). The distribution of many of the less common fishes, such as the walleye, smallmouth bass, largemouth bass and many cyprinids including the bluntnose minnow, is more limited (PECO 1975). The largemouth bass is more common in the southern part of the Pond whereas the smallmouth bass, walleye and bluntnose minnow are found near the northern part, primarily in habitat more riverine in nature, between Holtwood Dam and the Muddy Run Station (PECO 1975).

2. IMPINGEMENT OF FISHES

2.1. Present Impingement Sampling (September 2005-November 2006)

Impingement sampling program as outlined in the study plan and submitted to the agencies was implemented between 30 August 2005 to 17 November 2006 to characterize fish impingement at PBAPS Units 2 and 3. Specifically, the objectives of impingement sampling were to determine the numbers, seasonal patterns, species, and size distributions of fish impinged on the outer intake screens of each unit.

2.1.1. Frequency of Sampling

Impingement sampling began on 30 August 2005 and was terminated on 17 November 2006. Sampling occurred on 110 days during this time, 104 days at Unit 2 and 104 days at Unit 3. Sampling initially occurred once per week and then was increased to two or three times per week prior to the timing of the American shad outmigration (primarily October and November). Once juvenile American shad were observed emigrating downriver from upriver monitoring locations, impingement was monitored five times per week. In 2005, this occurred on 10 October, with the first juvenile American shad caught at PBAPS on 13 October. Sampling five days per week continued until 6 December 2005, when water temperatures dropped to survival threshold limits for American shad within the Pond. Sampling was resumed to once per week after 6 December 2005. In 2006, a sampling effort of five days per week began on 23 October when the first emigrating American shad was collected and continued until the end of the study on 17 November.

Sampling involved sorting through trash bins at the terminus of the outer screen house. Once debris passed over a vibrating screen at the end of the sluiceway, it was dewatered and collected in a trash bin. After 24-h, the bin was removed from the system and placed outside of the screen house with a protective net over the top to avoid avian predation. Specimens that accumulated in the trash bin at the end of 24-h period constituted a sample. These specimens were dead and no return bypass system exists to move them out safely. Occasionally, sampling could not be completed due to mechanical problems and/or accumulation of excessive debris.

Environmental variables including intake water temperature, dissolved oxygen, and water clarity (Secchi) were recorded at the time of sampling. These data along with those on fishes are presented in Appendix A and B.

2.1.2. Sample Processing

For each sample collection period, all fish were separated from the debris, identified to species, measured for total length to the nearest millimeter, categorized as to condition, and enumerated. If excessive numbers of a particular species were collected in a sample, the total number in each length group for that species was estimated from a sub-sample count or weight extrapolation. Care was taken so that the sub-sampling was random and did not bias the selection of individuals by size.

The raw fish catch data were adjusted for sub-sampling that occurred in the fall of 2005 and 2006, due to logistical constraints relative to leaf debris load; 27 sub-samples were processed in 2005 and six in 2006 (Table 5-1). For each sub-sampling event, the amount of debris in a bin was visually estimated by the personnel as a proportion of a full bin (i.e., 50% full, 100%, etc.). Then a random sample of at least 15% of the debris and fish was removed and sorted to collect impinged specimens. Based on the amount of sample processed, the total number of fish impinged was estimated for that given day. Later, the number of fish impinged was adjusted for collection efficiency (see below Section 5.1.3). The monthly expanded catches of each species at Units 2 and 3 along with their standard errors (SE) and the collection values used are presented in Appendix B. However, summarized monthly catches of common species impinged are discussed herein.

2.1.3. Collection Efficiency Tests

Because it was assumed that some dead fish impinged on the traveling screens may have not passed into the collection bins, collection efficiency tests were conducted on five different dates. However, for a variety of factors some tests were not considered reliable or representative and data from these trials had to be excluded in estimation of total number of fish impinged. For example, the tests conducted on April 24, July 11, and July 18, 2006, were excluded from the evaluation of collection efficiency. It was determined that the pre-killed fish were released into the portals too far upstream (approximately eight feet) of the screen for the fish to be carried against the screen by the intake flow. An additional trial on September 8, 2006 was excluded because it was determined that the traveling screen wash system on the particular screen tested was not functioning properly and most of the fish were carried over into the intake canal. Appendix C provides a complete list of intake screen efficiency tests conducted.

For each efficiency test, either dyed (Bismark Brown) or radio tagged dead fish of several species and representative sizes to those predominantly collected in impingement samples were released in front of traveling screens through access portals approximately 10 ft upstream of the screens or directly in front of the screens through doors on the traveling screen covers. It was determined that if the fish were not released close (< 2ft) to the screens, the likelihood of their complete recapture was low.

Collection efficiency was estimated at 84% (Standard Error, SE = 4.3%) for Unit 2 and 86.5% (SE = 5.7%), based on three trials deemed reliable at Unit 2 and four at Unit 3 (Table 5-2). All impingement catch data were adjusted upward to account for these efficiency values for each Unit.

The study protocol specified sampling each unit intake once per week; however, there were instances when sampling one or both unit intakes did not occur due to logistical constraints at PBAPS. When a weekly sample was missed, the estimated values from the previous and following weeks were averaged and those numbers were assigned to the missed sampling date and the following six days until the next sampling event occurred.

2.1.4. Estimation of Confidence Intervals

The precision of impingement estimates for each species, month, and unit was calculated using the method recommended be MD DNR as follows:

$$\overline{c_S} = \frac{\sum_{i=1}^{n_s} c_i}{n_s},$$

with variance

$$\hat{\text{var}}(\overline{c_S}) = \frac{\sum_{i=1}^{n_s} \left(c_i - \overline{c}\right)^2}{n_s - 1}$$

Where c = catch per unit day, n_s = number of days sampled in a month, $\overline{c_S}$ = monthly mean catch per day. Catches were adjusted for collection efficiency (e). Three estimates of collection efficiency were available for Unit 2 and four for Unit 3 (Table 5-2). Mean and variance of collection efficiency were calculated as follows:

$$\overline{e_S} = \frac{\sum_{i=1}^{n_s} e_i}{n_s}$$

$$\hat{\text{var}}\left(\overline{e_S}\right) = \frac{\sum_{i=1}^{n_s} \left(e_i - \overline{e}\right)^2}{n_s - 1}$$

An estimate of the total fish impinged $\left(\hat{C}_s\right)$ at each unit is:

$$\hat{C}_s = N\frac{\overline{c}_s}{\overline{e}_s}$$

where N = number of days per month. The variance was estimated as follows:

$$\hat{\text{var}}\left(\hat{C}_s\right) = \frac{N^2}{\overline{e}_s^{\,2}}\left[\hat{\text{var}}(\overline{c}_s) + \frac{\left(1-\overline{C}_s\right)}{\overline{C}_s}\overline{c}_s + \frac{\overline{c}_s^{\,2}}{\overline{e}_s^{\,2}}\hat{\text{var}}\left(\overline{e}_s\right)\right].$$

Total catch was estimated as:

$$\hat{C}_y = \sum_{i=1}^{15} \hat{C}_{s_i}$$

with variance

$$\hat{\text{var}}_y = \sum_{i=1}^{15} \hat{\text{var}}_{s_i}$$

For all estimates the standard error = $\sqrt{\hat{\text{var}}}$.

Appendix B provides monthly impingement estimates and standard errors of each species and the collection efficiency values used. Estimates are shown separately for Unit 2 and 3.

2.2. Historical Impingement Sampling (1973-1979)

Intensive impingement sampling was conducted at the outer traveling screens of Units 2 and 3 to determine: (1) the species composition, (2) the number of fishes impinged, and (3) the impact of fish losses due to impingement on the fish community of Conowingo Pond. Samples for Unit 2 were collected from November 1973-January 1979, and from December 1974-March 1979 at Unit 3. The following data were recorded with each sample: intake water temperature, Pond elevation, number of circulating water pumps in operation, average daily river flow, time of day, and date. These data were used to develop separate statistical relationships between each common species impinged per 12-h at each unit and external variables (Mathur *et al.* 1977). Each model was validated using an independent data set (i.e., data set that was not included in the development of each model). These models were based on data collected in late-1973 to 1975. However, with the availability of additional data collected beyond 1975, the latter data have been included in the models. These models were used to predict the number of fish impinged per 12-h and compared with the observed impingement rate to assess whether trends in variability in fish impingement were similar in the two periods. If the predicted values fell within the confidence bands developed for the historical period, it was interpreted that no significant changes in the factors influencing variability in impingement rates had occurred and the observed variability in impingement was similar to that observed historically.

2.2.1. Impingement Sampling For American Shad Outmigrants

As part of the American shad restoration program on the Susquehanna River, impingement of emigrating juvenile American shad on outer intake screens has been quantified during fall in most years since 1982; no sampling occurred in 1988 and 1998. Sampling occurred primarily three times weekly from October through mid-December. These data provide information on size, timing, and origin (hatchery versus wild) of juvenile American shad outmigrants. Although the primary focus of this program has been for enumeration of American shad impinged, collected samples also provide information on other fishes as well. Appendix A provides the data on species composition observed during the current sampling.

2.3. Characterization of Impingement

2.3.1. Species Composition and Seasonal Trends

A total of 61,504 fish representing 40 species and 532 crayfish were caught over the course of the study (Table 5-3). Gizzard shad represented 86.9% of the catch. Bluegill and channel catfish comprised an additional 6.9% and 4.1% of the catch, respectively. Individually, the remaining 38 species made up less than 0.3% of the catch.

Some differences in impingement between units were observed (Table 2-3). A greater impingement occurred at Unit 3 than at Unit 2. Some 60.2% of the fish representing 37 species were collected at Unit 3, and 39.7% of the fish comprising 32 species were collected at Unit 2 (Table 2-3). Two species, gizzard shad and bluegill, contributed substantially to the difference in impingement between units.

Impingement rates exhibited seasonal patterns relative to all species combined (Figure 2-1). Impingement was highest in October and November of 2005 and in September 2006 through mid-November 2006 with 85% of fish impinged during these periods. The lowest monthly impingement (0.1%) occurred in March (Figure 2-1).

Because of the episodic nature of impingement of fishes or coincident with specific extreme hydrological event, a high variability either due to seasonal availability was observed. A similar pattern was reported in an earlier study (Mathur et al. 1977). With the exception of channel catfish, most impingement occurred in October through December. This was most evident for gizzard shad. Gizzard shad migrate downstream during fall and many gizzard shad are in moribund state or die at water temperature < 45° F. It is likely that many of these gizzard shad may have been swept onto screens.

As expected, most American shad impingement occurred during their emigration period (primarily in October and November). The relatively large number of walleye impinged in September through December 2005 is perhaps a reflection of a high production of young walleye in 2005 and their tendency to pursue clupeid prey; examination of stomach contents of impinged walleye revealed heavy feeding on young gizzard shad. It is likely that walleye were pursuing abundant young gizzard shad and became victim of impingement. Walleye were not commonly observed in either historical impingement or fishery samples (PECO 1977).

Length frequency data for all species collected are presented in Appendix A. Virtually all (94.4%) of the fish collected were < 140 mm and primarily age 0 or young of the year fish.

2.3.2. Comparison of Current Study to Historic Data (Assessment of Trends)

As stated previously, intensive sampling occurred for several years at both Unit 2 and Unit 3. In general, impingement rates for the most common fishes were highest from November to March. Channel catfish, white crappie, bluegill, and gizzard shad were most frequently impinged. Most of these fishes averaged less than 140 mm. In the present study, gizzard shad, bluegill, and channel catfish were most commonly impinged; impingement was generally higher in October through December than in other months. Most fishes impinged were less than 140 mm.

The trends in variability in impingement rates (number of fish per 12-h) in the present study were assessed by comparing with those predicted by regression models developed for the historic data (1973-1978) for all fishes combined (excluding gizzard shad), channel catfish, and bluegill separately for Units 2 and 3. In general, predictability of impingement rate was higher for Unit 3 (range of $R^2 = 0.512$ for channel catfish to 0.582 for all fishes) than for Unit 2 (range of $R^2 = 0.145$ for channel catfish to 0.404 for bluegill). Depending upon the species or unit, the influencing variables affecting impingement were river flow, water temperature, number of pumps, and Pond elevation. The appropriate models were used to predict impingement rates (number of fish per 12-h) of channel catfish, bluegill, all fish combined, and compared with the observed values in the current study to assess if the trends had changed significantly. Plots of these comparisons along with 90% confidence intervals are shown in Figures 5-2 to 5-4. Although predicted values tended to be higher than observed at low impingement values and lower at high values particularly for channel catfish and bluegill the overall observed variability in impingement rates was within the range of historical variation; one would expect 10% of the values to fall outside the 90% confidence limits on a random chance alone. The models tended to over-predict impingement of all fishes combined and channel catfish at lower impingement values and under predicted for bluegill at both units.

2.3.3. Species Composition During Outmigration Sampling

A total of 45 taxa were impinged during the outmigration sampling between 1997 and 2006 (Table 5-5). Gizzard shad were most common with bluegill, the other commonly impinged species. Of the migratory fishes, juvenile American shad were most common. The number of American shad impinged, though relatively low, is a reflection of intensive efforts to restore the species via a release of hatchery-reared larvae and naturally produced young in upstream areas; adult pre-spawned American shad have been given access to upstream areas since 1997 though their transport had occurred more than a decade earlier. The onset of juvenile American shad emigration in October through November is generally coincident with increasing river flow and lowering of water temperature.

3. CONCLUSIONS

Impingement sampling conducted from September 2005 to November 2006 at Units 2 and 3 indicated about 87% of the total catch were young gizzard shad, 6.9% were bluegill, and 4.1% were channel catfish. Most gizzard shad were impinged in October to December, and many of these may have been in moribund state or dead when water temperatures were < 45° F. Gizzard shad, bluegill, and channel catfish comprised about 98% of these fish with other species of interest (American shad 627 and walleye 932) comprising most of the remainder. As in the past study (Mathur *et al.* 1977), due to the episodic nature of impingement a large variability was observed in the present sampling. Most impinged fishes were less than 140 mm long.

The species composition and trends in impingement rates were similar to those observed during the intensive sampling in 1973 to 1978. Statistical models, developed from historic data, indicated that the observed variability impingement rates of common fishes in the present study were, in general, within the historic variability.

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TABLES

Table 2-1

Summary of impingement subsample events at Peach Bottom Atomic Station, Units 2 and 3, September 2005-November 2006.

Collection Number	Collection Date	Unit Sampled	Percentage of bin subsampled	Subsample Multipier
MDM05003	10/13/05	2	50	2
MDM05005	10/15/05	2	30	3.3
MDM05007	10/18/05	2	30	3.3
MDM05008	10/18/05	3	30	3.3
MDM05013	10/21/05	2	15	6.6
MDM05014	10/21/05	3	15	6.6
MDM05019	10/26/05	2	20	5
MDM05020	10/26/05	3	20	5
MDM05028	11/1/05	3	30	3.3
MDM05032	11/3/05	3	75	1.3
MDM05033	11/4/05	2	25	4
MDM05034	11/4/05	3	50	2
MDM05035	11/7/05	2	50	2
MDM05037	11/8/05	2	25	4
MDM05039	11/9/05	2	25	4
MDM05040	11/9/05	3	50	2
MDM05041	11/10/05	2	50	2
MDM05042	11/10/05	3	25	4
MDM05043	11/11/05	2	25	4
MDM05044	11/11/05	3	25	4
MDM05045	11/14/05	2	50	2
MDM05047	11/15/05	2	75	1.3
MDM05048	11/15/05	3	50	2
MDM05049	11/16/05	2	50	2
MDM05063	11/29/05	2	50	2
MDM05069	12/2/05	2	25	4
MDM05070	12/2/05	3	25	4
MDM06083	10/23/06	2	30	3.3
MDM06084	10/23/06	3	30	3.3
MDM06090	10/26/06	3	30	3.3
MDM06095	10/31/06	2	30	3.3
MDM06096	10/31/06	3	30	3.3
MDM06116	11/17/06	3	30	3.3

Table 2-2

Summary of efficiency tests, deemed reliable, conducted at the Peach Bottom Atomic Power Station Outer Screen House, 2006.

Efficiency Test Date	Unit Tested	Release Location	Species Tested	Number Released	Number Recovered	Efficiency Percentage
9/8/2006	2	H-J screen	Bluegill	50	48	96.0%
9/8/2006	2	B-C screen	Gizzard shad	50	48	96.0%
11/13/2006	2	F screen	Walleye	5	3	60.0%
Total Unit 2						***84.0%***
9/8/2006	3	J-K screen	Bluegill	50	48	96.0%
9/8/2006	3	E-F screen	Gizzard shad	50	50	100.0%
9/8/2006	3	on G screen	Yellow perch	10	10	100.0%
11/13/2006	3	C screen	Walleye/Crappie	6	3	50.0%
Total Unit 3						***86.5%***

Table 2-3

Number of impinged fish collected at PBAPS Units 2 and 3, August 30, 2005 through November 17, 2006.

Common Name	Scientific Name	Collection location		Combined	
		Unit 2	Unit 3	Total	%
Alewife	*Alosa pseudoharengus*	17	21	38	0.1
American shad	*Alosa sapidissima*	68	115	183	0.3
Gizzard shad	*Dorosoma cepedianum*	21065	32367	53432	86.9
Central stoneroller	*Campostoma anomalum*	0	2	2	0.0
Common carp	*Cyprinus carpio*	9	14	23	0.0
Golden shiner	*Notemigonus crysoleucas*	8	7	15	0.0
Comely shiner	*Notropis amoenus*	30	29	59	0.1
Common shiner	*Luxilus cornutus*	1	0	1	0.0
Spottail shiner	*Notropis hudsonius*	6	15	21	0.0
Swallowtail shiner	*Notropis procne*	1	0	1	0.0
Spotfin shiner	*Cyprinella spiloptera*	14	31	45	0.1
Bluntnose minnow	*Pimephales notatus*	0	1	1	0.0
Creek chub	*Semotilus atromaculatus*	0	1	1	0.0
Mimic shiner	*Notropis volucellus*	0	2	2	0.0
Quillback	*Carpiodes cyprinus*	10	1	11	0.0
White sucker	*Catostomus commersoni*	0	1	1	0.0
Northern hogsucker	*Hypentelium nigricans*	1	9	10	0.0
Shorthead redhorse	*Moxostoma macrolepidotum*	4	1	5	0.0
White catfish	*Ameiurus catus*	0	1	1	0.0
Yellow bullhead	*Ameiurus natalis*	0	1	1	0.0
Channel catfish	*Ictalurus punctatus*	1141	1364	2505	4.1
Flathead catfish	*Pylodictis olivaris*	48	77	125	0.2
Mummichog	*Fundulus heteroclitus*	1	1	2	0.0
White perch	*Morone americana*	5	5	10	0.0
Striped bass	*Morone saxatilis*	0	2	2	0.0
Rock bass	*Ambloplites rupestris*	27	51	78	0.1
Redbreast sunfish	*Lepomis auritus*	0	3	3	0.0
Green sunfish	*Lepomis cyanellus*	24	59	83	0.1
Pumpkinseed	*Lepomis gibbosus*	4	5	9	0.0
Bluegill	*Lepomis macrochirus*	1763	2510	4273	6.9
Smallmouth bass	*Micropterus dolomieu*	11	20	31	0.1
Largemouth bass	*Micropterus salmoides*	9	24	33	0.1
White crappie	*Pomoxis annularis*	56	64	120	0.2
Black crappie	*Pomoxis nigromaculatus*	0	1	1	0.0
Tessellated darter	*Etheostoma olmstedi*	8	22	30	0.0
Yellow perch	*Perca flavescens*	33	92	125	0.2
Logperch	*Percina caprodes*	0	3	3	0.0
Walleye	*Stizostedion vitreum*	75	138	213	0.3
Banded darter	*Etheostoma zonale*	1	0	1	0.0
Greenside darter	*Etheostoma blennioides*	1	1	2	0.0
Totals		24442	37062	61504	100

Table 2-4

Monthly estimated number of fish impinged at Peach Bottom Atomic Power Station, Units 2 and 3, August 2005 to November 2006. Impingement adjusted for collection efficiency along with Standard errors (SE) and nonsampled days.

	American shad		Bluegill		Channel catfish		Gizzard shad		Walleye		Others		Total	
Month	Estimated catch	SE	Estimated catch	SE	Estimated catch	SE	Estimated catch	SE	Estimated catch	SE	Estimated catch	SE	Estimated catch	SE
						Unit 2								
AUG 2005	0		37	0.0	1107		1255		74		148		2620	
SEP 2005	0	0.0	29	49.7	1029	1463.1	3929	2459.3	21	30.3	107	114.0	5114	2864.5
OCT 2005	64	148.7	2516	2738.9	305	360.4	75780	165316.4	79	90.5	394	300.9	79139	165339.9
NOV 2005	30	74.3	1462	1336.4	80	120.4	52751	84762.3	98	95.3	548	603.9	54970	84775.2
DEC 2005	0	0.0	1893	3695.8	116	132.7	728	720.3	69	101.0	237	250.4	3042	3777.3
JAN 2006	0	0.0	199	148.5	310	311.4	37	38.0	0	0.0	81	116.6	627	366.2
FEB 2006	0	0.0	108	169.9	742	1101.2	50	98.0	0	0.0	100	113.4	1000	1124.2
MAR 2006	0	0.0	28	40.4	240	262.9	0	0.0	0	0.0	92	80.4	360	277.9
APR 2006	0	0.0	12	35.8	381	136.6	12	35.8	0	0.0	71	85.7	476	169.1
MAY 2006	0	0.0	0	0.0	834	313.1	52	37.3	22	55.0	148	123.2	1055	343.0
JUN 2006	36	62.5	0	0.0	821	308.0	48	37.6	24	29.7	274	137.3	1202	346.3
JUL 2006	0	0.0	65	56.6	932	803.8	572	974.9	9	37.0	323	186.4	1901	1279.0
AUG 2006	0	0.0	0	0.0	989	1184.0	66	59.5	0	0.0	81	115.2	1137	1191.1
SEP 2006	0	0.0	384	531.6	938	736.4	536	350.7	0	0.0	196	181.7	2054	990.5
OCT 2006	124	161.0	1847	2765.7	384	351.8	1670	1774.4	7	40.5	752	533.6	4785	3351.7
NOV 2006	0	0.0	67	77.3	83	75.8	246	306.5	0	0.0	163	124.6	560	348.1
Total for Unit 2	254	239.7	8647	5562.7	9291	2571.5	137731	185809.3	404	187.9	3716	993.2	160042	185913.2

Table 2-4

Continued.

	American shad		Bluegill		Channel catfish		Gizzard shad		Walleye		Others		Total	
Month	Estimated catch	SE	Estimated catch	SE	Estimated catch	SE	Estimated catch	SE	Estimated catch	SE	Estimated catch	SE	Estimated catch	SE
						Unit 3								
AUG 2005	0		0		538		215		0		0		753	
SEP 2005	0	0.0	49	107.2	520	824.7	2136	2044.0	14	33.1	132	158.1	2851	2212.6
OCT 2005	105	195.7	2316	3307.7	174	135.1	65716	143636.2	109	148.9	505	487.4	68925	143675.4
NOV 2005	42	130.1	1920	3174.4	146	337.9	68293	96837.9	310	586.3	673	777.4	71384	96895.5
DEC 2005	0	0.0	1874	2414.3	174	149.9	696	602.4	31	58.6	189	165.6	2964	2499.0
JAN 2006	0	0.0	545	800.5	817	750.7	36	45.0	0	0.0	315	252.7	1713	1127.0
FEB 2006	0	0.0	194	364.1	380	546.6	8	32.5	0	0.0	73	81.1	655	662.6
MAR 2006	0	0.0	27	57.2	108	65.9	0	0.0	0	0.0	63	69.5	197	111.6
APR 2006	0	0.0	0	0.0	231	167.1	0	0.0	23	29.1	150	104.4	405	199.1
MAY 2006	29	66.6	7	35.9	767	641.0	14	34.2	7	35.9	72	100.4	896	655.0
JUN 2006	12	34.8	12	34.8	382	491.3	0	0.0	0	0.0	162	117.6	566	507.5
JUL 2006	0	0.0	81	88.3	1559	893.2	762	1346.3	18	33.1	403	213.6	2822	1632.5
AUG 2006	0	0.0	14	42.6	1175	938.7	803	1587.6	7	35.9	129	123.7	2129	1849.3
SEP 2006	0	0.0	1275	2406.2	2870	3793.3	2072	2128.3	9	34.8	408	224.6	6633	4975.9
OCT 2006	180	231.1	1590	3132.4	376	399.9	2344	3618.5	0	0.0	762	456.0	5251	4829.8
NOV 2006	7	34.4	2338	7126.2	156	124.8	225	160.7	0	0.0	529	496.1	3255	7146.5
Total for Unit 3	374	339.8	12239	9697.0	10372	4315.7	143321	173307.4	528	613.3	4566	1252.9	171399	173638.1
Total both units	627	415.8	20886	11179.2	19663	5023.7	281051	254087.7	932	641.4	8282	1598.8	331442	254389.3

Table 2-5

Summary of the species composition and number of fish collected during outmigration impingement sampling of Units 2 and 3 at the Peach Bottom Atomic Power Station, 1997-2006.

Year	1997	%	1999	%	2000	%	2001	%	2002	%	2003	%	2004	%	2005	%	2006	%
Number days sampled	14		23		22		28		23		23		15		46		17	
Number of Taxa	26		22		14		23		24		27		17		31		23	
American Shad	64	0.1	285	5.3	100	5.7	65	2.2	18	*	7	0.3			135	0.2	59	2.8
Blueback Herring	358	0.5	112	2.1	6	0.3	105	3.5	2	*	48.0	2.0					1	*
Alewife	1	*			2	0.1	1	*	5	*	2	0.1	6.0	0.4	29	*	6	0.3
Alosa sp.			30.0	0.6														
Gizzard shad	73,944	98	4,463	82	1,292	74	1,281	43	944,379	99	1,534	63	1,346	86	56,944	93	1,013	48
Central stoneroller																	1.0	*
Carp	8	*	76	1.4	4	0.2	4	0.1	6	*	3	0.1			16	*		
Golden shiner	3	*	2	*			3	0.1	2	*	3	0.1	1	0.1	2	*	7	0.3
Comely shiner			4	0.1	2	0.1	5	0.2	12	*	16	0.7	46	2.9	29	*	3	0.1
Spottail shiner			4	0.1			7	0.2	1	*	1	*	1	0.1	7	*	6	0.3
Spotfin shiner	1	*	3	0.1			4	0.1	11	*	4	0.2	7	0.4	15	*	14	0.7
Swallowtail shiner															1	*		
Mimic shiner																	2	0.1
Notropis sp.																		
Bluntnose minnow									9	*							1	*
Creek chub																		
Quillback	4	*	1.0	*					4	*	1	*	1	0.1	2	*	1	*
Rainbow smelt	11	*									1	*						
White sucker	1	*									1	*						
Shorthead redhorse			1.0	*											1	*		
Northern hogsucker	2	*													10	*		
White catfish	1	*							1	*								
Yellow bullhead	1	*	2.0	*	1.0	0.1			1	*	1	*			1	*	1	*
Brown bullhead																		
Channel catfish	113	0.1	79	1.5	100	5.7	1,326	44.4	129	*	80	3.3	21	1.3	346	0.6	177	8.4
Flathead catfish													2	0.1	19	*	71	3.4
White perch															9	*		
Mummichog							1	*							1	*		
Striped bass			1	*			1	*							2	*		

* < 0.1%

Table 2-5

Continued.

Pumpkinseed	37	0.0	1	*			9	0.3	21	*	2	0.1	2	0.1	5	*	3	0.1
Bluegill	773	1.0	221	4.1	205	11.8	71	2.4	11,363	1.2	549	22.4	66	4.2	3,351	5.5	659	31.1
Smallmouth bass	15	0.0	27	0.5	4	0.2	40	1.3	45	*	10	0.4	5	0.3	13	*		
Largemouth bass	10	0.0	9	0.2			17	0.6	9	*	4	0.2	8	0.5	22	*	9	0.4
White crappie	87	0.1	80	1.5	16	0.9	15	0.5	4	*	42	1.7	13	0.8	65	0.1	50	2.4
Black crappie	5	0.0	1	*	1	0.1	4	0.1	1	*	1	0.0						
Yellow perch					5	0.3	11	0.4	24	*	97	4.0	32	2	117	0.2	2	0.1
Walleye	5	0.0	1	*			6	0.2			3	0.1			198	0.3		
Tesselated darter	5	0.0									5	0.2			15	*		
Banded darter															1	*		
Greenside darter															1	*		
Logperch	1	0.0															1	*
TOTAL	**75,559**	**100**	**5,413**	**100**	**1,742**	**100**	**2,984**	**100**	**956,150**	**100**	**2,450**	**100**	**1,563**	**100**	**61,429**	**100**	**2,117**	**100**

* < 0.1%

FIGURES

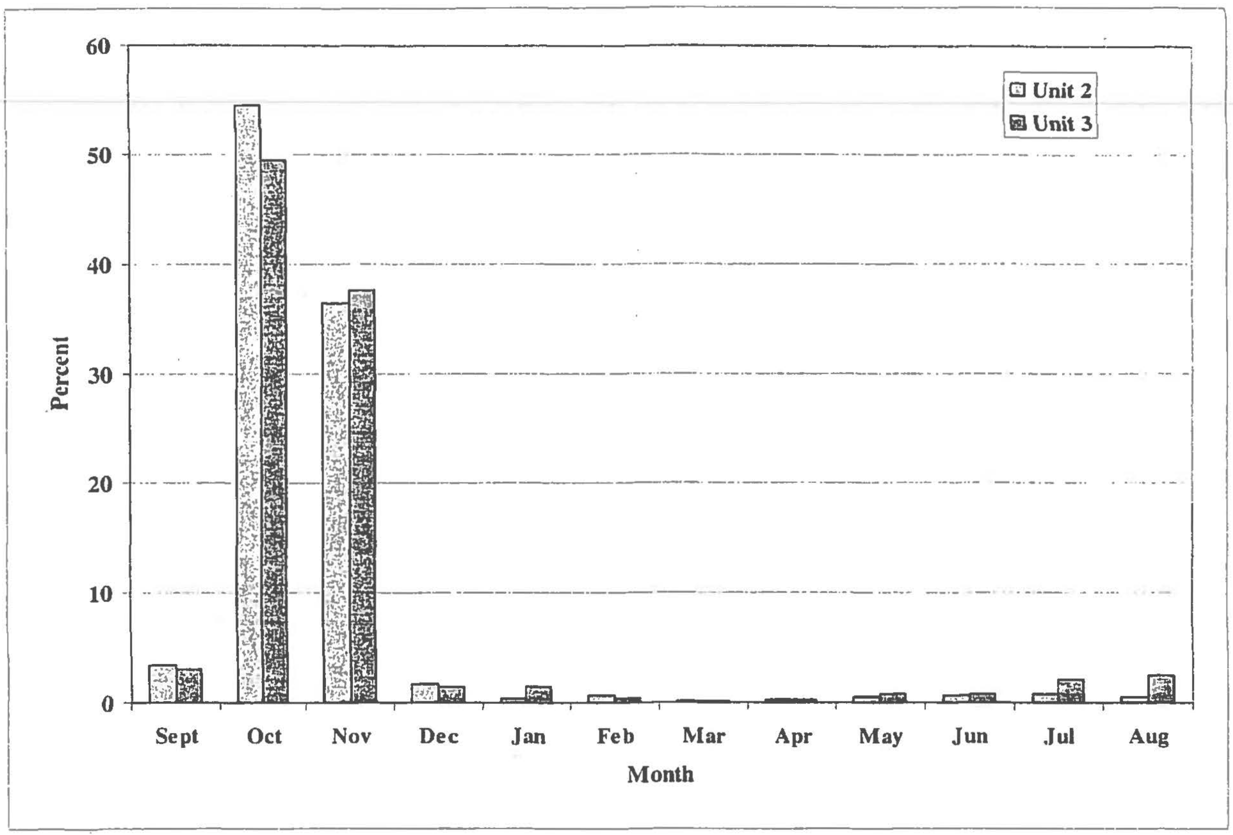
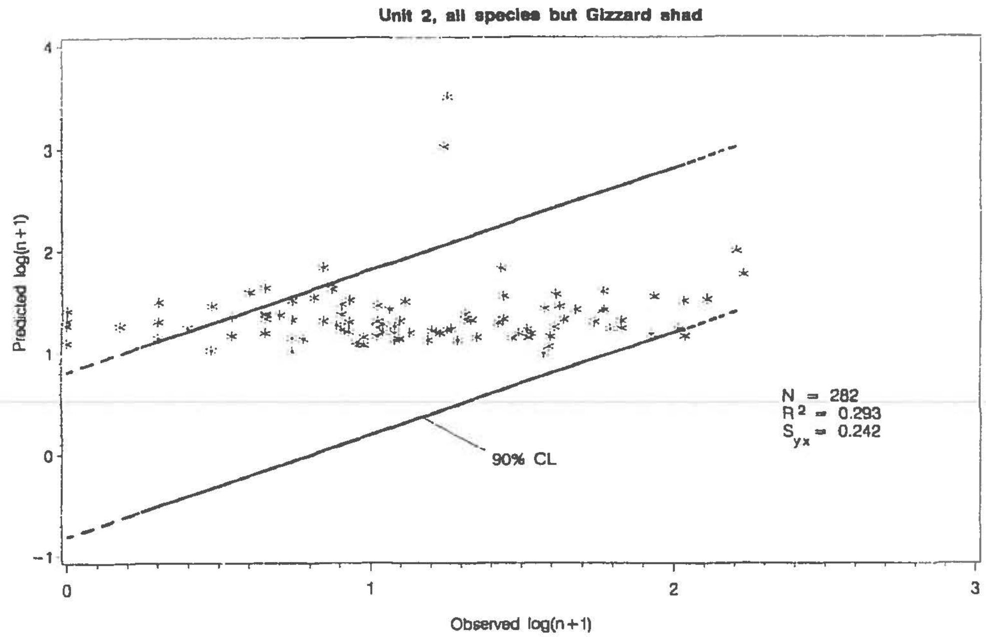


Figure 3
Monthly catch of all impinged fish at PBAPS, 2005-2006



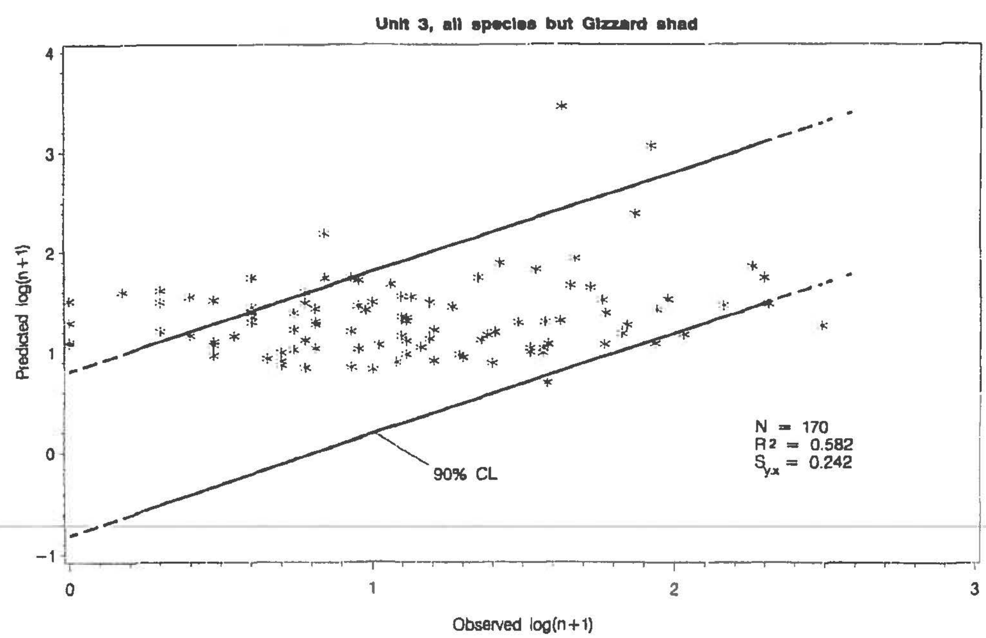
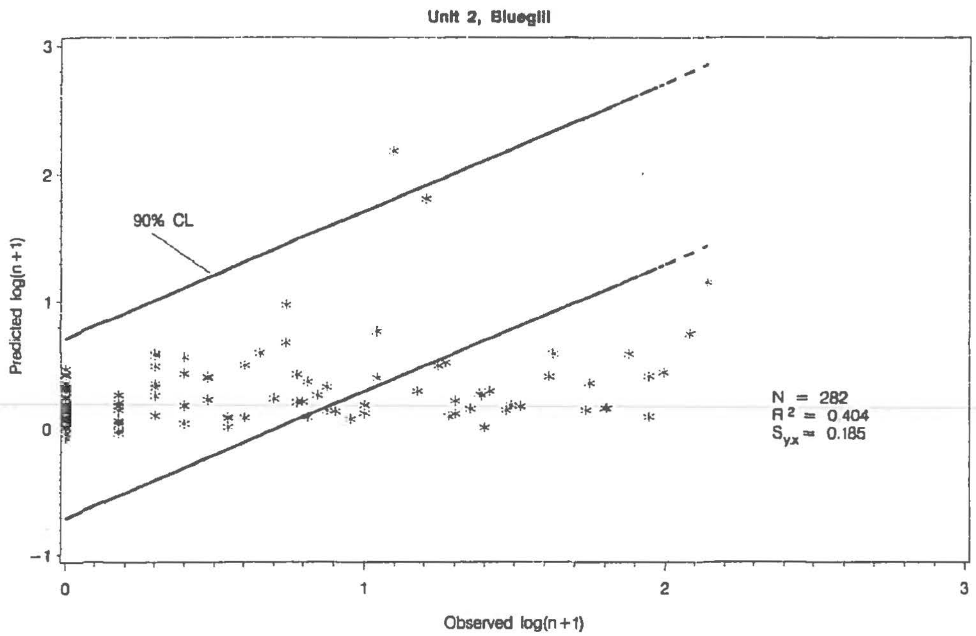


Figure 2-2.

Comparison of observed and predicted impingement values (log of number of fish/12 h + 1) along with 90% confidence intervals of total fish (gizzard shad excluded) at Peach Bottom Atomic Power Station Unit 2 and Unit 3, August 2005 – November 2006. Note the trends in variability in impingement was similar in the two periods



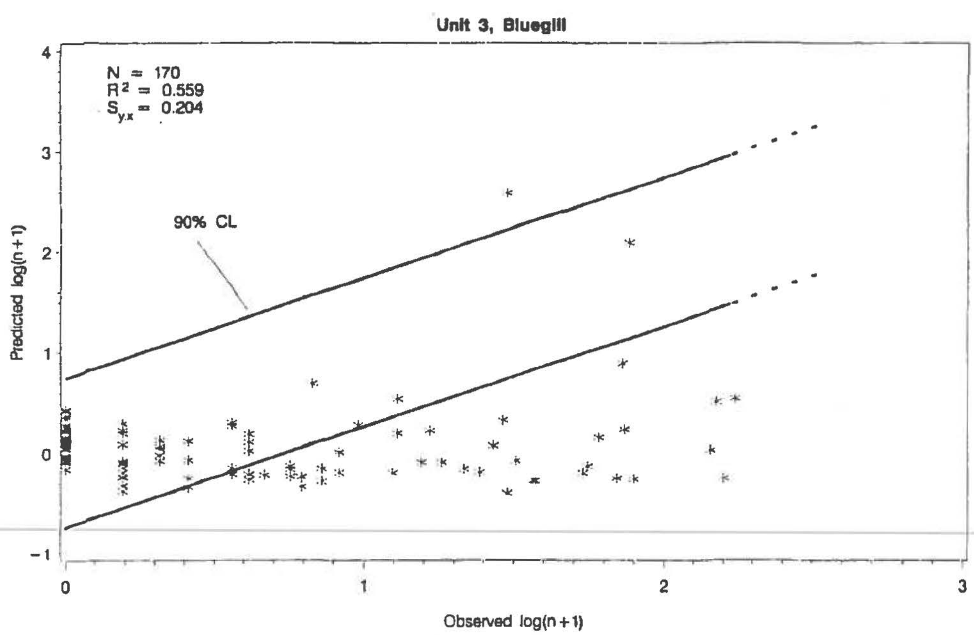


Figure 2-3.

Comparison of observed and predicted impingement values (log of number of fish/12 h + 1) along with 90% confidence intervals of bluegill at Peach Bottom Atomic Power Station Unit 2 and Unit 3, August 2005 – November 2006. Note the trends in variability in impingement in the two periods was similar.

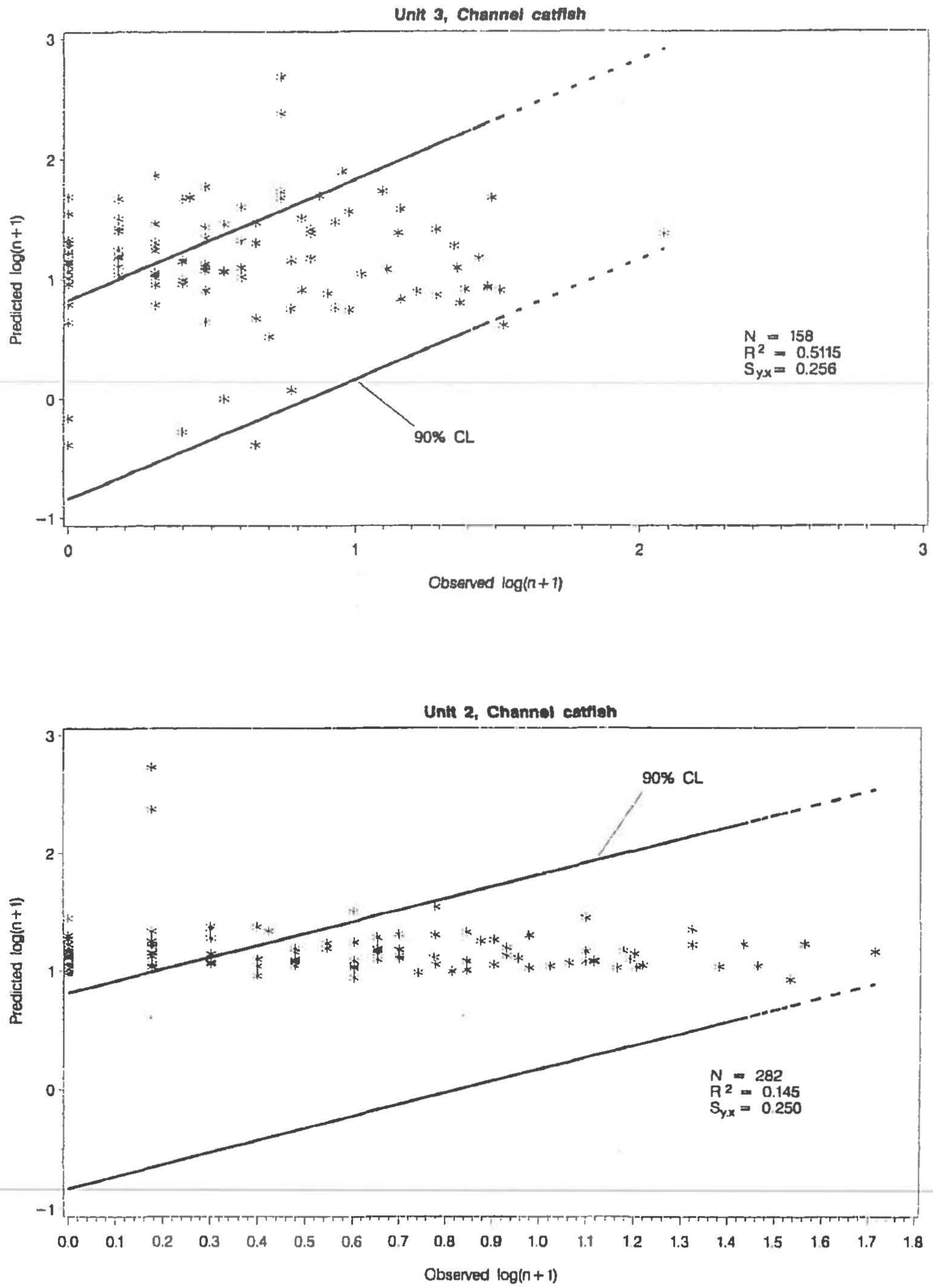


Figure 2-4.

Comparison of observed and predicted impingement values (log of number of fish/12 h + 1) along with 90% confidence intervals of channel catfish at Peach Bottom Atomic Power Station Unit 2 and Unit 3, August 2005 – November 2006. Note the trends in variability in impingement in the two periods was similar.

Appendix A

CONOWINGO RESERVOIR-ECOLOGICAL STUDY IMPINGMENT FIELD DATA

			UNIT 2 (Station 10)							UNIT 3 (Station 20)					River Flow	Number of Circ.	Circ. pump
Sample #	DATE	TIME	TEMP. C'	D.O	SECCHI	BIN %	Sample #	DATE	TIME	TEMP. C'	D.O	SECCHI	BIN %	DATE	in cfs	pumps	in cfs
DDR05027	8/29/2005	915	28.9° C	7.4ppm			DDR05026	8/29/2005	·	29.1° C	7.7ppm			8/29/2005	4078	6	3342
DDR05028	9/6/2005	945	26.1° C	9.3ppm	1.1M		DDR05029	9/6/2005		26.1° C	8.7ppm	1.1M		9/6/2005	12960	6	3342
DDR05030	9/20/2005	900	27.0° C	6.8ppm	.8M		DDR05030	9/20/2005		27.0° C	7.1ppm	.8M		9/20/2005	4329	5	2785
DDR05032	9/22/2005	945	25.7° C	7.1ppm	1.3M		DDR05033	9/22/2005		25.9° C	7.8ppm	1.1M		9/22/2005	3700	3	1671
DDR05034	9/27/2005	1500	23.0° C	7.2ppm	0.9M	30%	DDR05035	9/27/2005	1500	23.0° C	7.6ppm	0.9M	30%	9/27/2005	2573	3	1671
DDR05036	9/29/2005		20.8° C	8.95ppm	1M	25%	DDR05037	9/29/2005		23.9° C	7.7ppm	.9M	25%	9/29/2005	3567	3	1671
DDR05039	10/1/2005	1020	22.5° C	8.9ppm	1M		DDR05038	10/1/2005		23.2° C	9.9ppm	1M		10/1/2005	3568	3	1671
DDR05056	10/3/2005		23.8° C	8.6ppm	1M		DDR05055	10/4/2005		23.8° C	7.9ppm	1M		10/3/2005	4016	3	1671
DDR05060	10/5/2005		23.8° C	8.5ppm	1.1M		DDR05059	10/5/2005		24.2° C	8.4ppm	1.1M		10/5/2005	4736	3	1671
DDR05061	10/10/2005	1100	19.1° C	7.7ppm	.2M	30%	DDR05062	10/10/2005	1057	19.2° C	7.8ppm	.2M	15%	10/10/2005	29441	3	1671
DDR05063	10/12/2005	830	20.6° C	8ppm	0.75M		DDR05064	10/12/2005	905	19.5° C	7.9ppm	.8M		10/12/2005	21774	5	2785
MDM05001	10/13/2005						MDM05002	10/13/2005						10/13/2005	20407	5	2785
MDM05003	10/14/2005	1030	18.5° C	8.1ppm	0.75M		MDM05004	10/14/2005		18.5° C	8.0ppm	.75M	100%	10/14/2005	18963	5	2785
MDM05005	10/15/2005	940	17.1° C	8.1ppm	.9 M	80%	MDM05006	10/15/2005	1230	17.1° C	8.2ppm	.9M	70%	10/15/2005	18201	5	2785
MDM05007	10/18/2005		16.5° C	Broken meter	.9M		MDM05008	10/18/2005		16.2° C		.9M		10/18/2005	30387	5	2785
MDM05009	10/19/2005	904	16.8° C	9.4ppm	.9M	50%	MDM05010	10/19/2005	907	16.8° C	9.4ppm	.9M	50%	10/19/2005	26190	5	2785
MDM05011	10/20/2005	910	16.3° C	9.4ppm	.8M		MDM05012	10/20/2005	1030	15.8° C	9.6ppm	.9M		10/20/2005	23757	6	3342
MDM05013	10/21/2005	800	14.6° C	9.3ppm	1M	85%	MDM05014	10/21/2005	1030	14.8° C	9.35ppm	1M	100%	10/21/2005	21158	6	3342
MDM05015	10/24/2005	800	15.0° C	9.65ppm	.7M	15%	MDM05016	10/24/2005	1030	14.8° C	9.35ppm	1M	100%	10/24/2005	19317	6	3342
MDM05017	10/25/2005	900	12.6° C	11.2ppm	.9M	30%	MDM05018	10/25/2005	1100	15.0° C	9.65ppm	.7M	15%	10/25/2005	22971	6	3342
MDM05019	10/26/2005	900	15.5° C	9.65ppm	1M	100%	MDM05020	10/26/2005	1100		broken	1M	100%	10/26/2005	44276	6	3342
MDM05021	10/27/2005	900	11.8° C	11.7ppm	.7M	15%	MDM05022	10/27/2005	1100	10.8° C	12.0ppm	.7M	15%	10/27/2005	81246	6	3342
MDM05023	10/28/2005	815	10.9° C	9.5ppm	.6M	15%	MDM05024	10/28/2005		10.8° C	11.5ppm	.7M	12%	10/28/2005	118140	6	3342
MDM05025	10/31/2005	830	8.9° C	11.25ppm	.4M	10%	MDM05026	10/31/2005		8.9° C	11.2ppm	.5M	10%	10/31/2005	58320	6	3342
MDM05027	11/1/2005	830	10.0° C	11.2ppm	.7M	30%	MDM05028	11/1/2005		10.0° C	11.0ppm	.7M	65%	11/1/2005	47572	6	3342
MDM05029	11/2/2005		10.8° C	11.1ppm	.7M	30%	MDM05030	11/2/2005		10.5° C	11.0ppm	.7M	30%	11/2/2005	40535	6	3342
MDM05031	11/3/2005		11.2° C	10.6ppm	.8M	70%	MDM05032	11/3/2005	1030	10.1° C	11.2ppm	.8M	30%	11/3/2005	36136	6	3342
MDM05033	11/4/2005	815	11.7° C	10.6ppm	.9M	45%	MDM05034	11/4/2005	820	11.7° C	10.9ppm	.9M	30%	11/4/2005	33926	6	3342
MDM05035	11/7/2005	815	12.2 C	9.07ppm	1.1M	30%	MDM05036	11/7/2005						11/7/2005	28522	6	3342
MDM05037	11/8/2005	1107	11.8° C	10.8ppm	1.1M	66%	MDM05038	11/8/2005	1107	13.0° C	10.8ppm	1.1M	30%	-11/8/2005	25664	6	3342
MDM05039	11/9/2005	815	12.8° C	10.1ppm	1.2M	60%	MDM05040	11/9/2005	1030	12.5° C	10.3ppm	1.2M	50%	11/9/2005	24158	6	3342
MDM05041	11/10/2005	1030	13.0° C	10.1ppm	1.0M	50%	MDM05042	11/10/2005	800	13.0° C	10.0ppm	1.0M	85%	11/10/2005	23940	6	3342
MDM05043	11/11/2005	815	11.8° C	10.0ppm	1.1M	75%	MDM05044	11/11/2005	1030	13.0° C	9.8ppm	1.1M	75%	11/11/2005	24282	6	3342
MDM05045	11/14/2005	815	11.2° C	10.4ppm	1.0M	25%	MDM05046	11/14/2005	1030	11.2° C	10.4ppm	1.0M	50%	11/14/2005	36476	6	3342
MDM05047	11/15/2005	830	11.0° C	10.6ppm	1.1M	30%	MDM05048	11/15/2005	1030	13.0° C	9.8ppm	1.1M	75%	11/15/2005	33161	6	3342
MDM05049	11/16/2005	1000	11.5° C	11.0ppm	1.3M	66%	MDM05050	11/16/2005	900	11.4° C	11.0ppm	1.3M	50%	11/16/2005	30075	6	3342
MDM05051	11/17/2005		11.0° C	10.6ppm	1.0M	10%	MDM05052	11/17/2006		11.0° C	10.6ppm	1.0M	15%	11/17/2005	30572	6	3342
MDM05053	11/18/2005	815	10.5° C	10.6ppm	1.0M	20%	MDM05054	11/18/2005	1030	10.5° C	10.6ppm	1.0M	20%	11/18/2005	45223	6	3342

Appendix A

CONOWINGO RESERVOIR-ECOLOGICAL STUDY IMPINGMENT FIELD DATA

			UNIT 2 (Station 10)							UNIT 3 (Station 20)					River Flow	Number of Circ.	Circ. pump
Sample #	DATE	TIME	TEMP. C'	D.O	SECCHI	BIN %	Sample #	DATE	TIME	TEMP. C'	D.O	SECCHI	BIN %	DATE	in cfs	pumps	in cfs
MDM05055	11/21/2005	815	7.7° C	11.9ppm	1.3M	15%	MDM05056	11/21/2005	925	7.2° C	12.1ppm	1.3M	15%	11/21/2005	54049	6	3342
MDM05057	11/22/2005	815	8.0° C	12.0ppm	.9M	10%	MDM05058	11/22/2005	1030	7.8° C	12.0ppm	.9M	10%	11/22/2005	46729	6	3342
MDM05059	11/23/2005	815	7.8° C	11.8ppm	1.0 M	10%	MDM05060	11/23/2005	1030	7.8° C	11.4ppm	1.0M	15%	11/23/2005	41660	6	3342
MDM05061	11/28/2005	815	5.0° C	9.5ppm	2.0M	10%	MDM05062	11/28/2005	1030	4.9° C	9.9ppm	9.9M	50%	11/28/2005	26939	4	2228
MDM05063	11/29/2005	815	5.5° C	12.6ppm	1.45M	70%	MDM05064	11/29/2005	1030	5.0° C	13.0ppm	1.45M	25%	11/29/2005	25173	4	2228
MDM05065	11/30/2005	850	5.8° C	13.0ppm	1.2M	15%	MDM05066	11/30/2005	935	5.5° C	12.6ppm	1.2M	2%	11/30/2005	50661	4	2228
MDM05067	12/1/2005	850	8.3° C	12.2ppm	1.1M	50%	MDM05068	12/1/2005	840	8.0° C	11.6ppm	1.1M	10%	12/1/2005	194375	4	2228
MDM05069	12/2/2005	940	10.0° C	11.7ppm	.5M	100%	MDM05070	12/2/2005	1010	8.5° C	12.0ppm	.5M	100%	12/2/2005	218118	4	2228
MDM05071	12/5/2005	815	6.0° C	12.8ppm	.30M	5%	MDM05072	12/5/2005	1030	10.1° C	11.2ppm	.8M	30%	12/5/2005	93476	4	2228
MDM05073	12/6/2005	907	4.8° C	13.8ppm	.5M	50%	MDM05074	12/6/2005	900	4.8° C	13.5ppm	.5M	15%	12/6/2005	73655	4	2228
MDM05075	12/13/2005	1045	2.0° C	13.7ppm	.9M	5%	MDM05076	12/13/2005	1045	1.0° C	14.3ppm	1.1M	10%	12/13/2005	30613	4	2228
MDM05077	12/20/2005	935	2.0° C	14.2ppm	.8M	10%	MDM05078	12/20/2005	940	.5° C	14.6ppm	.8M	5%	12/20/2005	31790	4	2228
MDM05079	12/27/2005	910	2.0° C	13.8ppm	.1.25M	10%	MDM05080	12/27/2005	920	1.8° C	13.7ppm	1.25M	5%	12/27/2005	34197	4	2228
MDM06001	1/3/2006	815	8.3° C	13.3ppm	.8.6M	5%	MDM06002	1/3/2006	1030	4.0° C	13.0ppm	.6M	3%	1/3/2006	77925	4	2228
MDM06003	1/10/2006	815	9.2° C	12.3ppm	2.25M	5%	MDM06004	1/10/2006	1030	5.0° C	12.2ppm	2.75M	20%	1/10/2006	62195	4	2228
MDM06005	1/17/2006	815	3.2° C	15.2ppm	.75M	15%	MDM06006	1/17/2006	1030	3.2° C	14.6ppm	.75M	30%	1/17/2006	106014	4	2228
MDM06007	1/24/2006	815	5.3° C	12.8ppm	.6M	15%	MDM06008	1/24/2006	1030	4.0° C	13.5ppm	.6M	20%	1/24/2006	104607	4	2228
MDM06009	1/31/2006	815	5.5° C	12.4ppm	1.2M	5%	MDM06010	1/31/2006	1030	4.0° C	13.4ppm	1.2M	5%	1/31/2006	51839	4	2228
MDM06011	2/6/2006	815	4.8° C	13.4ppm	.4M	5%	MDM06012	2/6/2006	835	4.2° C	13.6ppm	.4M	15%	2/6/2006			
MDM06013	2/14/2006	950	1.5° C	14.3ppm	1.6M	15%	MDM06014	2/14/2006	945	1.8° C	14.0ppm	1.8M	5%	2/14/2006	49200	2	2228
MDM06015	2/21/2006	900	4.2° C	12.1ppm	1.4M	<5%	MDM06016	2/21/2006	910	3.6° C	13.0ppm	1.4M	20%	2/21/2006	36500	2	2228
MDM06017	2/28/2006	900	2.5° C	13.6ppm	1.2M	1%	MDM06018	2/28/2006	910	3.5° C	13.2ppm	1.25M	1%	2/28/2006	26200	2	2228
MDM06019	3/7/2006	945	3.5° C	13.3ppm	1.5M	<1%	MDM06020	3/7/2006	1000	3.0° C	13.5ppm	1.66M	<1%	3/7/2006	19000	2	2228
MDM06021	3/14/2006	1130	16.0° C	12.6ppm	56"	15%	MDM06022	3/14/2006	1135	9.2° C	12.6ppm	56"	NA ?	3/14/2006	25400	2	2228
MDM06023	3/21/2006	845	6.0° C	12.4ppm	.4M	1%	MDM06024	3/21/2006	900	6.0° C	12.7ppm	.4M	1%	3/21/2006	38500	2	2228
MDM06025	3/28/2006	930	7.5° C	11.8ppm	1.1M	15%	MDM06026	3/28/2006	935	7.0° C	12.0ppm	1.2M	≤1%	3/28/2006	23200	2	2228
MDM06027	4/4/2006	900	12.5° C	13.8ppm	.8M	NA ?	MDM06028	4/4/2006	910	15.3° C	11.8ppm	.8M	NA ?	4/4/2006	20200	2	2228
No Sample	4/11/2006		Bin wasn't pulled				No Sample	4/11/2006		Bin wasn't pulled				4/11/2006	28600	4	2228
MDM06029	4/18/2006	900	16.2° C	11.0ppm	30"	NA ?	MDM06030	4/18/2006	910	16.0° C	10.1ppm	30"	NA ?	4/18/2006	26500	4	2228
MDM06031	4/25/2006	1020	15.5° C	9.6ppm	30"	50-75%	MDM06032	4/25/2006	1030	15.5° C	9.7ppm	30"	75%	4/25/2006	59100	4	2228
MDM06033	5/2/2006	1005	17.0° C	11.2ppm	.75M	50%	MDM06034	5/2/2006	1015	17.0° C	11.2ppm	.75M	10%	5/2/2006	34500	4	2228
MDM06035	5/9/2006	900	19.1° C	8.2ppm	1M	NA ?	MDM06036	5/9/2006	910	19.5° C	8.3ppm	.75M	NA ?	5/9/2006	19800	4	2228
MDM06037	5/16/2006	900	19.0° C	7.3ppm	.75M	10%	MDM06038	5/16/2006	910	19.0° C	7.4ppm	.75M	10%	5/16/2006	33100	4	2228
MDM06039	5/23/2006	900	16.40° C	9.2ppm	29"M	5%	MDM06040	5/23/2006	1000	16.4° C	9.2ppm	29"M	25%	5/23/2006	27300	4	2228
MDM06041	5/30/2006	930	23.0° C	9.5ppm	1.1M	15%	MDM06042	5/30/2006	920	22.0° C	9.1ppm	1.1M	25%	5/30/2006	19500	4	2228
MDM06043	6/6/2006		Bin wasn't pulled				No Sample	6/6/2006		Bin wasn't pulled							

Appendix A

CONOWINGO RESERVOIR-ECOLOGICAL STUDY IMPINGMENT FIELD DATA

			UNIT 2 (Station 10)							UNIT 3 (Station 20)					River Flow	Number of Circ.	Circ. pump
Sample #	DATE	TIME	TEMP. C°	D.O	SECCHI	BIN %	Sample #	DATE	TIME	TEMP. C°	D.O	SECCHI	BIN %	DATE	in cfs	pumps	in cfs
MDM06045	6/13/2006	900	21.0° C	8.7M	.8M	15%	MDM06046	6/13/2006	930	21.0° C	8.8ppm	.8M	2%	6/13/2006	29700	6	3242
MDM06047	6/20/2006	900	24.3° C	8.4ppm	37"	33%	MDM06048	6/20/2006	1000	24.3° C	8.2ppm	37"	10%	6/20/2006	16800	6	3242
MDM06049	6/27/2006	910	25.2° C	7.8ppm	.4M	50%	MDM06050	6/27/2006	915	25.2° C	7.7ppm	.4M	33%	6/27/2006	80000	6	3242
MDM06051	7/6/2006	900	no data recorded			12%	MDM06052	7/6/2006		no data recorded			12%	7/6/2006	64200		
MDM06053	7/11/2006	915	25.2° C	8.2ppm	.5M	50%	MDM06054	7/11/2006	905	24.2° C	8.0ppm	.5M	25%	7/11/2006	36500	6	3242
MDM06055	7/18/2006	815	28.5° C	8.2ppm	.8M	6%	MDM06056	7/18/2006	800	28.0° C	8.5ppm	.7M	15%	7/18/2006	34000	6	3242
MDM06057	7/25/2006		Bin broken				MDM06058	7/25/2006	830	28.4° C	6.81ppm	27"	50%	7/25/2006	33900	6	3242
MDM06059	8/1/2006	845	29.2° C	7.1ppm	.9M	5%	MDM06060	8/1/2006	848	29.0° C	7.9ppm	1.2M	25%	8/1/2006	22700	6	3242
MDM06061	8/8/2006	1010	30.2° C	6.3ppm	.9M	25%	MDM06062	8/8/2006	1013	30.2° C	6.3ppm	.9M	80%	8/8/2006	14500	6	3242
MDM06063	8/15/2006	855	issues with bin:area flooded				MDM06064	8/15/2006		28.5° C	7.4ppm	40"	10%	8/15/2006	9400	6	3242
MDM06065	8/21/2006	1015	28.0° C	7.5ppm	1.2M		MDM06066	8/21/2006	935	28.2° C	7.8ppm	1.0M	5%	8/21/2006	8200	6	3242
MDM06067	8/29/2006	900	27.3° C	7.0ppm	42"	50%	MDM06068	8/29/2006	1000	27.2° C	7.1ppm	42"		8/29/2006	18000	6	3242
MDM06069	9/5/2006	900	19.1° C	9.4ppm	22"	20%	MDM06070	9/5/2006	1000	19.1° C	9.3ppm	22"	60%	9/5/2006	106600	6	3242
MDM06071	9/12/2006	900	21.2° C	8.2ppm	25"	40%	MDM06072	9/12/2006	1000	21.2° C	8.0ppm	25"	50%	9/12/2006	25800	6	3242
MDM06073	9/19/2006	900	22.5° C	8.8ppm		20%	MDM06074	9/19/2006	1000	20.0° C	8.7ppm		20%	9/19/2006	30700	6	3242
MDM06075	9/28/2006	900	22.0° C	8.7ppm		5%	MDM06076	9/28/2006	1000	19.0° C	8.9ppm		12%	9/28/2006	14400	6	3242
MDM06077	10/2/2006	900	18.8° C	8.4ppm	1.0M	5%	MDM06078	10/2/2006	910	18.8° C	8.5ppm	1.0M	10%	10/2/2006	21600	6	3242

Appendix B

Estimated number of fish impinged at PBAPS from August 2005 to November 2006.
Efficiency for Unit 2 is 0.84 (SE=0.0432) and for Unit 3 is 0.865 (SE=0.0596)

Location	Common name	Expanded catch	SE
	August 2005		
Unit 2	Gizzard shad	1255	
Unit 2	Spotfin shiner	111	
Unit 2	Channel catfish	1107	
Unit 2	White perch	37	
Unit 2	Bluegill	37	
Unit 2	Walleye	74	
		2620	
	September 2005		
Unit 2	Gizzard shad	3929	2459.3
Unit 2	Comely shiner	29	49.7
Unit 2	Common shiner	7	35.8
Unit 2	Spotfin shiner	14	42.4
Unit 2	Channel catfish	1029	1463.1
Unit 2	Flathead catfish	7	35.8
Unit 2	Green sunfish	14	34.1
Unit 2	Bluegill	29	49.7
Unit 2	Smallmouth bass	7	35.8
Unit 2	Tessellated darter	7	35.8
Unit 2	Yellow perch	7	35.8
Unit 2	Walleye	21	30.3
Unit 2	River crayfish	14	34.1
		5114	2864.5
	October 2005		
Unit 2	American shad	64	148.7
Unit 2	Gizzard shad	75780	165316.4
Unit 2	Comely shiner	5	36.7
Unit 2	Spottail shiner	10	49.6
Unit 2	Spotfin shiner	10	49.6
Unit 2	Quillback	5	39.3
Unit 2	Channel catfish	305	360.4
Unit 2	Flathead catfish	7	39.0
Unit 2	Rock bass	15	64.0
Unit 2	Green sunfish	49	88.3
Unit 2	Pumpkinseed	7	39.0
Unit 2	Bluegill	2516	2738.9
Unit 2	Smallmouth bass	2	36.9
Unit 2	Largemouth bass	5	36.7
Unit 2	White crappie	73	93.5
Unit 2	Tessellated darter	2	36.9
Unit 2	Yellow perch	22	55.4
Unit 2	Walleye	79	90.5
Unit 2	River crayfish	181	227.8
		79139	165339.9

Appendix B

Continued.

Location	Common name	Expanded catch	SE
	November 2005		
Unit 2	Alewife	13	56.2
Unit 2	American shad	30	74.3
Unit 2	Gizzard shad	52751	84762.3
Unit 2	Common carp	5	35.5
Unit 2	Golden shiner	7	45.2
Unit 2	Comely shiner	6	37.9
Unit 2	Spottail shiner	2	35.7
Unit 2	Swallowtail shiner	2	35.7
Unit 2	Northern hogsucker	2	35.7
Unit 2	Channel catfish	80	120.4
Unit 2	Flathead catfish	20	68.5
Unit 2	White perch	5	37.3
Unit 2	Rock bass	25	52.1
Unit 2	Green sunfish	2	35.7
Unit 2	Pumpkinseed	4	37.5
Unit 2	Bluegill	1462	1336.4
Unit 2	Smallmouth bass	13	45.7
Unit 2	Largemouth bass	11	46.1
Unit 2	White crappie	37	49.8
Unit 2	Tessellated darter	2	35.7
Unit 2	Yellow perch	23	83.4
Unit 2	Walleye	98	95.3
Unit 2	Banded darter	2	35.7
Unit 2	River crayfish	370	570.3
		54970	84775.2
	December 2005		
Unit 2	Alewife	42	83.2
Unit 2	Gizzard shad	728	720.3
Unit 2	Common carp	5	36.9
Unit 2	Comely shiner	21	38.1
Unit 2	Shorthead redhorse	5	36.9
Unit 2	Channel catfish	116	132.7
Unit 2	Flathead catfish	5	36.9
Unit 2	White perch	5	36.9
Unit 2	Rock bass	16	40.5
Unit 2	Pumpkinseed	11	41.9
Unit 2	Bluegill	1893	3695.8
Unit 2	Largemouth bass	26	59.0
Unit 2	White crappie	11	41.9
Unit 2	Tessellated darter	5	36.9
Unit 2	Yellow perch	74	192.6
Unit 2	Walleye	69	101.0
Unit 2	River crayfish	11	41.9
		3042	3777.3

Appendix B

Continued.

Location	Common name	Expanded catch	SE
	January 2006		
Unit 2	Gizzard shad	37	38.0
Unit 2	Golden shiner	7	36.9
Unit 2	Comely shiner	37	83.0
Unit 2	Spottail shiner	7	36.9
Unit 2	Spotfin shiner	7	36.9
Unit 2	Channel catfish	310	311.4
Unit 2	Rock bass	7	36.9
Unit 2	Bluegill	199	148.5
Unit 2	River crayfish	15	35.2
		627	366.2
	February 2006		
Unit 2	Gizzard shad	50	98.0
Unit 2	Common carp	8	33.4
Unit 2	Golden shiner	8	33.4
Unit 2	Comely shiner	25	53.1
Unit 2	Quillback	8	33.4
Unit 2	Channel catfish	742	1101.2
Unit 2	Rock bass	8	33.4
Unit 2	Bluegill	108	169.9
Unit 2	White crappie	8	33.4
Unit 2	Tessellated darter	8	33.4
Unit 2	Yellow perch	8	33.4
Unit 2	Greenside darter	8	33.4
Unit 2	River crayfish	8	33.4
		1000	1124.2
	March 2006		
Unit 2	Comely shiner	18	34.0
Unit 2	Quillback	18	34.0
Unit 2	Channel catfish	240	262.9
Unit 2	Rock bass	9	37.0
Unit 2	Bluegill	28	40.4
Unit 2	Tessellated darter	18	45.4
Unit 2	River crayfish	28	27.0
		360	277.9
	April 2006		
Unit 2	Gizzard shad	12	35.8
Unit 2	Channel catfish	381	136.6
Unit 2	Rock bass	12	35.8
Unit 2	Bluegill	12	35.8
Unit 2	Smallmouth bass	36	62.5
Unit 2	River crayfish	24	46.5
		476	169.1

Appendix B

Continued.

Location	Common name	Expanded catch	SE
	May 2006		
Unit 2	Alewife	7	36.9
Unit 2	Gizzard shad	52	37.3
Unit 2	Common carp	15	35.2
Unit 2	Comely shiner	37	38.0
Unit 2	Quillback	22	40.8
Unit 2	Shorthead redhorse	7	36.9
Unit 2	Channel catfish	834	313.1
Unit 2	Mummichog	7	36.9
Unit 2	Green sunfish	7	36.9
Unit 2	Smallmouth bass	7	36.9
Unit 2	Yellow perch	7	36.9
Unit 2	Walleye	22	55.0
Unit 2	River crayfish	30	51.4
		1055	343.0
	June 2006		
Unit 2	American shad	36	62.5
Unit 2	Gizzard shad	48	37.6
Unit 2	Common carp	12	35.8
Unit 2	Golden shiner	12	35.8
Unit 2	Quillback	12	35.8
Unit 2	Shorthead redhorse	12	35.8
Unit 2	Channel catfish	821	308.0
Unit 2	Flathead catfish	12	35.8
Unit 2	Green sunfish	12	35.8
Unit 2	Largemouth bass	12	35.8
Unit 2	Walleye	24	29.7
Unit 2	River crayfish	190	99.4
		1202	346.3
	July 2006		
Unit 2	Gizzard shad	572	974.9
Unit 2	Spotfin shiner	9	37.0
Unit 2	Channel catfish	932	803.8
Unit 2	Flathead catfish	46	68.3
Unit 2	Rock bass	74	79.0
Unit 2	Bluegill	65	56.6
Unit 2	Smallmouth bass	18	45.4
Unit 2	White crappie	9	37.0
Unit 2	Tessellated darter	9	37.0
Unit 2	Yellow perch	9	37.0
Unit 2	Walleye	9	37.0
Unit 2	River crayfish	148	127.7
		1901	1279.0

Appendix B

Continued.

Location	Common name	Expanded catch	SE
	August 2006		
Unit 2	Gizzard shad	66	59.5
Unit 2	Channel catfish	989	1184.0
Unit 2	Green sunfish	7	36.9
Unit 2	River crayfish	74	109.1
		1137	1191.1
	September 2006		
Unit 2	Gizzard shad	536	350.7
Unit 2	Shorthead redhorse	9	35.8
Unit 2	Channel catfish	938	736.4
Unit 2	Flathead catfish	54	105.0
Unit 2	Green sunfish	9	35.8
Unit 2	Bluegill	384	531.6
Unit 2	River crayfish	125	139.5
		2054	990.5
	October 2006		
Unit 2	American shad	124	161.0
Unit 2	Gizzard shad	1670	1774.4
Unit 2	Common carp	4	36.9
Unit 2	Golden shiner	4	36.9
Unit 2	Comely shiner	24	56.0
Unit 2	Spottail shiner	7	40.5
Unit 2	Spotfin shiner	7	40.5
Unit 2	Bluntnose minnow	37	117.1
Unit 2	Mimic shiner	7	36.5
Unit 2	Northern hogsucker	12	49.0
Unit 2	Channel catfish	384	351.8
Unit 2	Flathead catfish	133	143.0
Unit 2	Rock bass	24	80.2
Unit 2	Green sunfish	16	48.1
Unit 2	Bluegill	1847	2765.7
Unit 2	White crappie	157	251.5
Unit 2	Walleye	7	40.5
Unit 2	River crayfish	319	407.1
		4785	3351.7

Appendix B

Continued.

Location	Common name	Expanded catch	SE
	November 2006		
Unit 2	Alewife	4	35.7
Unit 2	Gizzard shad	246	306.5
Unit 2	Golden shiner	12	34.3
Unit 2	Comely shiner	4	35.7
Unit 2	Spotfin shiner	4	35.7
Unit 2	Channel catfish	83	75.8
Unit 2	Flathead catfish	32	47.5
Unit 2	Green sunfish	4	35.7
Unit 2	Bluegill	67	77.3
Unit 2	White crappie	28	73.2
Unit 2	River crayfish	75	40.3
		560	348.1
Unit 2 total		160042	185913.2
	August 2005		
Unit 3	Gizzard shad	215	
Unit 3	Channel catfish	538	
		753	
	September 2005		
Unit 3	Gizzard shad	2136	2044.0
Unit 3	Comely shiner	14	33.1
Unit 3	Spotfin shiner	55	122.1
Unit 3	Channel catfish	520	824.7
Unit 3	Flathead catfish	7	34.7
Unit 3	Green sunfish	7	34.7
Unit 3	Bluegill	49	107.2
Unit 3	Smallmouth bass	7	34.7
Unit 3	Tessellated darter	21	51.8
Unit 3	Walleye	14	33.1
Unit 3	River crayfish	21	51.8
		2851	2212.6

Appendix B

Continued.

Location	Common name	Expanded catch	SE
	October 2005		
Unit 3	American shad	105	195.7
Unit 3	Gizzard shad	65716	143636.2
Unit 3	Common carp	12	43.7
Unit 3	Comely shiner	19	57.9
Unit 3	Spottail shiner	2	35.8
Unit 3	Spotfin shiner	17	53.7
Unit 3	Yellow bullhead	2	35.8
Unit 3	Channel catfish	174	135.1
Unit 3	Flathead catfish	19	57.9
Unit 3	White perch	2	35.8
Unit 3	Striped bass	2	35.8
Unit 3	Rock bass	22	68.8
Unit 3	Green sunfish	29	66.3
Unit 3	Bluegill	2316	3307.7
Unit 3	Smallmouth bass	28	76.3
Unit 3	Largemouth bass	10	37.4
Unit 3	White crappie	64	107.2
Unit 3	Tessellated darter	7	42.5
Unit 3	Yellow perch	117	371.1
Unit 3	Walleye	109	148.9
Unit 3	River crayfish	153	231.4
		68925	143675.4

Appendix B

Continued.

Location	Common name	Expanded catch	SE
	November 2005		
Unit 3	Alewife	16	55.8
Unit 3	American shad	42	130.1
Unit 3	Gizzard shad	68293	96837.9
Unit 3	Common carp	20	82.1
Unit 3	Golden shiner	2	34.7
Unit 3	Comely shiner	44	95.4
Unit 3	Spottail shiner	6	41.1
Unit 3	Spotfin shiner	9	40.9
Unit 3	Northern hogsucker	31	84.6
Unit 3	Channel catfish	146	337.9
Unit 3	Flathead catfish	25	85.5
Unit 3	Mummichog	2	34.7
Unit 3	White perch	4	34.6
Unit 3	Striped bass	6	41.1
Unit 3	Rock bass	50	132.7
Unit 3	Green sunfish	16	58.8
Unit 3	Bluegill	1920	3174.4
Unit 3	Smallmouth bass	5	34.4
Unit 3	Largemouth bass	26	48.5
Unit 3	White crappie	28	51.1
Unit 3	Tessellated darter	34	131.3
Unit 3	Yellow perch	160	653.2
Unit 3	Walleye	310	586.3
Unit 3	Greenside darter	2	34.7
Unit 3	River crayfish	188	299.8
		71384	96895.5

Appendix B

Continued.

Location	Common name	Expanded catch	SE
	December 2005		
Unit 3	Alewife	26	70.8
Unit 3	Gizzard shad	696	602.4
Unit 3	Common carp	10	40.7
Unit 3	Golden shiner	5	35.9
Unit 3	Comely shiner	26	57.4
Unit 3	Spotfin shiner	5	35.9
Unit 3	Creek chub	5	35.9
Unit 3	Channel catfish	174	149.9
Unit 3	Rock bass	26	49.4
Unit 3	Redbreast sunfish	5	35.9
Unit 3	Green sunfish	15	39.3
Unit 3	Pumpkinseed	5	35.9
Unit 3	Bluegill	1874	2414.3
Unit 3	Smallmouth bass	5	35.9
Unit 3	Largemouth bass	5	35.9
Unit 3	White crappie	15	33.5
Unit 3	Tessellated darter	15	39.3
Unit 3	Yellow perch	20	42.5
Unit 3	Walleye	31	58.6
		2964	2499.0
	January 2006		
Unit 3	Gizzard shad	36	45.0
Unit 3	Comely shiner	14	42.6
Unit 3	Spottail shiner	43	45.5
Unit 3	Channel catfish	817	750.7
Unit 3	Rock bass	79	120.9
Unit 3	Redbreast sunfish	7	35.9
Unit 3	Green sunfish	136	201.3
Unit 3	Bluegill	545	800.5
Unit 3	White crappie	7	35.9
Unit 3	Yellow perch	7	35.9
Unit 3	River crayfish	22	30.6
		1713	1127.0
	February 2006		
Unit 3	Alewife	8	32.5
Unit 3	Gizzard shad	8	32.5
Unit 3	Channel catfish	380	546.6
Unit 3	Rock bass	24	51.6
Unit 3	Bluegill	194	364.1
Unit 3	Tessellated darter	24	35.6
Unit 3	River crayfish	16	39.9
		655	662.6

Appendix B

Continued.

Location	Common name	Expanded catch	SE
	March 2006		
Unit 3	Channel catfish	108	65.9
Unit 3	Bluegill	27	57.2
Unit 3	Largemouth bass	9	35.9
Unit 3	Black crappie	9	35.9
Unit 3	Tessellated darter	9	35.9
Unit 3	River crayfish	36	31.0
		197	111.6
	April 2006		
Unit 3	Central stoneroller	12	34.8
Unit 3	White sucker	12	34.8
Unit 3	Channel catfish	231	167.1
Unit 3	Redbreast sunfish	12	34.8
Unit 3	Green sunfish	12	34.8
Unit 3	Smallmouth bass	12	34.8
Unit 3	Tessellated darter	23	29.1
Unit 3	Walleye	23	29.1
Unit 3	River crayfish	69	63.2
		405	199.1
	May 2006		
Unit 3	Alewife	7	35.9
Unit 3	American shad	29	66.6
Unit 3	Gizzard shad	14	34.2
Unit 3	Common carp	7	35.9
Unit 3	Golden shiner	7	35.9
Unit 3	Comely shiner	14	34.2
Unit 3	Quillback	7	35.9
Unit 3	Channel catfish	767	641.0
Unit 3	Green sunfish	7	35.9
Unit 3	Bluegill	7	35.9
Unit 3	Yellow perch	7	35.9
Unit 3	Walleye	7	35.9
Unit 3	River crayfish	14	34.2
		896	655.0
	June 2006		
Unit 3	American shad	12	34.8
Unit 3	Channel catfish	382	491.3
Unit 3	Bluegill	12	34.8
Unit 3	Smallmouth bass	12	34.8
Unit 3	River crayfish	150	112.4
		566	507.5

Appendix B

Continued.

Location	Common name	Expanded catch	SE
	July 2006		
Unit 3	Gizzard shad	762	1346.3
Unit 3	White catfish	9	35.9
Unit 3	Channel catfish	1559	893.2
Unit 3	Flathead catfish	27	39.4
Unit 3	Rock bass	18	44.2
Unit 3	Green sunfish	9	35.9
Unit 3	Pumpkinseed	9	35.9
Unit 3	Bluegill	81	88.3
Unit 3	Smallmouth bass	72	50.5
Unit 3	Largemouth bass	9	35.9
Unit 3	White crappie	18	33.1
Unit 3	Yellow perch	18	44.2
Unit 3	Logperch	18	44.2
Unit 3	Walleye	18	33.1
Unit 3	River crayfish	197	171.5
		2822	1632.5
	August 2006		
Unit 3	Gizzard shad	803	1587.6
Unit 3	Common carp	14	34.2
Unit 3	Comely shiner	14	42.6
Unit 3	Channel catfish	1175	938.7
Unit 3	Flathead catfish	7	35.9
Unit 3	Rock bass	7	35.9
Unit 3	Green sunfish	7	35.9
Unit 3	Bluegill	14	42.6
Unit 3	White crappie	14	34.2
Unit 3	Walleye	7	35.9
Unit 3	River crayfish	65	85.2
		2129	1849.3
	September 2006		
Unit 3	Gizzard shad	2072	2128.3
Unit 3	Golden shiner	9	34.8
Unit 3	Spottail shiner	9	34.8
Unit 3	Shorthead redhorse	9	34.8
Unit 3	Channel catfish	2870	3793.3
Unit 3	Flathead catfish	139	158.7
Unit 3	Green sunfish	9	34.8
Unit 3	Bluegill	1275	2406.2
Unit 3	Smallmouth bass	17	42.8
Unit 3	Walleye	9	34.8
Unit 3	River crayfish	217	136.3
		6633	4975.9

Appendix B

Continued.

Location	Common name	Expanded catch	SE
	October 2006		
Unit 3	Alewife	7	35.5
Unit 3	American shad	180	231.1
Unit 3	Gizzard shad	2344	3618.5
Unit 3	Golden shiner	4	35.9
Unit 3	Spottail shiner	26	51.2
Unit 3	Spotfin shiner	49	92.6
Unit 3	Bluntnose minnow	32	103.0
Unit 3	Creek chub	12	47.6
Unit 3	White sucker	15	46.7
Unit 3	Channel catfish	376	399.9
Unit 3	Flathead catfish	223	325.0
Unit 3	Rock bass	42	78.0
Unit 3	Green sunfish	43	78.9
Unit 3	Pumpkinseed	7	39.3
Unit 3	Bluegill	1590	3132.4
Unit 3	Smallmouth bass	4	35.9
Unit 3	Largemouth bass	4	35.9
Unit 3	White crappie	84	142.7
Unit 3	Yellow perch	4	35.9
Unit 3	Logperch	4	35.9
Unit 3	River crayfish	204	184.7
		5251	4829.8
	November 2006		
Unit 3	Alewife	10	33.6
Unit 3	American shad	7	34.4
Unit 3	Gizzard shad	225	160.7
Unit 3	Central stoneroller	11	46.1
Unit 3	Golden shiner	7	34.4
Unit 3	Spottail shiner	11	46.1
Unit 3	Spotfin shiner	7	34.4
Unit 3	Bluntnose minnow	3	34.7
Unit 3	Channel catfish	156	124.8
Unit 3	Flathead catfish	59	101.0
Unit 3	Rock bass	46	144.0
Unit 3	Green sunfish	103	323.4
Unit 3	Pumpkinseed	11	46.1
Unit 3	Bluegill	2338	7126.2
Unit 3	Largemouth bass	84	250.1
Unit 3	White crappie	55	79.1
Unit 3	Yellow perch	11	46.1
Unit 3	River crayfish	109	169.0
		3255	7146.5
Total for Unit 3		171399	173638.1
Total for period		331442	254389.3

Appendix C

Summary of efficiency tests conducted at Peach Bottom Atomic Power Station Outer Screen House, 2006.

Efficiency Test Date	Unit Tested	Release Location	Species Tested	Number Released	Number Recovered	Efficiency Percentage
4/24/06	2	E-F portal	Gizzard shad	165	45	27.3%
4/24/06	3	E-F portal	Gizzard shad	165	17	10.3%
7/11/06	2	E-F portal	Gizzard shad	125	29	23.2%
7/11/06	3	E-F portal	Gizzard shad	125	61	48.8%
7/18/06	2	C-D portal	Gizzard shad	140	88	62.9%
7/18/06	2	C-D portal	Bluegill	111	61	55.0%
7/18/06	3	C-D portal	Gizzard shad	140	77	55.0%
7/18/06	3	C-D portal	Bluegill	111	59	53.2%
9/8/06	2	H-J screen	Bluegill	50	48	96.0%
9/8/06	2	B-C screen	Gizzard shad	50	48	96.0%
9/8/06	2	on C screen	Yellow perch	10*	1	10.0%
9/8/06	3	J-K screen	Bluegill	50	48	96.0%
9/8/06	3	E-F screen	Gizzard shad	50	50	100.0%
9/8/06	3	on G screen	Yellow perch	10*	10	100.0%
11/13/2006*	2	J-K portal	Walleye	5	5	100.0%
11/13/2006*	2	F screen	Walleye	5	3	60.0%
11/13/2006*	3	C-D portal	Walleye/Crappie	6	5	83.3%
11/13/2006*	3	C screen	Walleye/Crappie	6	3	50.0%

* Fish were radio tagged and only counted as recovered if found in debris bin.

Appendix D

Length frequencies (mm) of fishes impinged fishes collected at PBAPS, 2005-2006.

		21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171	181	191	201	211	221	231	241	251
Species	**N**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**150**	**160**	**170**	**180**	**190**	**200**	**210**	**220**	**230**	**240**	**250**	**260**
Blueback herring	1					1																			
Alewife	42					5	5	14	9		2		1	3											
American shad	181						2	5		3	14	20	39	41	26	14	6	1							
Gizzard shad	5316		2	63	815	1267	1186	1224	460	131	48	41	23	15	7	3	3	3	1	1		1			
Central stoneroller	2						1		1																
Common carp	18				2	2	4	2	3	2															
Golden shiner	15					1	1	4	5	1	2		1												
Comely shiner	53			1		5	30	11	5		1														
Common shiner	1									1															
Spottail shiner	18		1	2		1	5	7	2																
Swallowtail shiner	1			1																					
Spotfin shiner	44		4	4	8	13	7	5	1	2															
Bluntnose minnow	1		1																						
Creek chub	1						1																		
Mimic shiner	2		1	1																					
Quillback	12				2				1		1		2		1	1	2								
White sucker	1										1														
Northern hogsucker	11										5	5	1												
Shorthead redhorse	3																					1			
White catfish	1																								
Yellow bullhead (00)	0																								
Channel catfish	2077	1	2	23	177	318	349	234	162	149	153	170	108	87	37	26	15	8	8	5	4	9	5	6	2
Margined madtom	1							1																	
Flathead catfish	127				2	9	33	37	15	10	3	2	2		1		1	3	1		1	2			1
Mummichog	2					1		1																	
White perch	10						3	5	1		1														
Stripeed bass	2													1	1										
Rock bass	74		1	9	24	16	11	2	1	6	1		1						1		1				
Redbreast sunfish	3					1	2																		
Green sunfish	82		4	14	18	22	9	4	1		2	1		2	1	1	1	2							
Pumpkinseed	10			1	1	3		1				2		2											
Bluegill	3139	1	69	789	1176	602	250	135	52	27	8	8	7	3	3	3	1	1		1	1	1			
Smallmouth bass	27				2	3		1	1				1					1	1					2	1
Largemouth bass	33					3	14	6	1	1		1	2	2					1			1			
White crappie	126			2	3	6	19	26	19	16	14	14	3	2	1	1									
Black crappie	1																								
Tessellated darter	29			12	10	5	2																		
Yellow perch	134				1		1	39	77	7	2		1	1	1				1		1		1		
Logperch	3			1				1	1																
Walleye	213				1		1	1	2	4	12	8	6	6	3			4	2	7	13	17	21	13	30
Banded darter	1			1																					
Greensided darter	3						3																		
River crayfish (00)	0																								
Totals	**11967**	**2**	**85**	**924**	**2242**	**2284**	**1939**	**1766**	**820**	**360**	**270**	**272**	**198**	**165**	**82**	**49**	**29**	**23**	**16**	**14**	**21**	**32**	**27**	**21**	**34**

Appendix D

Continued.

Species	261 270	271 280	281 290	291 300	301 310	311 320	321 330	331 340	341 350	351 360	361 370	371 380	381 390	391 400	401 410	411 420	421 430	431 440	441 450	451 460	461 470	471 480	481 490	491 500	501 510
Blueback																									
Alewife								1					1								1				
American shad																1		1	1		1	2	2		2
Gizzard shad					1		2	1	1	2	1		4	3			3		1	2	1				
Central stoneroller																									
Common carp			1		1																				1
Golden shiner																									
Comely shiner																									
Common shiner																									
Spottail shiner																									
Swallowtail shiner																									
Spotfin shiner																									
Bluntnose minnow																									
Creek chub																									
Mimic shiner																									
Quillback											1							1							
White sucker																									
Northern hogsucker																									
Shorthead redhorse						1									1										
White catfish									1																
Yellow bullhead (00)																									
Channel catfish	4	4	2	1	1	1		1				1	1	1	1		1								
Margined madtom																									
Flathead catfish		1		1					2																
Mummichog																									
White perch																									
Stripeed bass																									
Rock bass																									
Redbreast sunfish																									
Green sunfish																									
Pumpkinseed																									
Bluegill																								1	
Smallmouth bass	1	1			2		2	3	1	1		1					1				1				
Largemouth bass										1															
White crappie																									
Black crappie		1																							
Tessellated darter																									
Yellow perch				1																					
Logperch																									
Walleye	25	13	11		1	1	1	5		2		1				1						1			
Banded darter																									
Greensided darter																									
River crayfish (00)																									
Totals		20	14	3	6	3	5	11	5	6	2	3	6	4	2	2	5	2	2	2	4	3	2	1	3

ATTACHMENT I

40 CFR §122.21(r) NPDES APPLICATION REQUIREMENTS FOR FACILITIES WITH COOLING WATER INTAKE STRUCTURES

FOR

PEACH BOTTOM ATOMIC POWER STATION

Prepared for:

Exelon

by URS Corporation

October 2008

Table of Contents

1. INTRODUCTION

1.1 Regulatory Requirement

40 CFR §122.21(r) contains National Pollutant Discharge Elimination System (NPDES) application requirements for facilities with cooling water intake structures. §122.21(r)(1)(ii) states that Phase II existing facilities must submit to the Director for review the information required under paragraphs (r)(2), (3), and (5) of §122.21. This information consists of physical data for each cooling water source, cooling water intake structure (CWIS), and cooling water system utilized at the facility.

This document is intended to:

- Fulfill the regulatory requirement for submittal of §122.21(r) information for Peach Bottom Atomic Power Station (PBAPS), a Phase II existing facility.

1.2 Facility Description & Classification

1.2.1 Facility Description

PBAPS is a two-unit (Units 2 & 3) nuclear-fueled boiling water reactor electric power generating facility with a generating capacity of nominally 2,304 megawatts (MW). Unit 2 began commercial operation in June 1974 and Unit 3 entered commercial service in December 1974. The facility is located in York County, Pennsylvania on the west shore of the Conowingo Reservoir at River Mile (RM) 18, about 5 miles upstream from the Pennsylvania-Maryland border (see attached location map and aerial photograph).

PBAPS withdraws water for its cooling and service/process water needs from the Conowingo Reservoir (also known as Conowingo Pool or Conowingo Pond; henceforth called the Pond or Conowingo Pond in this report) of the Susquehanna River through an outer intake structure located on the shoreline. Water flows through the screens of the outer intake structure, through two 3-acre intake ponds (one serving each unit), and then through an inner intake structure/pumphouse. These components supply water for once-through cooling of the main condensers and for plant services (process/equipment needs).

1.2.2 Facility Classification

PBAPS meets the regulatory definition of a Phase II facility since it is an existing facility that meets the following four criteria stated in §125.91:

- It is a point source;
- It uses cooling water intake structures with a total design intake flow of 50 million gallons per day (MGD) or more to withdraw cooling water from waters of the United States;
- As its primary activity, it both generates and transmits electric power, or generates electric power but sells it to another entity for transmission; and
- It uses at least 25 percent of water withdrawn exclusively for cooling purposes, measured on an annual basis.

2. SOURCE WATER PHYSICAL DATA [§122.21(r)(2)]

2.1 Narrative Description

Regulatory requirement at §122.21(r)(2)(i): "A narrative description and scaled drawings showing the physical configuration of all source water bodies used by your facility, including areal dimensions, depths, salinity and temperature regimes, and other documentation that supports your determination of the waterbody type where each cooling water intake structure is located."

2.1.1 Susquehanna River

The Susquehanna River originates near Cooperstown, New York at Otsego Lake and flows for about 444 miles to the Chesapeake Bay at Havre de Grace, Maryland (SRBC, 2005). Three hydroelectric dams in the lower Susquehanna River form a reservoir system stretching 32 river miles (Hainly et al 1997). These are: Conowingo Dam at about RM 10, Holtwood Dam at about RM 25, and Safe Harbor Dam at about RM 32.

Conowingo Dam, located in Maryland, creates the Conowingo Pond that extends about 14 miles upstream into Pennsylvania. PBAPS is located on the west side of the Susquehanna River within the Conowingo Pond at RM 18. The Conowingo Pond is normally maintained at elevations between 104.5 and 108.5 feet (Conowingo Datum, which is 0.7 feet below the more standard National Geodetic Vertical Datum of 1929). The Conowingo Pond has a surface area of about 9,000 acres and a design storage capacity of about 310,000 acre-feet, of which 71,000 acre-feet are usable storage.

Bathymetric contours of the pond (surveyed 1993) in the vicinity of PBABS are provided in Reed and Hoffman (1997). Measured from the edge of the intake bay structure in the Pond, the river width is about a mile and a quarter. Depths to bottom sediments rapidly approach 15 feet (from the normal water surface elevation of 108.5 feet) within 250 feet of the PBAPS intake structure, after which the bottom flattens out for about 1,500 feet.

The limit of tidal influence in the Susquehanna River is downstream of Conowingo Dam in Maryland, near the mouth of Deer Creek at RM 6 (Webb & Heidel, 1970). Thus, the PBAPS intake is located in a freshwater waterbody.

Historical temperature data for the Conowingo Pond indicate that strong seasonal thermal stratification is absent (Normandeau, 2000; RMC, 1985). Water temperatures begin to rise in late winter to mid-summer and then decline and are a few degrees higher at the surface than at the bottom. Highest water temperatures are reached in summer and coincide with natural low flow in the Pond. Increased flows from storm events flush the Pond with cooler water and reduce water temperatures. Temperatures measured at the CWIS during the 2005-2006 impingement sampling events confirm this temperature trend.

2.2 Hydrological & Geomorphological Features

Regulatory requirement at §122.21(r)(2)(ii): "Identification and characterization of the source waterbody's hydrological and geomorphological features, as well as the methods you used to conduct any physical studies to determine your intake's area of influence within the waterbody and the results of such studies."

2.2.1 Susquehanna River

The drainage area of the Susquehanna River encompasses parts of New York, Pennsylvania and Maryland and covers 27,510 square miles (mi^2) (Hainly et al, 1995). The river at the PBAPS intake is an impoundment formed by the Conowingo Dam.

The reservoir bottom across the Pond at PBAPS is uneven (Reed and Hoffman, 1997). Depth to bottom (from the normal water surface elevation of 108.5 feet) drops to 15 feet within 250 feet of the PBAPS intake structure. Shallows less than 10 feet deep are located about 1,700 to 2,700 feet from the intake bay structure and about three-quarters of a mile from the intake bay structure near the opposite shoreline. The deepest part of the channel cross-section at PBAPS is along the opposite shore where a pool elevation over 25 feet occurs a few hundred feet from the bank.

Sediments in the Pond consist of sand, river coal, silt and clay (Hainly et al, 1995). The USGS divides the Pond into three subareas (Mt. Johnson Island, Middle Reservoir, Lower Reservoir) each with different overall sediment characteristics. The PBAPS CWIS is located at the lowermost end of the Mt. Johnson Island Subarea. Sand and coal content decrease from 45 and 30 percent, respectively, in Mt. Johnson Island Subarea to 5 and 2 percent, respectively, just above the dam in the Lower Reservoir Subarea. In contrast, silt and clay content increases from 18 and 7 percent, respectively, in the Mt. Johnson Island Subarea to 58 and 35 percent, respectively, above the dam. Sediment thickness also increases from the upper to lower reaches of the Pond. Sediment thicknesses range zero to ten feet in the Mt. Johnson Island Subarea, ten to 20 feet in the Middle Reservoir Subarea, and greater than 20 feet in the Lower Reservoir Subarea.

No physical studies were conducted at PBAPS specifically to determine the intake's area of influence within the waterbody for the purposes of this report. In accordance with the Proposal for Information Collection submitted and reviewed by the Department, PBAPS is subject only to performance standards for impingement mortality. A desktop analysis was performed to define the approximate area of influence within the 0.5 fps velocity contour. The USEPA considers this velocity to be a *de minimis* value relative to significant impingement concerns. Based on the physical dimensions of the outer screen structure, the design intake flow, the minimum Pond water elevation of 104.0 feet and the bathymetry of the Conowingo Pond in the vicinity of the outer screen structure, the approach velocity at the outer screenhouse trash racks is computed (using $v = Q / A$) to be 0.39 fps. The design through-blade velocity of the trash racks is 0.48 fps and the velocity of the water in the pool between the trash racks and the screens ranges from 0.44 fps (immediately behind the trash racks) to 0.58 fps (immediately in front of the screens). Therefore, the hydraulic zone of influence at PBAPS exists only between the trash racks and the outer screenhouse traveling water screens, specifically within 4-ft of the screens, and does not extend beyond the CWIS into the Conowingo Pond.

2.3 Locational Maps

Regulatory requirement at §122.21(r)(2)(iii): "Locational maps."

Locational maps identifying the Conowingo Pond, the CWIS and, the pumphouses are provided in Section 6 as Attachments.

3. COOLING WATER INTAKE STRUCTURE DATA [§122.21(r)(3)]

3.1 Narrative Description of Configuration

Regulatory requirement at §122.21(r)(3)(i): "A narrative description of the configuration of each of your cooling water intake structures and where it is located in the waterbody and in the water column."

The PBAPS CWIS provides a continuous supply of water from the Conowingo Pond to Units 2 and 3 and includes the following major components:

- Outer Screenhouse Structure
  - Twenty-nine (29) active trash racks
  - Twenty-four (24) through-flow traveling water screens
- Two (2) Intake Basins
- Inner Screenhouse Structure
  - Six (6) dual-flow circulating water traveling screens
  - Four (4) through-flow service water traveling water screens
- Six (6) Circulating Water Pumps
- 6 Service Water Pumps
- 8 High Pressure Service Water Pumps
- 2 Emergency Service Water Pumps
- 3 Outer Screen Wash Water Pumps
- 2 Inner Screen Wash Water Pumps
- 2 Fire Protection Pumps

The outer screenhouse structure is approximately 480 feet long and 32 feet high. The structure occupies the water column from the surface down to the level of the bottom of the trash racks, at an elevation of 84'-0" (Conowingo Datum). The operating floor level of the screenhouse is at elevation 116'-0" (Conowingo Datum) and is enclosed with walls and a roof. To prevent large debris and ice chunks from entering the intake, there are 29 active trash racks with ¼-inch wide by 3-inch deep steel bars spaced 3 ½ inches on center on the face of the outer intake structure. Divers manually clean the trash racks periodically when needed and collected debris is disposed of offsite. Structures for a previous automatic raking system with a manual collection system are still in place. 24

traveling water screens (12 per unit) are located approximately 44 feet inboard of the trash racks. Each screen, most recently rebuilt by Hawco Screens, Inc., is 10 feet wide with a ⅜-inch square opening mesh. Debris, including fish, is removed from the screens by a high-pressure spray-wash system on the ascending side of the screens to sluiceways (one per unit). The debris from the screens is collected in dumpsters and disposed of off-site. No fish are returned from the outer screenhouse structure to the Conowingo Pond.

Water flows from the outer screenhouse structure into two intake basins (one per unit) before reaching the inner screenhouse structure. Water from the basins enters the inner screenhouse structure through eight bays (4 per unit). Six of the bays, each with their own traveling screen, direct the water to six circulating water pumps (3 per unit). These screens are dual-entry, single-exit (dual-flow) traveling screens, originally manufactured by FMC, with ¼-inch by ½-inch opening mesh. The remaining two bays (one bay per unit) have four traveling screens installed (2 per bay), which are a single-entry, single-exit (through-flow) design. The water pumped from these two bays provides service water to the units. Debris, including fish, is removed from the screens by a high-pressure spray-wash system on the ascending side of the screens to sluiceways (1 per unit). The debris is collected in dumpsters and disposed of off-site.

Approximately 47 feet downstream of the inner dual-flow and through-flow screens are the six circulating water pumps (three per unit) and six service water pumps (three per unit), respectively.

The pumps that withdraw water from the intake structure and their design flow rates are shown in the following table.

TABLE 1 – PBAPS INTAKE PUMP DESIGN CAPACITIES

Operation	Number of Installed Pumps	Design Flow (gpm)[1]
Condenser Cooling	6 (3 per unit)	250,000 each
Service Water	6 (2 and 1 spare per unit)	14,000 each
High Pressure Service Water	8 (4 per unit)	4,700 each
Emergency Service Water	2 (common to both units)	8, 000 each
Outer Screen Wash	3 (1 per unit and 1 common to both units)	4,400 each[2]
Inner Service Water Screen Wash	2 (1 per unit)	475 each
Fire Protection	2 (1 electric and 1 diesel driven)	2,500 each

[1]These flow capacities are based on the pump manufacturer's ratings and do not account for dual operation head loss, pipe capacity, and other "as-built" conditions.
2 These pumps withdraw water from the condenser discharge (not the intake).

The design intake flow, which takes into account operation of the pumps tabulated above and other factors, is stated in Section 3.3.

3.2 Latitude & Longitude

Regulatory requirement at §122.21(r)(3)(ii): "Latitude and longitude in degrees, minutes, and seconds for each of your the cooling water intake structures."

3.2.1 Outer Screenhouse

Latitude: 39° 45' 36" N Longitude: 76° 15' 55" W

3.3 Narrative Description of Operation

Regulatory requirement at §122.21(r)(3)(iii): "A narrative description of the operation of each of your cooling water intake structures, including design intake flows, daily hours of operation, number of days of the year in operation and seasonal changes, if applicable."

3.3.1 Units 2/3 CWIS

The Units 2/3 CWIS operates to provide a continuous supply of water from the Pond to PBAPS for once-through cooling of the main condensers, when condenser cooling is required, and for other plant service water needs.

The six circulating water pumps are started up as required for condenser cooling during plant startup to generate electricity and shut off when no longer required. Certain operational measures at PBAPS result in flow variations. Through most of the year (April through October), all six circulating water pumps are in operation. However, in the winter months (late November/early December through March) lower water temperatures in the Pond generally allow for two pumps (one per Unit) to be shut down. Once a year, for approximately one month, one unit is shut down for refueling and maintenance, leaving only three pumps in operation for the other operating unit.

The various service water pumps are started when necessary to meet the normal and emergency plant demands during plant operation or shutdown, and shut off when no longer required. Normally, two service water pumps per unit run to supply water for equipment and building cooling, to water treatment facilities for production of domestic and demineralized water, and for washing of the traveling screens in the inner screen structure associated with the circulating water pumps. One service water pump per unit is an installed spare. Normally, the other service water pumps (i.e., the high pressure and emergency service water pumps) and Fire Protection Pumps are maintained in standby for operation as necessary only during plant shutdown, in the event of an emergency, or required testing. Each pump bay is provided with a sluice gate, which may be closed in the event of high or low water levels in the Pond.

The outer and inner traveling water screens are normally operated automatically, but can be operated manually from local control panels. In normal (automatic) operation, rotation of the screens is activated by preset timers for a predetermined time as set by duration timers, and, additionally, by a set pressure differential across the screens. During automatic operation, required pumps and valves are started/opened to provide wash water to the screens. For the outer screen structure, the wash water is supplied from screen wash pumps that take suction from the cooling water discharge pond. After the trash is separated from the wash water, the wash water flows to a sump located in the trash pit and is pumped to the Pond. For the inner screen structure, wash water for the circulating water screens is supplied from the service water pump discharge headers, and wash water for the service water screens are supplied from screen wash pumps that take suction from the screen structure. For the inner screen structures, the trash is separated from the wash water and the wash water is returned to the intake water flow using sump pumps located in the trash pits.

Intake flows are calculated based on pump run time and design pump capacity.

Heated water is provided from the circulating water system discharge canal through a recirculation gate for freeze protection of the CWIS in the winter. Also, an air bubbler system is provided for the outer screen structure for breaking up surface ice formation at the inlet side of the structure.

Units 2/3 CWIS design intake flow, conservatively based on design pump capacities (excluding installed spare pumps, pumps that operate under shutdown, emergency, or testing conditions only, and pumps that do not increase intake flow requirements) and maximum operating demands, is shown in the following table.

TABLE 2 – PBAPS DESIGN INTAKE FLOW

Operation	Design Intake Flow (MGD)
Condenser Cooling Water	2,160.0
Service Water	80.6
High Pressure Service Water	0[1]
Emergency Service Water	0[1]
Screen Wash	0[1]
Fire Protection	0[1]
Total Design Intake Flow	2,240.6[1]

[1] Excludes shutdown, emergency, and testing periods

The PBAPS Units 2/3 CWIS operates to supply water to support facility demand in line with its power generation and process needs.

3.4 Flow Distribution & Water Balance

Regulatory requirement at §122.21(r)(3)(iv): "A flow distribution and water balance diagram that includes all sources of water to the facility, recirculating flows, and discharges."

A schematic diagram showing the flow distribution and water balance that includes all sources of water to PBAPS, recirculating flows, and discharges is provided in Section 6 as an Attachment.

3.5 Engineering Drawings

Regulatory requirement at §122.21(r)(3)(v): "Engineering drawings of the cooling water intake structure."

Engineering drawings of the Outer Intake Screenhouse, the Intake Basins and the Inner Intake Screenhouse are provided in Section 6 as Attachments.

4. COOLING WATER SYSTEM DATA [§122.21(r)(5)]

4.1 Narrative Description

Regulatory requirement at §122.21(r)(5)(i): "A narrative description of the operation of the cooling water system, its relationship to cooling water intake structures, the proportion of the design intake flow that is used in the system, the number of days of the year the cooling water system is in operation and seasonal changes in the operation of the system, if applicable)."

The once-through cooling water system at PBAPS consists of the CWIS, a supply conveyance network to the main condensers and other equipment requiring raw water for non-contact cooling or other processes, and a discharge conveyance network to dissipate waste heat and discharge wastewater into the Pond through a discharge structure or other outfalls. During normal operation, approximately 96 percent of the design intake flow is used for condenser cooling with the remainder used for plant services.

Non-contact cooling water is pumped from the CWIS through the main condensers, where it becomes heated, and then discharges into a discharge pond and canal that flows back to the Conowingo Pond downstream of the intake. The discharge pond and discharge canal also provide a place of discharge for heated water from the Service Water System, the High-Pressure Service Water System, and the Emergency Service Water System, and other process wastewaters. Helper cooling towers are installed in the discharge flow path, but are bypassed (the current PBAPS NPDES permit does not require them to be operated). The discharge canal is oriented parallel to the shoreline. The discharge structure consists of one rectangular fixed opening with three regulating gates that are controlled by differential water level measurements to maintain a discharge velocity of 5 to 8 fps. This is intended to enhance mixing of the discharge with the ambient water and also to prevent immature fish from entering the canal and being exposed to potential thermal shock during plant operation.

Screen wash water for the outer screen structure, derived from the discharge canal, is discharged to the Pond via Outfalls 002 and 005.

Virtually all intake water is for non-consumptive use at the plant, allowing for minor evaporative losses, approximately one per cent.

PBAPS is a base-load plant that is available to operate year round. Either unit could be in shutdown mode or operating at less than 100 percent capacity as a result of maintenance outages, reduced electric demand, or other factors. Based on annual operations from 2001 through 2006, the PBAPS station's average net facility capacity utilization rate was 93.5%. Typically, cooling water demand is less during the winter months (late November/early December through March) due to colder intake water temperatures. Cooling water system operation generally coincides with electric power generation with additional operating time needed before plant startup and after plant shutdown.

4.2 Design & Engineering Calculations

Regulatory requirement at §122.21(r)(5)(ii): "Design and engineering calculations prepared by a qualified professional and supporting data to support the description required by §122.21(r)(5)(i)."

The information provided to support the above description was derived from the references listed in Section 5.

4.2.1 Design Intake Flow

PBAPS has a design intake flow of 2,240.6 MGD (see section 3.3). The source waterbody for the PBAPS CWIS is a reservoir. In accordance with the Proposal for Information Collection submitted and reviewed by the Department, PBAPS is subject only to performance standards for impingement mortality.

4.2.2 Through- Screen Velocity

The through-screen velocity was calculated using formulas adapted from Pankratz (1988):

V = Q / WD * OA * TW * K

where:

V = through-screen velocity in feet per second (fps)
Q = flow rate in gallons per minute (gpm)
WD = water depth in feet (ft)
OA = proportion of screen open area to total screen area
TW = nominal screen tray width in ft

K = constant = 396 for through-flow screen; this provides unit conversion and accounts for a reduction in the screen open area due to typical screen features (e.g., boot seal at the bottom of the screen, mesh support frame, etc.)

and:

OA = (W x L) / ((W + D) x (L + d))

where:

d = screen horizontal wire diameter in inches (in)
D = screen vertical wire diameter (in)
W = width of screen opening (in)
L = vertical length of screen opening (in)

Although the normal water level of the Pond at PBAPS is between 104.5 feet and 108.5 feet (Conowingo Datum), the lowest the Pond can be without causing the shut down of the Muddy Run facility is 104.0 feet (Conowingo Pond Management Plan 2006). Therefore, this water elevation was used as the design minimum low water level in the through screen-velocity calculation. The design inputs and calculations of the through-screen velocity are provided in Section 6 as an Attachment. The results of these calculations show the maximum through-screen velocity at the outer screens at the design intake flow is conservatively estimated as 1.21 fps at a Pond elevation of 104.0.

The information provided to support the above description and engineering calculations was derived from the references listed in Section 5.

5. REFERENCES

Hainly, R.A., L.A. Reed, H.N. Flippo, Jr., and G.J. Barton, 1995. Deposition and Simulation of Sediment Transport in the Lower Susquehanna River Reservoir System. US Geological Survey Water-Resources Investigations Report 95-4122. 39p.

Kennedy, Robert H., 1998. United States Army Corps of Engineers Water Quality Technical Note MS-03. Basinwide Considerations for Water Quality Management: Importance of Phosphorus Retention by Reservoirs, July 1998. 12p.

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Olem, H. and G. Flock (eds), 1990. Lake and Reservoir Restoration Guidance Manual. 2nd Edition. EPA 440/4-90-006. 326p.

PADEP (Pennsylvania Department of Environmental Protection), 2003. Implementation Guidance for Section 95.6 Management of Point Source Phosphorous Discharges to Lakes, Pond, and Impoundments. Bureau of Water Supply and Wastewater Management. Document No. 391-2000-010. March 6, 2003.

Reed, L.A. and S.A. Hoffman, 1997. Sediment Deposition in Lake Clarke, Lake Aldred, and Conowingo Reservoir, Pennsylvania and Maryland, 1910-93. United States Geological Survey Water-Resources Investigations Report 96-4048. 14p with plates.

RMC (RMC Environmental Services). 1985. Water Quality Studies Relative to Objectives 1 to 3 of Article 34 for the Conowingo Hydroelectric Station (Project No. 405). August 1985.

SRBC (Susquehanna River Basin Commission). 2006. Draft Conowingo Pond Management Plan. Publication No. 242, April 2006.

SRBC (Susquehanna River Basin Commission), 2005. SRBC Overview. URL:http://www.srbc.net/geninfo.htm. Accessed February 2005.

Webb & Heidel, 1970. Maryland Geological Survey. Report of Investigations No. 13 – Extent of Brackish Water in the Tidal Rivers of Maryland. 1970.

6. ATTACHMENTS

Site Location/Topographic Map (*USGS Topographic Quadrangle Base Map*)

Figure 1 – Cooling Water Intake Structure Layout Aerial Photograph (USGS TerraServer)

Bathymetric Map (Reed and Hoffman, 1997)

Schematic of Water Flow. Exelon Nuclear. Figure Number NPDES-1, Rev 1, October 24, 2007

<u>Outer Screenhouse</u>

Drawing No. M-18-62, Sheet 1, General Arrangement 10' X 33' Traveling Water Screens, Hawco Screens, Inc., September 25, 1992.

Drawing No. M-18-64, Sheet 1, Traveling Water Screen Data Sheet, Hawco Screens, Inc., January 15, 1993.

Drawing No. 6280, Sheet C-100, C.W. Screen Structure Bottom Plan, Bechtel, 1976.

Drawing No. 6280, Sheet C-101, C.W. Screen Structure Bottom Plan, Bechtel, February 23, 1971.

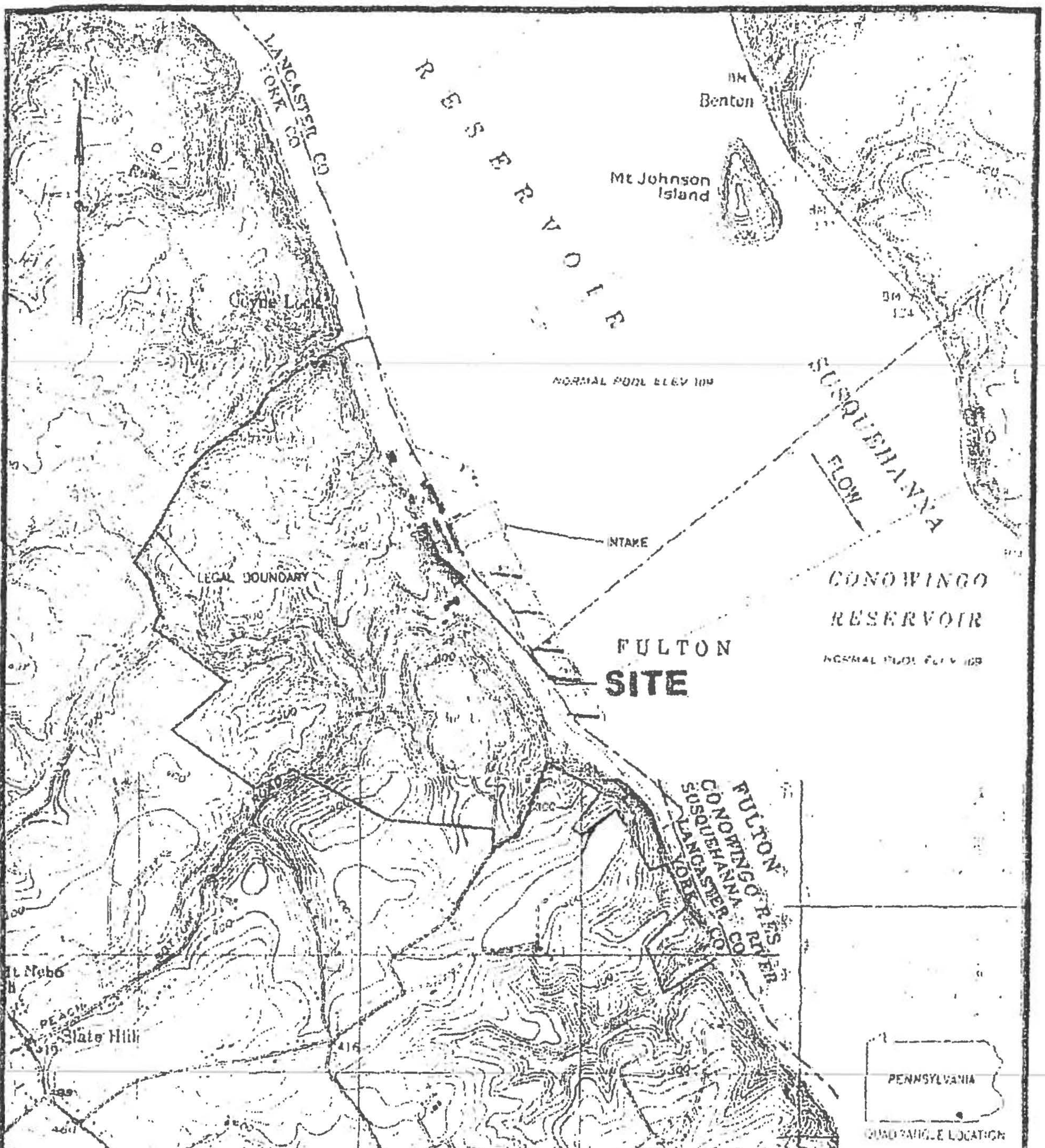
Drawing No. 6280, Sheet C-102, C.W. Screen Structure Sections, Bechtel, August 26, 1971.

Drawing No. 6280, Sheet SKC-289, Screen Structure Trash Collection Area, Bechtel, July 1967.

<u>Inner Screenhouse</u>

Drawing No. NE-259-1, Sheet 1, General Arrangement Traveling Water Screen Dual Flow With Curved Diverter Plates, FMC Corp., December 9, 1996.

Calculations of Through-Screen Design Intake Velocity for Peach Bottom Atomic Power Station Outer Screenhouse, prepared by URS Corporation, Fort Washington, PA, Rev. 2.



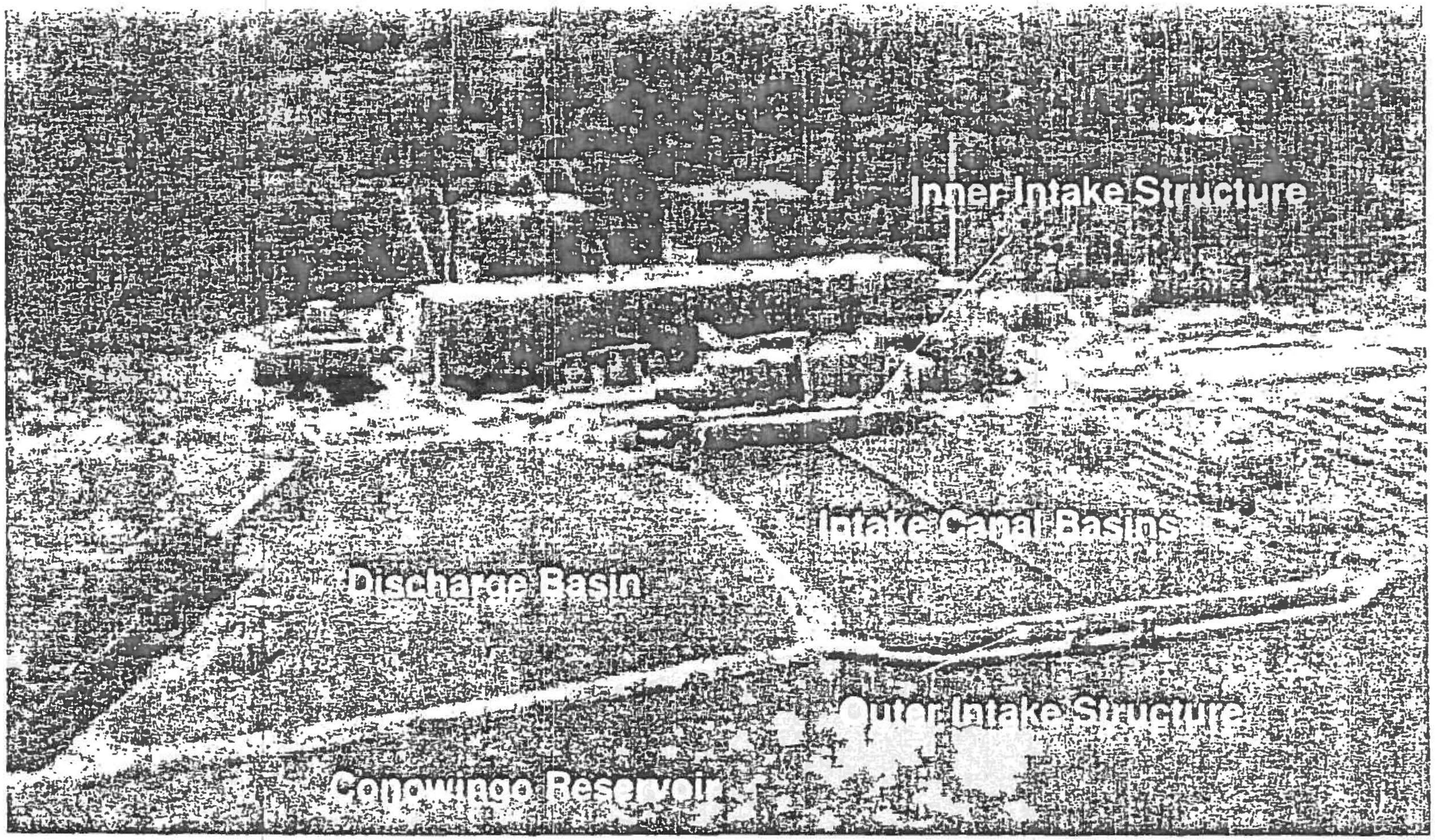
0 1000 2000 3000 FEET

GRAPHIC SCALE

CONTOUR INTERVAL = 20 FEET

REFERENCE: A PORTION OF USGS 7.5 MINUTE TOPOGRAPHIC MAPS: HOLTWOOD QUADRANGLE, PA; 1955, PHOTOREVISED 1990; WAKEFIELD QUADRANGLE, PA, 1955, PHOTOREVISED 1969 & 1976; DELTA QUADRANGLE, PA-MD, 1999; CONOWINGO DAM QUADRANGLE, MD-PA, 1995.

TITLE	TOPOGRAPHIC MAP		
PROJECT	EXELON NUCLEAR - PEACH BOTTOM ATOMIC POWER STATION DELTA, PA		
	Exelon		
SCALE AS SHOWN	DRAWN BY GCA	JOB NO. 3996673	
DATE 01/18/07	APPR. BY JJJO	FIG. NO.	



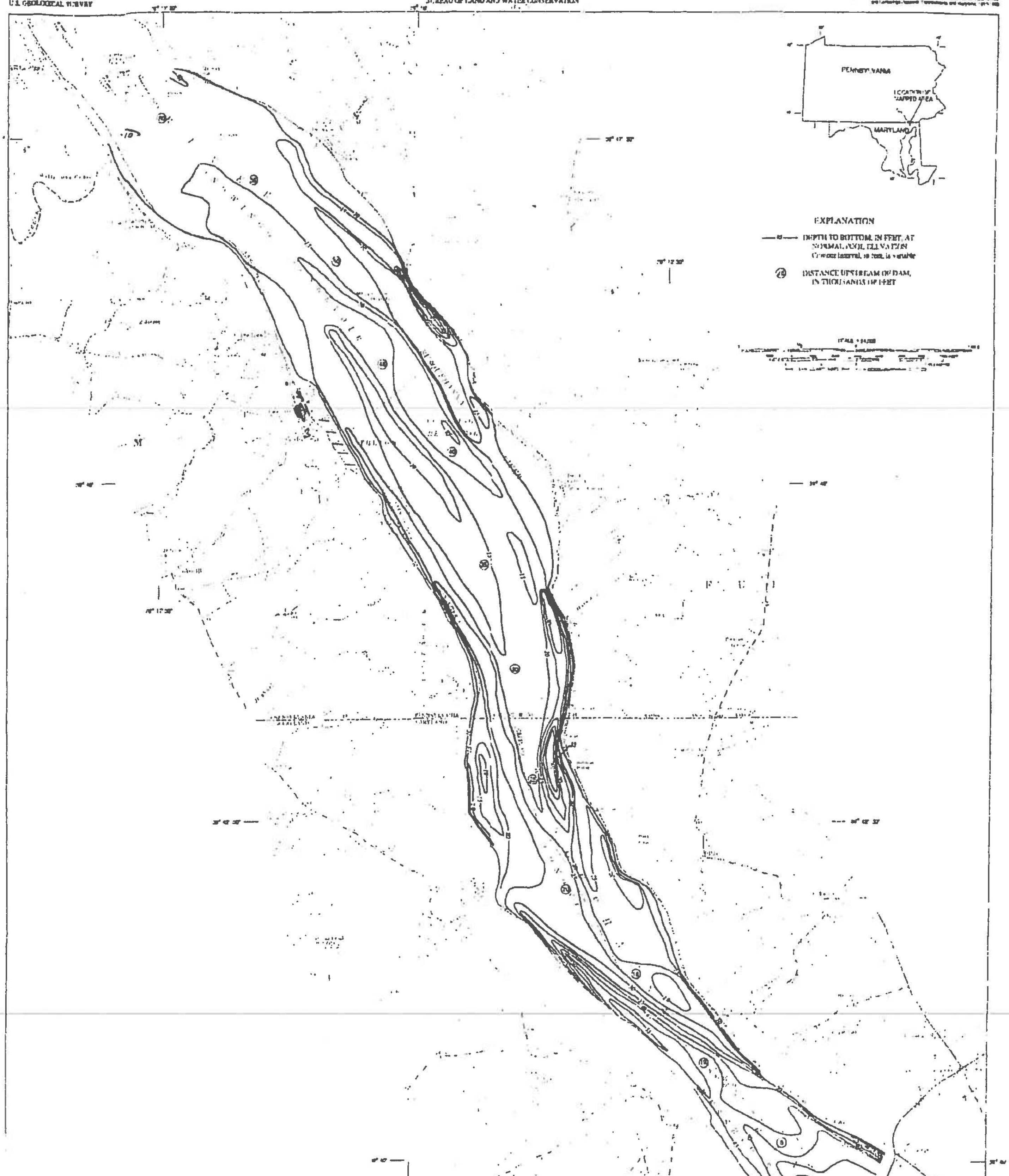
COOLING WATER INTAKE STRUCTURE LAYOUT

FIGURE 1

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF LAND AND WATER CONSERVATION

WATER-RESOURCES INVESTIGATIONS REPORT 96-4048

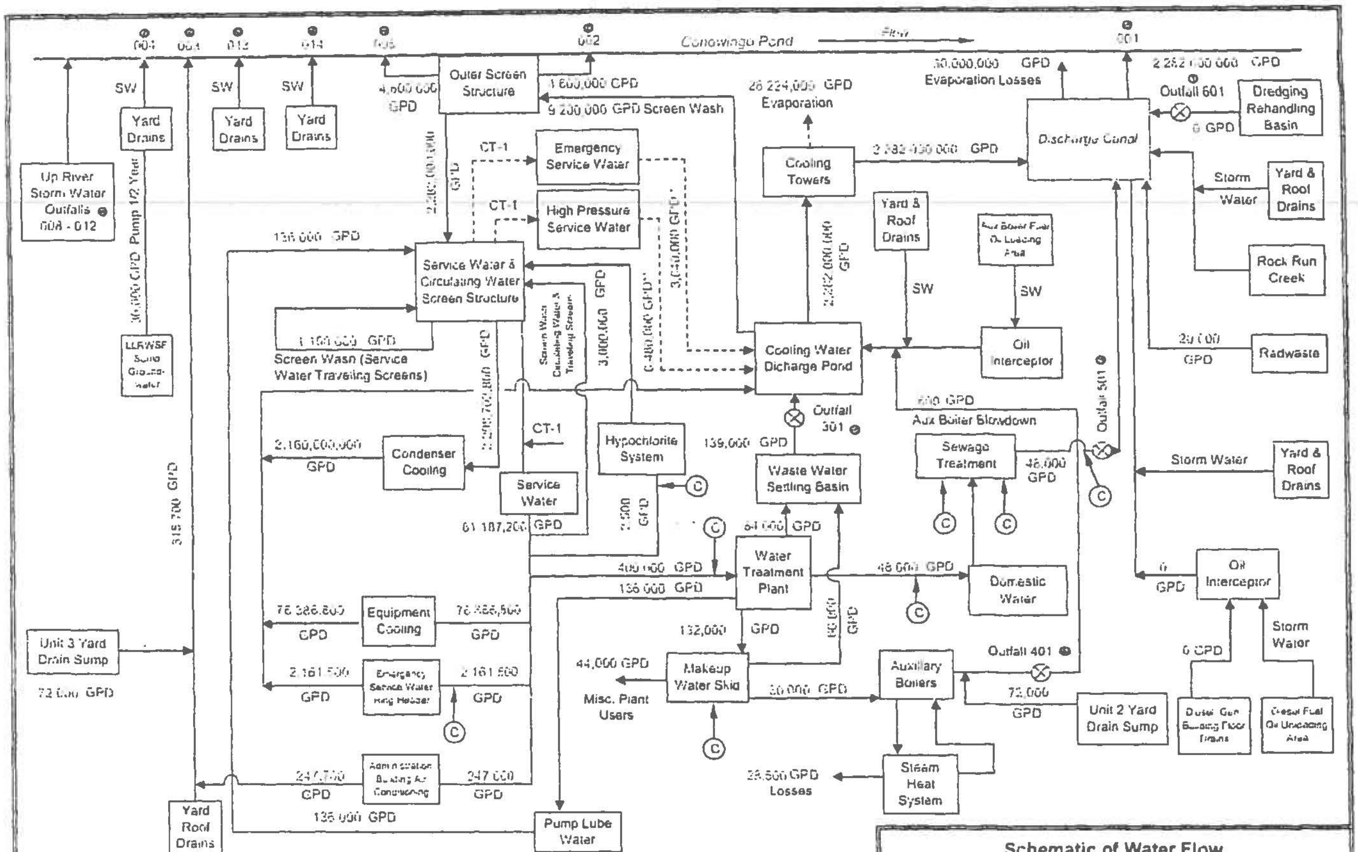


DEPTH FROM THE NORMAL WATER SURFACE (108.5 FEET) TO BOTTOM SEDIMENTS,
CONOWINGO RESERVOIR, PENNSYLVANIA AND MARYLAND, 1993

By

Lloyd A. Reed and Scott A. Hoffman

1997

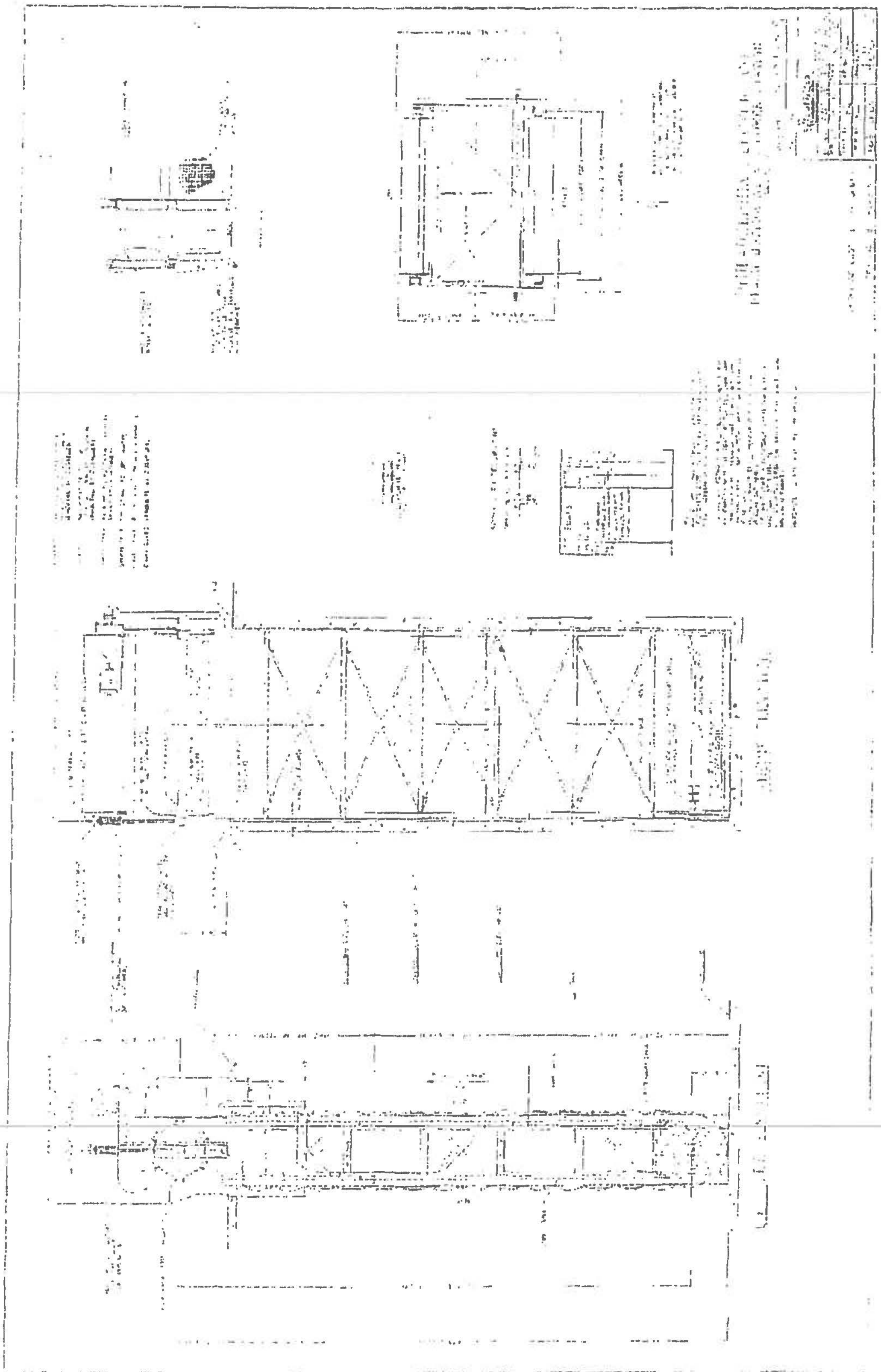


Legend

- (C)→ Point of Chemical Addition
- Sampling Port
- Outfall Number
- → Flowpath
- - ▸ Alternate Route

Notes:
SW = Storm Water
CT = Cooling Tower
GPD = Gallons Per Day
LLRWSF = Low-level Radwaste Storage Facility
* = During Testing - 8 Hours; not used during typical operation
** = During Testing - 24 Hours; not used during typical operation
(C)→ Denotes point of chemical addition (additives listed in Module 1, Section 7 of the permit application).

Revision Dates	Schematic of Water Flow		
	Exelon Nuclear Peach Bottom Atomic Power Station Delta, York County, Pennsylvania		
	Line Drawing	NPDES Permit Number: PA 0009733	
	Date:	Job Number:	Figure Number:
11/27/2007	2/28/2005	20242531.00001	NPDES - 1

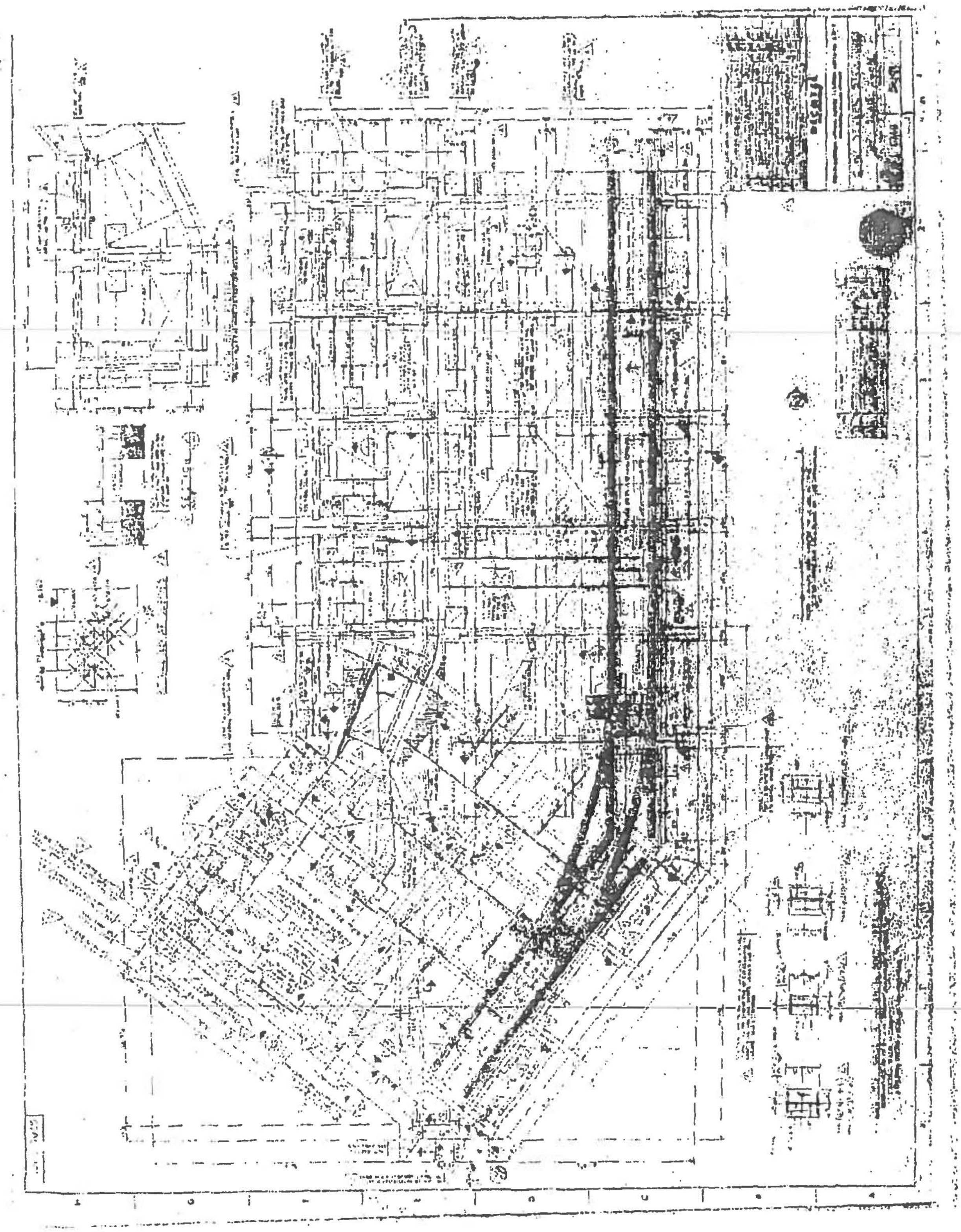


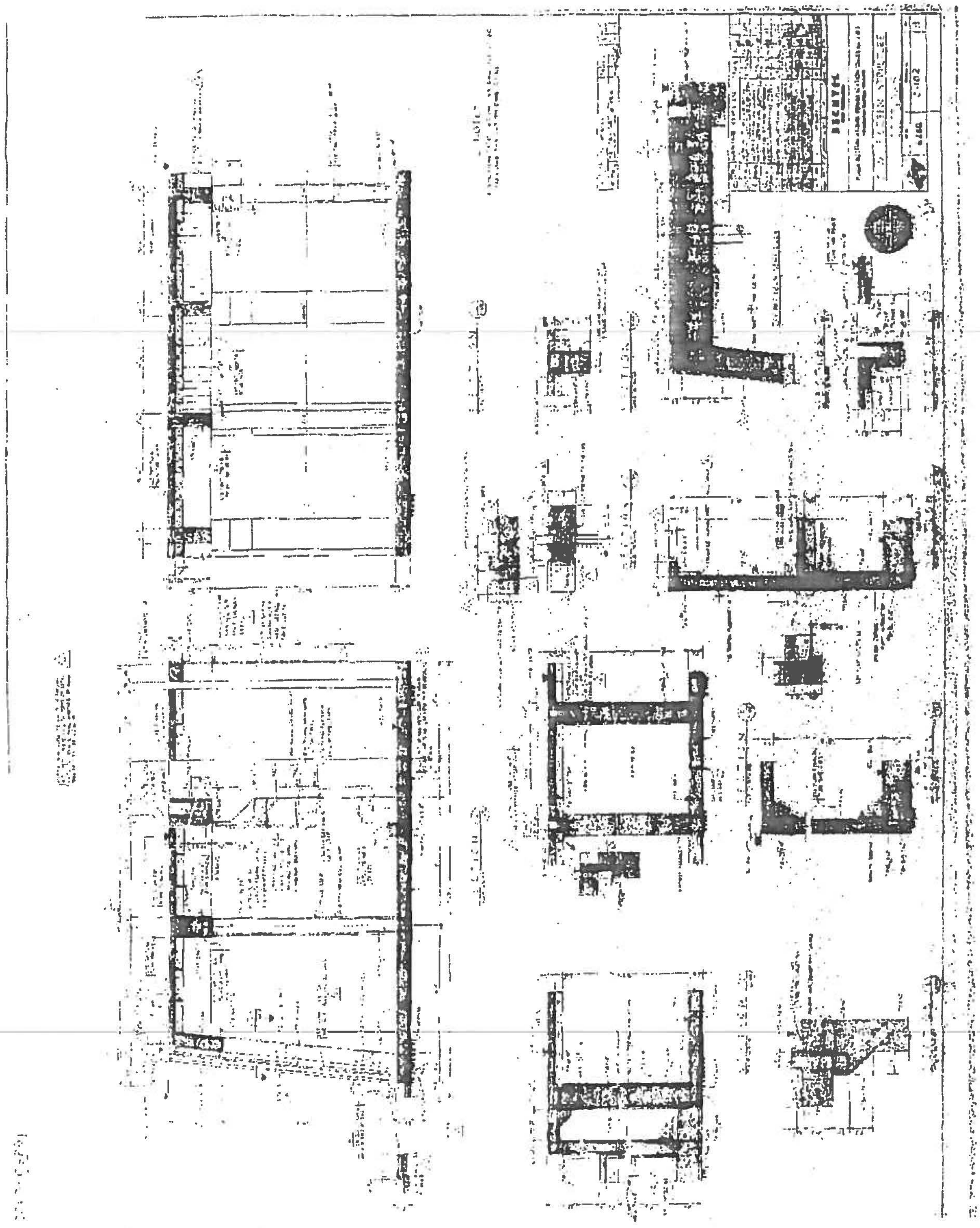
Hewco Screens, Inc.	DATE: 01-15-93	CHK'D BY: KT	TITLE: T.W.S. DATA SHEET
	DRAWN BY: RQ	APP BY:	

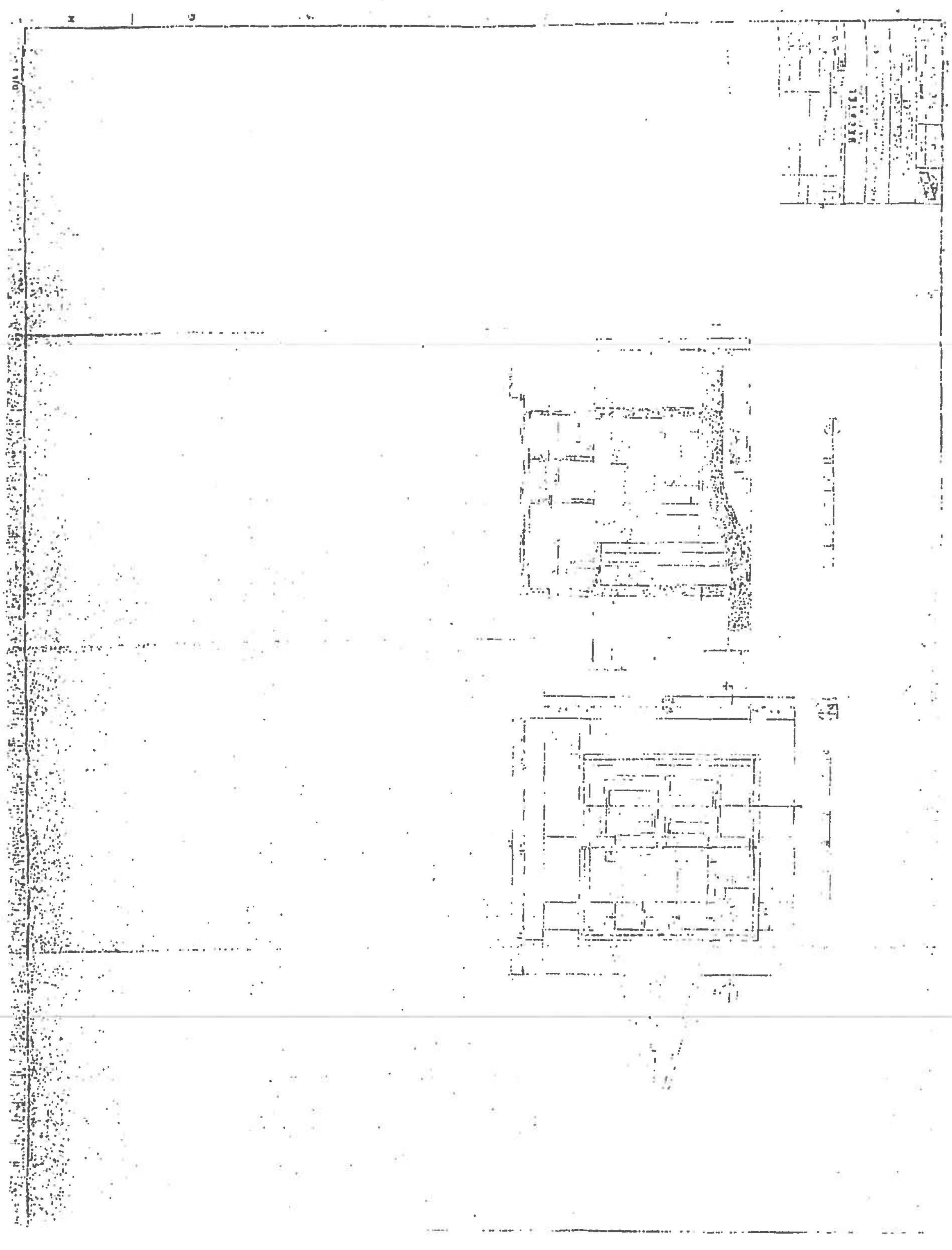
APPENDIX III.
TRAVELING WATER SCREEN DATA SHEET
PHILADELPHIA ELECTRIC COMPANY
PEACH BOTTOM ATOMIC POWER STATION
UNITS 2 AND 3
OUTER SCREEN STRUCTURE SCREENS
PURCHASE ORDER # BW660813
SPEC. # 6280-M-18

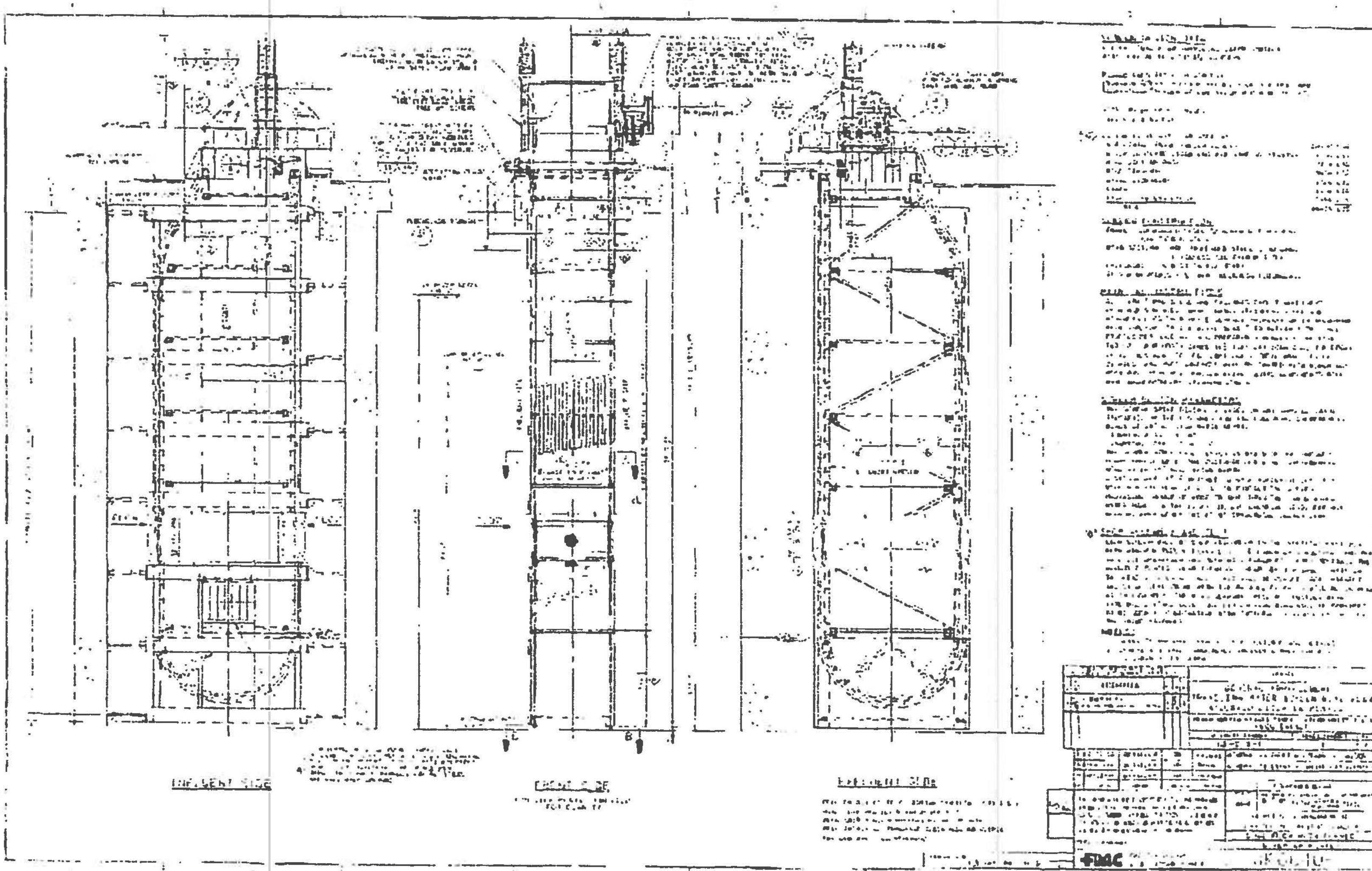
Station: PBAPS		Unit(s): 2+3		
Drawing: M-18-64		Sheet: 1	Rev: 0	
Date	Description	EVAL	IR	APP
2/14/01	INCORPORATE DWG INTO DOCUMENT CONTROL REGISTER PER ELR 73-00727. INITIAL ISSUE OF DOCUMENT	TB	LA	HW

DESIGN FLOW	67,000 GPM
DIFFERENTIAL HEADLOSS:	
% OF CLEANLINESS	
100%	.04 FT.
75%	.08 FT.
50%	.21 FT.
25%	.88 FT.
WATER DEPTH AT DESIGN FLOW	20'-0"
NORMAL HIGH WATER DEPTH	24'-6"
MATERIALS:	
SHAFTS: HEAD/FOOT	ANSI C1018 / TYPE 304SS
FRAME WORK:	CARBON STEEL
CHAIN AND ROLLERS:	ANSI C1045 SIDEBARS/ NON-LUBED 17-4 Ph SS PINS, ROLLERS, AND BUSHINGS
SCREEN PANELS:	
NUMBER/ DIMENSIONS	39 PER SCREEN 24" X 10'-0"
MATERIALS:	
FRAME:	CARBON STEEL
MESH:	14 GA. 3/8" SQ. OPEN 304 SS
MAX. DEFLECTION AT 5' DIFF.	.482 IN.
GEAR REDUCER	BY PECO
MANUFACTURE:	WESTINGHOUSE
TYPE AND SIZE	HELICAL GEAR 54Q
SPEED RATIO:	304.1 : 1
SPROCKET RATIO:	8 : 55
SCREEN TRAVEL SPEED:	5/10 F.P.M
WASH WATER:	264 GPM @ 80 PSI 294 GPM @ 100 PSI
WEIGHT:	
COMPLETE ASSEMBLY:	27,800 LBS.
SCREEN PANEL:	229 LBS.
CHAIN:	20.2 LBS. PER FT.
DIMENSIONS:	
DEPTH OF WELL	32'-0"
WIDTH OF WELL	11'-2"
LENGTH BETWEEN SHAFTS	33'-0"
SCREEN TYPE AND SIZE	10' X 33' 6 TOOTH 24" PITCH
DRIVER:	BY PECO
MANUFACTURER	WESTINGHOUSE
RPM/HP	1800 RPM/ 2 HP 900 RPM/ 1 HP






BECHTEL


INFLUENT SIDE
FRONT SIDE
EFFLUENT SIDE
FMC

URS CORPORATION
Fort Washington, PA

EXELON GENERATION COMPANY
Peach Bottom Atomic Power Station 316(b) Project

PEACH BOTTOM THROUGH-SCREEN VELOCITY

PREPARED FOR

Exelon

Prepared By: Teresa Jack, P.E., Senior Engineer — **Date:** September 21, 2007

Reviewed By: Jonilla Posey, P.E., Project Manager — **Date:** September 24, 2007

Approved By: John Dayman, P.E., Project Engineer — **Date:** September 24, 2007

Rev.	Date	Prepared by	Rev'wd by	Approved by
0	10/3/07	TAJ	JLP	JMD
1	10/24/07	RdS	JLP	JMD
2	11/28/07	RdS	JLP	JMD
3				

Peach Bottom Atomic Power Station 316b Project

THROUGH-SCREEN VELOCITY CALCULATION

Calculation Purpose:

Calculate the design through-screen velocity for the Peach Bottom outer cooling water intake structure.

Calculation Objectives:

1. Identify the screen physical parameters and design intake flow rate.
2. Calculate the proportion of open screen area to screen surface area.
3. Calculate the design through-screen velocity at the Outer CWIS under the listed assumptions.

System Description:

The Exelon Peach Bottom Atomic Power Station is a nominal 2.304 MW boiling water reactor atomic generating station with two active operating units (Units 2 and 3). Cooling water for the once-through condenser cooling system is withdrawn from the Conowingo Pond of the Susquehanna River by six CW pumps and discharged after use to the Conowingo Pond downstream of the CWIS. The cooling water intake is located on the shoreline of the Conowingo Pond. The water flows through the outer screen structure into two 3-acre intake basins and then through the original, inner intake structure. 29 active trash racks on the outer screen structure prevent ice and large objects from entering the outer screenhouse structure. There are 24 through-flow traveling water screens in the outer screenhouse.

Calculation Methodology:

The through-screen velocity will be calculated using formulas adapted from Pankratz, 1988.

V = Q / (WD * OA * TW * K) **(Formula 1)**

where:

Q = flow rate in gallons per minute (gpm)
V = through-screen velocity in feet per second (fps)
WD = water depth in feet (ft)
OA = proportion of screen open area to total screen area
TW = nominal screen tray width in ft
K = constant* = 396 for through-flow screen for unit conversion and reduction of screen open area due to typical screen features

and OA = (W x L) / ((W + D) * (L + d)) **(Formula 2)**

where:

d = screen horizontal (shute) wire diameter in inches (in)
D = screen vertical (warp) wire diameter (in)
W = width of screen opening (in)
L = vertical length of screen opening (in)

Peach Bottom Atomic Power Station 316b Project

THROUGH-SCREEN VELOCITY CALCULATION

Design Inputs:

1. Pump Design Capacities:

Unit No. 2 Circulating Pump	360.0	MGD	556.92	cfs	250,000	gpm	(Ref. 5)
Unit No. 2 Circulating Pump	360.0	MGD	556.92	cfs	250,000	gpm	(Ref. 5)
Unit No. 2 Circulating Pump	360.0	MGD	556.92	cfs	250,000	gpm	(Ref. 5)
Unit No. 3 Circulating Pump	360.0	MGD	556.92	cfs	250,000	gpm	(Ref. 5)
Unit No. 3 Circulating Pump	360.0	MGD	556.92	cfs	250,000	gpm	(Ref. 5)
Unit No. 3 Circulating Pump	360.0	MGD	556.92	cfs	250,000	gpm	(Ref. 5)
Service Water Pumps	80.6	MGD	124.75	cfs	56,000	gpm	(Ref. 6)
TOTALs	**2240.6**	**MGD**	**3466.3**	**cfs**	**1,556,000**	**gpm**	

Peach Bottom Max Withdrawal Rate	2240.6	MGD	
2. Number of screens	24		(Ref. 2)
3. Nominal Water Withdrawal Rate (per screen)	64,833	gpm	
4. Screen Width	10.00	feet	(Ref. 2)
5. Screenhouse Floor Elevation	84.0	feet	(Ref. 3)
6. Minimal Design Water Elevation	104.0	feet	(Ref. 7)
7. Water Height (Depth)	20.0	feet	
8. Mesh Size (Square)	0.375	inch	(Ref. 2)
9. Wire Size	14	Gauge	(Ref. 2)
10. Wire Width (Avg)	0.0800	inch	(Ref. 4)

Assumptions:

1. The minimum Pond level (below which Muddy Run would shut down) of 104.0 feet is used to calculate the design through-screen velocity even though the minimum permitted water height for the Conowingo Pond is 100.5 feet.
2. No changes to as-built configuration after dates of references used.
3. All twenty-four active intake screens are normally in service and 100% clean.
4. All pumps normally operate at their design capacity ratings.
5. Assume that the design flow is split evenly between all intake screens.
6. The constant for Formula 1 includes units conversion (gpm to cfs) and other screen factors.
7. Check velocity for worst-case scenario, with maximum no. of pumps for each unit operating.

References Used:

1. Page 78 and 79 of Screening Equipment Handbook, 2nd Edition, 1995. Tom M. Pankratz.
2. Drawing M-18-64_sht_00001, TWS Data Sheet, 1/15/93.
3. Drawing 6280, Sheets C-100-102, C.W. Screen Structure (Bottom Plan, Top Slab Plan, & Sections), Bechtel 1971-1976.
4. Standard Handbook for Mechanical Engineers, eight edition, p. 6-45
5. Design Basis Document: Circulating Water and Cooling Tower System, P-S-22, Revision 14, PECO Nuclear
6. Design Basis Document: Service Water System, P-S-17, Revision 9, PECO Nuclear
7. Conowingo Pond Management Plan, April 2006, pg. 22.

Summary and Conclusions:

The calculated design through-screen velocity for the Peach Bottom Outer CWIS is 1.205 fps

Peach Bottom Atomic Power Station 316b Project

THROUGH-SCREEN VELOCITY CALCULATION

Calculations:

1. Screen Physical Parameters and Design Intake Flow Rate

Formulas Used:
none

Given:

Q=	64.833	gpm per screen
Screen (outer): D=d=	0.0800	in
W=L=	0.375	in
WD=	20.0	ft
K=	396	
TW=	10.0	ft

Calculate:
N/A

2. Proportion of Open Screen Area to Total Screen Area

Formulas Used:
Formula 2

Given:
screen parameters as above

Calculate:
Outer Screenhouse
OA = (W x L) / ((W + D) * (L + d)) = **0.6793**

Peach Bottom Atomic Power Station 316b Project

THROUGH-SCREEN VELOCITY CALCULATION

Calculations: cont.

3. Design Through-screen Velocity at Outer CWIS

Formulas Used:
Formula 1

Given:
screen parameters as above and calculated screen open area proportion

Calculate:

V = Q / (WD * OA * TW * K) = **1.205** fps

ATTACHMENT II

STATISTICAL ANALYSIS OF IMPINGEMENT AT PEACH BOTTOM ATOMIC POWER STATION, 2005-2006

FOR

PEACH BOTTOM ATOMIC POWER STATION

Prepared for:

Exelon

by URS Corporation

October 2008

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1.0 Determination of Discreet Populations

1.1 Basic Statistics

To determine whether impingement from Units 2 and 3 could be analyzed together, numbers were first standardized to a sampling period of 24hr, adjusted for sub-sampling and collection gear efficiency (Appendix A, Section A.3.4). Since impingement numbers at each unit did not follow a normal distribution each dataset was $\log_{10}$ transformed to ensure normality (Table 1, Figure 1). Data from both units were combined and treated as one population since no statistical difference between impingement by unit was seen when data were compared using a paired two sample for mean t-test (Table 2).

Table 1 Tests of normality for raw and transformed impingement numbers from Units 2 and 3 showing $\log_{10}$ transformations were successful in attaining a normal distribution

	Unit 2	($\log_{10}$) Unit 2	Unit 3	($\log_{10}$) Unit 3
N of cases	104	104	104	104
Skewness	5.716	0.393	4.911	0.480
Kurtosis	38.469	0.093	28.360	-0.229
Shapiro-Wilk Test for Normality				
SW Statistic	0.322	0.980	0.368	0.974
SW P-Value	<0.001	0.109	<0.001	0.066
D'Agostino-Pearson K^2 Test for Normality				
K^2	156.5	2.924	139.3	4.454
P-Value	<0.001	0.232	<0.001	0.108

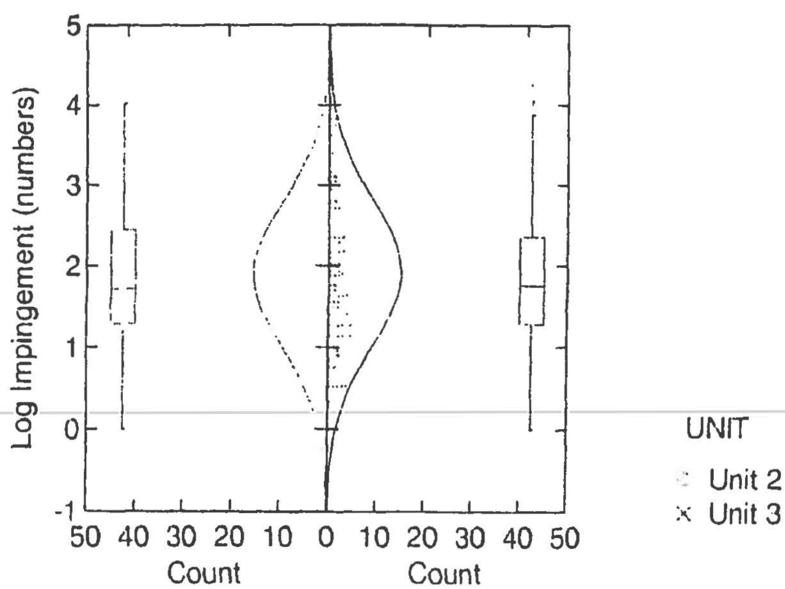

Figure 1 Density and box plots of Unit 2 and 3 ($\log_{10}$) impingement numbers showing similarities in distribution.

Table 2 t-Test: Paired Two Sample for Means for Units 2&3 at PBAPS (August 29, 2005 – November 17, 2006)

	(LOG_{10}) Unit 2	(LOG_{10}) Unit 3
Mean	1.89861	1.911273
Variance	0.812554	0.851769
Observations	104	104
Pearson Correlation	0.610908	
Hypothesized Mean Difference	0	
df	103	
t Stat	-0.16044	
t Critical two-tail	1.983264	
P(T<=t) two-tail	**0.87285**	

1.2 Gizzard shad (Dorosoma cepedianum)

The total number of impinged gizzard shad was analyzed separately from other species because its overall abundance was the primary driver of impingement totals throughout the study, and specifically during the fall of 2005. Neither untransformed gizzard shad impingement data nor transformed data sets were found to follow a normal distribution (Table 3).

Table 3 Tests of normality for raw and transformed gizzard shad impingement data showing transformations were unsuccessful in attaining a normal distribution, PBAPS (August 29, 2005 – August 30, 2006)

	Gizzard shad	(log_{10}) Gizzard shad	(Gizzard shad)^2	$\sqrt{\text{Gizzard shad}}$	$\sqrt[4]{\text{Gizzard shad}}$
N of cases	82	82	82	82	82
Skewness	3.431	0.311	5.122	2.182	1.124
Kurtosis	12.338	-1.143	27.964	4.283	0.544
Shapiro-Wilk Test for Normality					
SW Statistic	0.446	0.929	0.287	0.664	0.879
SW P-Value	<0.001	<0.001	<0.001	<0.001	<0.001
D'Agostino-Pearson K^2 Test for Normality					
K^2	83.62	9.734	120.3	47.58	15.09
P-Value	<0.001	0.009	<0.001	<0.001	<0.001

Since normality could not be attained, the data were analyzed using a (non-parametric) two-sample Kolmogorov-Smirnov test to test the potential differences in seasonal impingement. The results showed that fall 2005 gizzard shad IM differed from all other seasons, and therefore should be analyzed separately to determine any relationship with independent variables (Table 4).

Table 4 **Two-sample Kolmogorov-Smirnov non-parametric test for differences showing fall (2005) impingement differed from every other season**

	Fall	Winter	Spring	Summer
Fall	1			
Winter	-	1		
Spring	-	1	1	
Summer	-	1	1	1

Table 5 **Descriptive statistics for seasonal gizzard shad impingement at PBAPS (August 29, 2005 – August 30, 2006)**

	Fall	Winter	Spring	Summer
Count	45	11	12	14
Mean	**3,281.33**	**2.15**	**1.18**	**66.81**
Standard Error	887.28	0.73	0.39	28.05
Standard Deviation	5,952.08	2.42	1.34	104.96
Variance	35,427,216.09	5.84	1.79	11,016.52
Kurtosis	5.37	0.57	-1.47	1.28
Skewness	2.37	1.26	0.46	1.58
95% Confidence Interval	1,788.20	1.62	0.85	60.60

1.3 Remaining Impingement

The remaining data (all impingement excluding fall 2005 gizzard shad) were analyzed to assess whether there was a statistical difference in mean impingement within this dataset between seasons (fall 2005 [fish other than gizzard shad], winter 2005/06, spring 2006, summer 2006 and fall 2006). Normality was attained using a $\log_{10}$ transformation (see Table 7). ANOVA analysis showed that no one season differed from all other seasons, allowing the remaining IM data to be evaluated as a single population (Table 6).

Table 6 **Descriptive statistics, Analysis of Variance, and Bonferroni post hoc test for all impingement except fall 2005 gizzard shad against season, PBAPS (August 29, 2005 – August 30, 2006)**

Descriptives for impingement (w/o Fall 2005 Gizzard shad)

Groups	Count	Sum	Average	Variance
Fall	45	7,208.9	160.20	34,435
Winter	11	625.8	56.89	2,966
Spring	12	472.9	39.41	706
Summer	14	2,094.9	149.64	17,745

Analysis of Variance						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
Between Groups	202,896	3	67,632	2.96	0.04	2.72
Within Groups	1,783,253	78	22,862			
Total	1,986,148	81				

Bonferroni Matrix of Pairwise Comparison Probabilities				
	Fall	**Winter**	**Spring**	**Summer**
Fall	1			
Winter	0.083	1		
Spring	0.028	1	1	
Summer	1	0.063	0.026	1

Therefore, two separate populations of impingement data exist and were used in subsequent analyses: 1) Population I, consisting of gizzard shad impinged during fall 2005, and 2) Population II, comprised of all other impinged fish and gizzard shad collected in seasons other than fall 2005.

2.0 Regression Analysis

Environmental conditions may have an effect on impingement at the PBAPS. Stepwise multiple regression analysis was used to determine if independent variables potentially associated with fish abundance and distribution were correlated with impingement and could potentially explain variability in observed impingement rates. Environmental and operational variables used in this analysis are given in Table 8. Before performing the multiple regression analysis, the data for each population were log-transformed to satisfy assumptions for normality (Table 7).

Table 7 Tests of normality for raw and transformed Population I and II datasets showing $\log_{10}$ transformations were successful in attaining a normal distribution

	Population I	($\log_{10}$) Population I	Population II	($\log_{10}$) Population II
N of cases	45	45	82	82
Skewness	2.368	-0.029	2.440	-0.032
Kurtosis	5.365	-1.033	7.123	-0.551
Shapiro-Wilk Test for Normality				
SW Statistic	0.610	0.963	0.715	0.989
SW P-Value	<0.001	0.159	<0.001	0.691
D'Agostino-Pearson K^2 Test for Normality				
K^2	35.650	2.040	58.950	1.260
P-Value	<0.001	0.360	<0.001	0.531

When testing the relationship between variables, an R-squared (R^2) value was calculated, in addition to the p-value. This value measures the amount of variation that can be explained by a particular variable. In general, a higher calculated R^2 value indicates a stronger correlation between the independent variables (e.g., river flow) and the response variable (e.g., impingement), and vice-versa.

Because statistical analyses showed that two separate populations exist within the impingement dataset, regression analyses were performed on each population separately. A reverse stepwise regression was performed, where each of the variables was removed one by one (in increasing order of importance) and the statistical results for the remaining variables was observed.

Table 8 Environmental and operational values used in regression analysis (PBAPS August 29, 2005 – November 17, 2006)

Date	Pool Elevation (ft)	Daily Pool Elevation Δ (ft)	Through Screen Velocity (fps)	Water Temperature (°C)	Dissolved Oxygen (mg/l)	Turbidity (Secchi Depth, ft)	River Flow (cfs)
8/30/2005	107.6	3.23	0.984	29.0	7.6		4,078
9/6/2005	108.0	1.78	0.966	26.1	9.0	1.1	12,960
9/21/2005	106.6	2.26	0.855	27.0	7.0	0.8	4,329
9/23/2005	107.6	2.12	0.493	25.8	7.5	1.2	3,700
9/28/2005	107.8	1.70	0.489	23.0	7.4	0.9	2,573
9/30/2005	107.1	1.07	0.504	22.4	8.3	1.0	3,567
10/3/2005	105.5	3.60	0.541	23.8	8.3	1.0	4,016
10/5/2005	106.6	2.40	0.514	24.0	8.5	1.1	4,736
10/6/2005	107.0	2.00	0.505				
10/10/2005	106.8	1.05	0.510	19.2	7.8	0.2	29,441
10/12/2005	107.8	2.32	0.813	20.1	8.0	0.8	21,774
10/13/2005	108.0	2.31	0.807				20,407
10/18/2005	108.2	1.95	0.801	16.4		0.9	30,387
10/19/2005	108.4	1.82	0.793	16.8	9.4	0.9	26,190
10/20/2005	108.4	1.35	0.940	16.1	9.5	0.9	23,757
10/21/2005	108.1	2.49	0.965	14.7	9.3	1.0	21,158
10/24/2005	109.1	1.57	0.927	14.9	9.5	0.9	19,317
10/25/2005	108.9	2.21	0.935	13.8	10.4	0.8	22,971
10/26/2005	108.1	2.55	0.963	15.5	4.8	1.0	44,276
10/27/2005	108.9	2.84	0.932	11.3	11.9	0.7	81,246
10/28/2005	111.3	3.80	0.852	10.9	10.5	0.7	118,140
10/31/2005	109.5	1.88	0.912	8.9	11.2	0.5	58,320
11/1/2005	109.3	2.16	0.918	10.0	11.1	0.7	47,572
11/2/2005	108.9	1.44	0.935	10.7	11.1	0.7	40,535
11/3/2005	108.2	2.46	0.959	10.7	10.9	0.8	36,136
11/4/2005	108.5	1.45	0.947	11.7	10.8	0.9	33,926
11/7/2005	108.3	2.30	0.955	12.2	9.1	1.1	28,522
11/8/2005	108.6	2.24	0.944	12.4	10.8	1.1	25,664
11/9/2005	107.8	1.89	0.974	12.7	10.2	1.2	24,158
11/10/2005	108.4	1.43	0.951	13.0	10.1	1.0	23,940
11/11/2005	109.0	0.83	0.931	12.4	9.9	1.1	24,282
11/14/2005	108.6	2.42	0.943	11.2	10.4	1.0	36,476
11/15/2005	108.5	2.99	0.950	12.0	10.2	1.1	33,161
11/16/2005	108.4	0.91	0.951	11.5	11.0	1.3	30,075
11/17/2005	108.4	2.06	0.951	11.0	10.6	1.0	30,572
11/18/2005	108.5	2.65	0.948	10.5	10.6	1.0	45,223
11/21/2005	109.3	2.35	0.613	7.5	12.0	1.3	54,049
11/22/2005	109.0	2.19	0.619	7.9	12.0	0.9	46,729
11/23/2005	109.0	1.68	0.619	7.8	11.6	1.0	41,660
11/28/2005	108.3	2.82	0.637	5.0	9.7		26,939
11/29/2005	107.0	2.68	0.675	5.3	12.8	1.5	25,173

(Continued…)

Table 8 (Continued) Environmental and operational values used in regression analysis (PBAPS August 29, 2005 – November 17, 2006)

Date	Pool Elevation (ft)	Daily Pool Elevation Δ (ft)	Through Screen Velocity (fps)	Water Temperature (°C)	Dissolved Oxygen (mg/l)	Turbidity (Secchi Depth, ft)	River Flow (cfs)
11/30/2005	108.4	5.30	0.636	5.7	12.8	1.2	50,661
12/1/2005	113.5	6.38	0.524	8.2	11.9	1.1	194.375
12/2/2005	114.5	1.69	0.603	9.3	11.9	0.5	218.118
12/5/2005	111.2	2.15	0.570	8.1	12.0	0.6	93,476
12/6/2005	109.9	2.19	0.598	4.8	13.7	0.5	73,655
12/13/2005	108.7	1.47	0.628	1.5	14.0	1.0	30,613
12/20/2005	108.2	1.55	0.641	3.5	14.4	0.8	31,790
12/27/2005	108.1	1.82	0.643	1.9	13.8	1.3	34,197
1/3/2006	107.2	3.07	0.999	6.2	13.2	0.7	77,925
1/10/2006	106.6	2.24	1.028	7.1	12.3	2.5	62,195
1/17/2006	107.1	2.91	1.006	3.2	14.9	0.8	106,014
1/24/2006	108.5	0.68	0.950	4.7	13.2	0.6	104,607
1/31/2006	107.3	1.63	0.995	4.8	12.9	1.2	51,839
2/7/2006	108.2	0.75	0.639			0.4	
2/14/2006	107.0	2.40	0.673	1.7	14.2	1.7	49,200
2/21/2006	107.0	1.60	0.672	3.9	12.6	1.4	36,500
2/28/2006	107.2	2.89	0.668	3.0	13.4	1.2	26,200
3/7/2006	107.7	1.40	0.654	3.3	13.4	1.6	19,000
3/14/2006	107.9	0.66	0.647	12.6	12.6	1.4	25,400
3/21/2006	108.2	1.55	0.800	6.0	12.6	0.4	38,500
3/28/2006	107.9	1.55	0.971	7.3	11.9	1.2	23,200
4/4/2006	108.5	0.97	0.948	13.9	12.8	0.8	20,200
4/18/2006	108.2	2.03	0.962	16.1	10.6	0.8	26,500
4/25/2006	107.2	1.33	1.003	15.5	9.7	0.8	59,100
5/2/2006	107.7	1.71	0.982	17.0	11.2	0.8	34,500
5/9/2006	108.2	1.70	0.961	19.3	8.3	0.9	19,800
5/16/2006	107.6	1.78	0.986	19.0	7.4	0.8	33,100
5/23/2006	107.7	0.65	0.981	16.4	9.2	0.8	27,300
5/30/2006	107.8	2.17	0.976	22.5	9.3	1.1	19,500
6/13/2006	107.7	1.29	0.982	21.0	8.8	0.8	29,700
6/20/2006	107.6	1.71	0.986	24.3	8.3	0.9	16,800
6/27/2006	108.1	1.68	0.962	25.2	7.8	0.4	80,000
7/6/2006	107.8	2.32	0.978				64,200
7/11/2006	108.0	1.30	0.968	24.7	8.1	0.5	36,500
7/18/2006	107.2	0.95	1.003	28.3	8.4	0.8	34,000
7/25/2006	107.2	1.61	1.003	28.4	6.8	0.8	33,900
8/1/2006	107.4	2.31	0.992	29.1	7.5	1.1	22,700
8/8/2006	108.4	1.61	0.951	30.2	6.3	0.9	14,500
8/15/2006	107.7	2.32	0.981	28.5	7.4	0.9	9,400
8/21/2006	106.8	3.45	1.018	28.1	7.7	1.1	8,200
8/29/2006	107.7	1.98	0.981	27.3	7.1	1.0	18,000

2.1 *Population I*

Multiple regression analysis resulted in a highly significant correlation between TSV and $\log_{10}$(# gizzard shad impinged) during fall 2005 (Table 9)

The plot of $\log_{10}$(# gizzard shad impinged) values included in the regression analysis for Population I versus TSV is shown in Figure 2. The coefficient of determination (R^2) generated by the linear regression model (0.63) indicates that approximately 63 percent of the variation in $\log_{10}$(# gizzard shad impinged) can be accounted for by TSV

Table 9 Reverse Stepwise Multiple Regression Results for the Number of Gizzard Shad Impinged During the Fall 2005 (Population I).

Effect	Coefficient	Std Error	Std Coef	Tol.	df	F	'P'	Step Removed
River Flow	0	0	-0.011	0.08812	1	0.001	0.974	1
Pool Elevation	0.026	0.182	0.042	0.10791	1	0.02	0.888	2
Water Temperature	-0.021	0.04	-0.123	0.17155	1	0.279	0.601	3
Dissolved Oxygen	-0.13	0.113	-0.252	0.19291	1	1.321	0.259	4
Turbidity (Secchi Depth)	0.536	0.451	0.137	0.70392	1	1.412	0.243	5
Daily Pool Elevation Δ	-0.156	0.122	-0.166	0.55414	1	1.637	0.21	6
Through Screen Velocity	3.908	0.638	0.721	0.6718	1	37.53	<0.001	---

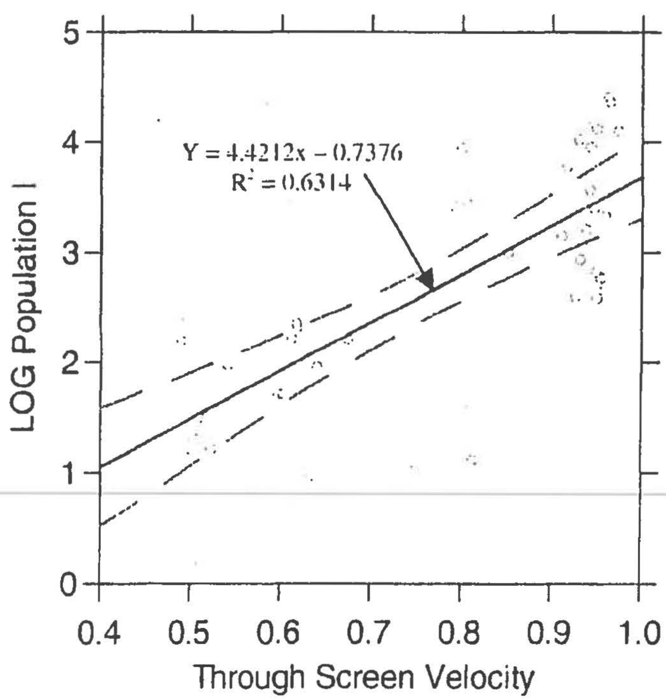

Figure 2 Regression Plot of ($\log_{10}$) impingement numbers as a Function of through screen velocity for Population I. Dashed lines represent 95% confidence intervals.

2.2 *Population II*

A step-wise multiple regression analysis was performed to determine if environmental variables were correlated with impingement using the Population II impingement dataset. Although three variables were statistically significant (Table 10), there were no strongly correlated relationships between observed impingement rates and these variables. The R^2 value of the most significant variable was 0.09, and the two most significant variables combined (pool elevation and TSV) had a coefficient value of approximately 0.15, indicating that only 15 percent of the variation in impingement could be explained by these two variables collectively (Table 11, Figure 3).

Table 10 Reverse Stepwise Multiple Regression Results for Population II.

Effect	Coefficient	Std Error	Std Coef	Tol.	df	F	'P'	Step Removed
Daily Pool Elevation Δ	-0.015	0.064	-0.028	0.77189	1	0.057	0.812	1
River Flow	0	0	0.155	0.33738	1	0.784	0.379	2
Water Temperature	-0.022	0.015	-0.353	0.17998	1	2.158	0.146	3
Turbidity (Secchi Depth)	-0.274	0.182	-0.178	0.74126	1	2.27	0.137	4
Pool Elevation	0.083	0.061	0.219	0.39747	1	1.833	0.007	---
Through Screen Velocity	0.646	0.319	0.22	0.88341	1	4.097	0.017	---
Dissolved Oxygen	-0.126	0.054	-0.561	0.18264	1	5.535	0.05	---

Table 11 Linear regression analysis – (log_{10}) Population II vs. individual parameters with resulting R^2 values.

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)	R^2
Pool Elevation	0.116	0.042	0.294	1	2.751	0.007	0.09
Through Screen Velocity	0.772	0.317	0.263	1	2.435	0.017	0.07
Dissolved Oxygen	-0.05	0.025	-0.225	1	-1.995	0.05	0.05

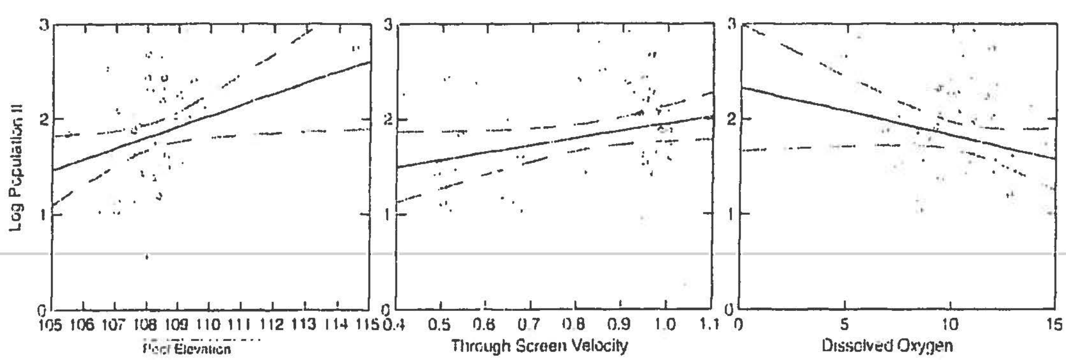

Figure 3 Regression Plot of (log_{10}) impingement numbers as a Function of Pool elevation, through screen velocity, and Dissolved oxygen individually for Population II. Dashed lines represent 95% confidence intervals.

3.0 Additional Analysis

All RS species/groups were also examined separately in an attempt to discern any correlation between a particular species' impingement rate and any of the environmental variables tested. The fall 2005 season encompassed 45 sampling events, due in part to an effort to sample intensively through the American shad migration period. Therefore, during this particular season there is generally a wide distribution in the values of tested environmental variables, making it useful for regression analysis. Each species was tested through multiple regression analysis against several environmental variables (see Table 8). No significant correlations ($R^2 > 0.50$) were found between any of the RS species (other than gizzard shad) and the variables tested (Table 12). Other seasons were subsequently tested in an effort to determine if any significant relationships could be observed. The results, however, are unreliable due to small sample sizes and substantial number of "0" values and are not presented here.

Table 12 Summary table for multiple regression analysis between RS species and environmental and operational variables for Fall 2005 at the PBAPS. Multiple R^2 values are calculated from multiple regressions incorporating the variables listed for each species, while R^2 values are calculated from linear regressions between impingement number and a single variable.

Effect	Coeffi-cient	Std Error	Std Coef	Toler-ance	t	P (2tail)	R^2	Multiple R^2
American Shad								
Through Screen Velocity	1.217	0.324	0.496	0.995	3.761	0.001	0.12	0.32
Turbidity (Secchi depth)	-0.564	0.234	-0.318	0.995	-2.41	0.021	0.03	
Bluegill								
Temperature	-0.126	0.03	-1.066	0.243	-4.15	0.000	0.005	0.41
Dissolved Oxygen	-0.29	0.09	-0.825	0.243	-3.213	0.003	0.01	
Turbidity (Secchi depth)	-0.945	0.339	-0.352	0.999	-2.785	0.008	0.04	
Channel Catfish								
Temperature	0.03	0.011	0.358	1	2.842	0.007	0.08	0.38
Turbidity (Secchi depth)	-0.976	0.241	-0.509	1	-4.045	0.000	0.06	
Comely shiner								
no variables resulting in p<0.05								
Gizzard shad								
Through Screen Velocity	4.387	0.509	0.796	1	8.611	0.000	0.63	0.63
Largemouth bass								
Pool Elevation	0.075	0.023	0.448	0.923	3.329	0.002	0.09	0.3
Daily Pool Elevation Δ	-0.12	0.035	-0.463	0.923	-3.443	0.001	0.10	
Smallmouth bass								
Temperature	-0.035	0.011	-0.819	0.296	-3.209	0.003	0.01	0.25
Dissolved Oxygen	-0.117	0.033	-0.913	0.296	-3.578	0.001	0.02	
Walleye								
Through Screen Velocity	1.374	0.351	0.5	0.961	3.918	0.000	0.12	0.37
Daily Pool Elevation Δ	-0.144	0.067	-0.3	0.799	-2.142	0.038	0.02	
River Flow	0	0	0.358	0.806	2.564	0.014	0.01	
White Crappie								
Temperature	-0.043	0.016	-0.709	0.296	-2.615	0.013	0.01	0.15
Dissolved Oxygen	-0.097	0.049	-0.53	0.296	-1.955	0.058	0.22	